

Technology-Assisted Toilets: An Assistive Technology for Improving Hygiene and Independence  
in the Bathroom

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## **Preface**

Prior to conducting this research, all of the necessary approvals were obtained from the University of Ottawa Research Ethics Board and the Bruyère Research Ethics Board. David Yachnin’s contributions to this thesis include being the primary researcher responsible for designing the research projects, applying for grants, obtaining Research Ethics Board approval, carrying out recruitment of participants, data collection, and conducting statistical analyses, and writing the manuscripts for publication. The collaborators and co-authors for each article provided assistance and consultation whenever it was needed, and provided feedback on all applications and manuscripts.

## Abstract

**Purpose:** Toileting is an activity of daily living that is often difficult to perform independently for rehabilitation patients, which can be detrimental to the patient's self-esteem and hygiene. Technology-Assisted Toilets (TATs) are commercially-available toilet seats which clean the user with a stream of water, and have a fan for drying. TATs are operated by a wall-mounted remote control. This thesis investigated whether TATs could improve stroke and geriatric rehabilitation patients' ability to clean themselves independently after a bowel movement, and improve psychosocial outcomes when toileting.

**Methods:** Stroke rehabilitation participants answered the Psychosocial Impact of Assistive Devices Scales (PIADS) to assess the psychosocial impact of their regular toileting, then used the TAT for a bowel movement on three occasions. In geriatric rehabilitation, participants completed two bowel movement trials; one using regular toileting and one using the TAT. In both studies, participants answered the PIADS and were visually assessed for cleanliness after each trial.

**Results:** Stroke rehabilitation patients had significantly higher PIADS when using the TAT. TATs cleaned participants completely in 73% of BM trials. In geriatric rehabilitation, participants gave TATs higher PIADS scores than regular toileting, but the difference was not statistically significant. Cleanliness level was equal between TAT and regular toileting.

**Conclusions:** These pilot studies show that TATs have the potential to be useful assistive devices for stroke and geriatric rehabilitation patients who have difficulty cleaning themselves independently in the bathroom. PIADS scores in both studies suggest that participants would be unlikely to abandon using TATs.

## **Chapter 1 - Introduction**

### **1.1 Outline of the Thesis**

The present chapter provides a background on the population of interest, the toileting technology that was investigated, and gives context to the need for better toileting care and assistive devices. This chapter also outlines the research questions, objectives, and hypotheses that guided this research.

The second chapter will provide greater detail on the use of Technology-Assisted Toilets (TATs), including their potential benefits, the interdisciplinary relevance of TATs, and the anticipated outcomes of TAT research. Additionally, it will summarize the three manuscripts contained in this thesis.

The third chapter presents a narrative review article on toileting in rehabilitation populations, with an emphasis on impairments concerning toileting hygiene.

The fourth chapter presents the first pilot study on TATs, which tested their use in stroke rehabilitation.

The fifth chapter presents a follow-up study on TAT use in geriatric rehabilitation.

The sixth chapter presents a discussion on TATs based on the results of the three manuscripts included in this thesis. It will elaborate on the implications of TAT research and suggest future studies that will ascertain whether TATs can be used as an effective assistive device in rehabilitation.

### **1.2 Statement of the Problem**

Toileting is one of the earliest activities that we must learn to complete independently. The fact that we complete this activity privately for the majority of our lives makes it much more difficult once we are forced to accept assistance to go to the bathroom. While we currently have assistive devices that

help those who are unable to reach the bathroom, transfer onto the toilet, or remain continent, there is a surprising lack of assistive devices that improve a person's ability to clean themselves independently in the bathroom. This thesis explores toileting issues in stroke and geriatric rehabilitation, and describes and discusses studies that were conducted concerning TATs, a currently available device that could be used to improve toileting independence and hygiene.

### **1.3 Background**

Toileting is an activity of daily living that is intensely private and often not discussed, but many elderly people are unable to toilet independently. Among adults aged 65 years or older the prevalence of toileting impairments has been estimated to range from 6% for community-dwelling adults (Lee, Lindquist, Segal, & Covinsky, 2006) to as high as 60% for nursing home residents (Jones, Sonnenfeld, & Harris-Kojetin, 2009). Health care professionals and caregivers must then provide assistance, and the resultant dependency is detrimental to the person's psychological well-being. Toileting impairments can have significant psychosocial consequences, such as depression, loss of self-esteem, and loss of dignity, and can retard recovery from illness and injury (Ory, Wyman, & Yu, 1986; Wyman, 1991).

While issues concerning continence are frequently studied, it is important to separate continence from toileting impairments. Incontinence refers to the inability to control when one voids or has a bowel movement. This usually means that a person who is incontinent will often soil themselves. This leads to improper toileting hygiene. Remaining continent is a challenge for many, but it does not include the full scope of toileting. In this research, "toileting impairment" refers to problems that involve the inability to clean oneself independently in the bathroom.

Toileting impairments can be caused by several aspects of physical disability. Impaired balance can make it difficult to successfully use or remain seated on the toilet, while mobility limitations can impair the ability to clean oneself. Impairment of wrist flexion in conditions such as rheumatoid arthritis

(Nordenskiöld, 1997), or lack of balance and strength due to stroke (Fujita et al., 2015) can make the required wiping motions impossible, and pain or restriction of range of motion to the elbow or shoulder owing to trauma or disease can make reaching the perineal and periurethral regions difficult (Ashraf et al., 2012, Kolakowsky-Hayner et al., 2012). In these instances the disabled person can no longer use a toilet without assistance.

Toileting is a largely stigmatized topic that is often considered undignified and embarrassing to discuss (Drennan, Cole, & Iliffe, 2011; Clark & Rugg, 2005; Siviter, 2013). Researchers tend not to focus on this topic, which has led to a lack of information on many aspects of toileting. The high prevalence rates for toileting impairment show the importance of proper toileting assistance, but there is very little research that focuses on improving the capability of those who cannot toilet independently.

Currently, assistive devices for toileting include items such as grab bars, raised toilet seats, commodes, and stabilizing arms for toilet seats. These devices are important in assisting patients to transfer onto the toilet and to remain balanced, but they do not address the inability of many patients to clean themselves. This research will investigate whether TATs, a widely available type of toilet, can be used to increase independence in toileting for geriatric rehabilitation patients. These devices are common in Japan, and are commercially available as a luxury item in North America, but their potential use as an assistive device has been overlooked.

TATs are toilets that clean and dry the user with a gentle stream of water and a fan, potentially eliminating the need for the user to be able to wipe him- or herself. TATs have several additional features that can be adjusted to increase their effectiveness, including stream position, water and dryer temperature, and water pressure. The toilet is operated using a wall-mounted remote control. These devices have the potential to enable geriatric rehabilitation patients to toilet independently by eliminating the need for them to wipe themselves.

### 1.3.1 Toileting in Stroke Rehabilitation

Stroke patients experience disability related to brain injury and its physical, perceptual, and cognitive consequences. Each of these deficits may contribute to difficult-to-perform, incomplete and unhygienic toileting. Common disabilities following stroke include hemiplegia, aphasia, and cognitive impairments that can vary in effect and severity based on the type of stroke and the area of the brain that is affected.

Hemiplegia is likely to have the most direct on toileting, since hemiplegia can physically restrict a person's ability to get to the bathroom, transfer onto the toilet, and clean themselves. A person whose dominant side becomes paralyzed may lack the strength to effectively wipe themselves, and problems with mobility can make it difficult to lean over to wipe or to reach the perineal area. In these cases, a device that could allow a person to clean themselves independently with these physical impairments would be beneficial.

An estimated 40–60% of stroke inpatients have isolated urinary incontinence, (Thomas et al., 2011) 8–30% have isolated fecal incontinence, (Kovindha, Wattanapan, Dejpratham, Permsirivanich, & Kuptniratsaikul, 2009; Harari, Coshall, Rudd, & Wolfe, 2003) and up to 33% have double incontinence, (Kovindha et al., 2009) giving prominence to the issue of effective toileting. One study showed that in stroke patients being discharged from hospital, only 51.6% were functionally independent for toileting one month following discharge, and 16.4% remained dependent after six months. (Thomas et al., 2011) These statistics indicate that stroke survivors have a considerable amount of difficulty toileting after stroke, and that there is a need for assistive devices that can reduce toileting impairments.

### **1.3.2 Toileting in Geriatric Rehabilitation**

Geriatric rehabilitation is a generally more diverse category that can include patients with a wide variety of conditions and disabilities. There is no universal definition for who can be included in geriatric rehabilitation, and the types of patients that are admitted for this kind of care differs depending on the institution and program. The Elisabeth Bruyère Hospital, in Ottawa, Ontario, and which was used as the study site for this thesis, uses the following criteria to admit patients into their geriatric rehabilitation program: The patient must be elderly and recovering from a recent illness, injury, surgery, or other condition resulting in loss of autonomy. Additionally, they must be well enough and have sufficient energy to participate in two, one-hour therapy sessions each day, able to learn and retain new information, and motivated to participate in the program.

This definition of geriatric rehabilitation includes patients with varied medical histories, but requires that the patients have lost a certain degree of independence. In scenarios in which mobility is compromised and autonomy is lost, it is common for toileting impairments to follow. This demonstrates that research concerning improving toileting independence is deeply relevant to the field of geriatric rehabilitation.

## **1.4 Relevance to Clinical Care**

If TATs are found to be effective as an assistive device for rehabilitation patients, there could be a number of important benefits for health care. Requiring toileting assistance can have a large impact on patient dignity and self-esteem (Drennan et al., 2011; Clark & Rugg, 2005; Siviter, 2013), so any reduction in the amount of assistance needed could lead to improvements in well-being and help to reduce depression. There could also be economic benefits for the health care system by reducing the amount time spent assisting patients in the bathroom. This would allow healthcare staff to allocate their time and resources to other tasks. Finally, improved hygiene could lead to a reduction in rashes, skin

breakdowns, and infections, making TATs clinically beneficial. These benefits would only exist if TATs are found to be at least as effective as standard toileting practices.

While current TATs could prove to be beneficial to disabled populations, they are not specifically designed for rehabilitation. It is quite possible certain features of these devices are not suitable for use in health care, or could be improved to make them more effective as assistive devices. For example, it is possible that the remote control may not be easy to understand or manipulate for elderly people with limited mobility, dexterity, or cognitive impairments. It is also possible that a feature such as automatic programming for the movement of the stream could lead to more thorough cleaning than someone would achieve by using the remote control. Aspects such as these could be modified in order to improve TATs for use in a rehabilitation setting.

## **1.5 Research Questions**

- a. Can TATs improve psychosocial outcomes for geriatric rehabilitation patients compared to standard toilets?
- b. Can TATs improve toileting hygiene after a bowel movement for geriatric rehabilitation patients when compared to standard toileting without assistance?

## **1.6 Hypothesis**

We hypothesized that without being given assistance to clean themselves in the bathroom, participants would report an improvement on psychosocial outcomes when using the TAT relative to using toilet paper. This would be shown by higher scores on the Psychosocial Impact of Assistive Devices Scale.

We predicted that TAT cleaning functions would be more effective than standard toileting care for geriatric rehabilitation patients who are cleaning themselves without assistance. Participants would show a higher degree of cleanliness after using the TAT, but it is likely that participants with certain impairments and disabilities will use the TAT less effectively than others.

## **1.7 Objectives**

1. To assess the impact of technology-assisted toilets (TATs) on psychosocial outcomes compared to standard toileting care for cleaning following a bowel movement in geriatric rehabilitation.
2. To investigate whether geriatric rehabilitation patients are able to independently clean themselves more effectively with a TAT than when using standard toileting.

In addition, through our observation of patient use of the TAT, we tried to identify features of the TAT that would need to be improved in order to make TATs more effective for use in rehabilitation. Finally, we hope to gather information on the perceptions of healthcare staff concerning the implementation of TATs as assistive devices.

## **Chapter 2 - Theoretical Basis of Technology-Assisted Toilets as Assistive Devices**

### **2.1 Theoretical Models for Aging, Disability and Toileting**

Detailed information concerning toileting is scarce, as it is not a commonly studied topic. As a result, there is no current defined model for the progression of toileting ability as people age. There are, however, a number of studies which have identified the progression of disability for activities of daily living (Jette, Tao, Norweg, & Haley, 2007; Binder et al., 2003; Kingston et al., 2012; Gerrard, 2013; Wloch, Kuh, & Cooper, 2016). These studies have included toileting in their analyses to varying degrees. It is important to consider that there are several separate that are involved in fully independent toileting, including the ability to dress, transfer, remain continent, and clean oneself. Studies of activities of daily living often use different definitions and measures of toileting ability, and some are unclear about what aspects of toileting they are considering.

In a discussion of outcome measures in rehabilitation settings, Jette et al. (2007) used a method of stratifying data into stages, with each stage representing a clinically significant difference in functional ability. In their analysis, having some difficulty using the bathroom indicated that a patient was in stage 1, suggesting that the patient would have great difficulty moving within a room. Binder et al. (2003) conducted a study in which they looked for clinical factors that can predict decline in activities of daily living (ADL) within 30 days of being discharged from hospital. Decline in self-performance of toileting was identified as one of the factors significantly associated with ADL decline. These studies show that toileting can be both an indicator of the severity of a patient's functional decline and a predictor that a patient will show functional decline in the near future.

In a cohort study of British 85 year-old adults, Kingston et al. (2012) determined a hierarchy of activities of daily living by asking participants whether they could complete certain activities. After ranking the frequency of impairments on these activities, completing a “full wash” was not possible by 33.7% of participants, 18.2% were unable to “transfer from toilet”, and 17.6% had difficulty dressing. These were the 6<sup>th</sup>, 12<sup>th</sup>, and 14<sup>th</sup> most difficult activities respectively. In this study, no definition of “full wash” is included, and it is unclear whether ability to clean oneself in the bathroom was considered.

Another study, which used data from the National Nursing Home Survey, analyzed functional independence score for six activities of daily living (Gerrard, 2013). The order of difficulty from least to most difficult for these items was; eating, maintaining continence, transferring, toileting, dressing, and bathing. In this case, no definition of toileting was provided.

Toileting difficulties are a relatively easy activity of daily living until later in life. A longitudinal study created a hierarchy of difficulty for these activities for participants at the ages of 43, 53, and 60-64. At age 60-64, getting to the toilet and using the toilet, which were two separate items, were ranked low in terms of difficulty. Only washing one’s face and feeding were considered easier (Wloch et al., 2016). This study did not provide details on toileting at age 43 or 53, or an explanation of what factors were considered in the category of using the toilet.

These theories of ADL decline show that while toileting may not be the first ADL to show decline, it is an important factor to consider when determining the functional status of rehabilitation patients. The studies presented above identify toileting as a highly prevalent, moderately difficult ADL that tends to decline later than other tasks, and that it can be used to predict future decline in functional ability.

## 2.2 Technology-Assisted Toilets (TATs) as Assistive Devices

Although TATs are commercially available in North America, they are currently considered to be luxury bathroom appliances rather than assistive devices. A taxonomy based on the recommendations of the Consortium for Assistive Technology Outcomes Research (CATOR) has been created for the classification of assistive device outcomes which can be used to demonstrate why TATs should be classified as assistive devices (Jutai, Fuhrer, Demers, Scherer, & DeRuyter, 2005). This taxonomy divides the outcomes associated with assistive devices into three vantages; Effectiveness, Social Significance, and Subjective Well-being. In this section, these vantages will be discussed in order to justify the classification of TATs as assistive devices.

The effectiveness vantage focuses on how an assistive device can affect a patient's ability to function (Jutai et al., 2005). Included in the effectiveness vantage are several different aspects of functioning, some of which are highly applicable to TATs. Effectiveness relates to a patient's ability to participate in life situations, such as self-care and domestic life. TATs could have a significant effect on self-care by making it easier for a patient to independently clean themselves in the bathroom, which could improve their ability to care for themselves. Effectiveness also takes into consideration devices that modify a user's environment. TATs are devices that are put in the bathroom to assist with a specific activity, as opposed to devices that assist a user's direct functioning, such as wheel chairs or hearing aids. This would suggest that TATs should be classified as devices that affect environmental factors. Effectiveness can also be assessed in terms of a device's effect on body or psychological functions. While TATs may improve some psychological outcomes by reducing the emotional burden associated with toileting assistance (Clark & Rugg, 2005), they would not have a large effect on a patient's body functions.

The second vantage, societal significance, is associated with the meaning that society places on outcomes for assistive devices (Jutai et al., 2005). The first outcome included in societal significance is caregiving. This reflects the way an assistive device might impact the amount of care that a patient receives. If TATs allow rehabilitation patients to toilet more independently, there could be a considerable reduction in the amount of care needed for a TAT user. Societal significance also addresses the cost-effectiveness of a device. While it is how TATs would impact cost, it is possible that the cost of purchasing and installing a TAT would be counterbalanced by reductions in the amount of care needed by TAT users. A factor of great importance within social significance is residential settings, which takes into account whether an assistive device will have an impact on where a patient will live. It is unclear what kind of impact TATs will have on whether a patient will be able to return home or will need to be placed in long-term care, but using a TAT could make it much easier for a patient to operate independently at home.

Subjective well-being is the third and final vantage of this taxonomic framework, and is primarily concerned with the degree to which patients feel that a device is impacting their well-being (Jutai et al., 2005). Multiple qualitative studies have documented that considerable impact that requiring assistance in the bathroom can have on a patient (Clark & Rugg, 2005; Drennan et al., 2011; Siviter, 2013). These articles clearly demonstrate that being unable to properly clean oneself in the bathroom can be detrimental to a patient's sense of dignity and self-esteem. This suggests that if using a TAT makes a patient able to toilet independently, there would be a considerable improvement in subjective well-being.

Using the taxonomic framework proposed by Jutai et al. (2005), it is clear that despite the fact that TATs are not currently considered assistive devices, they may have an impact on many of the dimensions that are considered critical when judging the usefulness of an assistive device. In addition, this

framework provides a useful guide to the outcomes that will need to be measured if TATs are to be used in health care. Researchers will need to investigate whether TATs improve toileting independence and self-care ability, whether they are cost-effective, whether they will impact a patient's ability to remain home, and whether patients feel that TATs are improving their day-to-day life.

### **2.3 Potential Benefits of TATs**

Inability to adequately clean oneself is a common problem among the community-dwelling elderly population (Lee et al., 2006) as well as in long-term care facilities (Jones et al., 2009), which leads to patients who rely on caregiver assistance to go to the bathroom. These difficulties are often caused by the inability to reach in order to wipe, inability to lean over while sitting on the toilet, difficulty remaining balanced while on the toilet, lack of upper body strength necessary to wipe properly, or loss of cognitive functioning. These issues have been identified across a number of medical conditions, including multiple sclerosis (Nusrat, Gulick, Levinthal, & Bielefeldt, 2012), stroke (Thomas et al., 2011), hip fracture (Wu et al., 2013), rheumatoid arthritis (Nordenskiold, 1997), traumatic brain injury (Kolakowsky-Hayner et al., 2012), and dementia (Drennan et al., 2011). For patients in these situations, there is little in the way of an alternative to assistance from a caregiver to improve independence when cleaning oneself in the bathroom.

TATs were not initially designed for use in the context of medical care, but they have potential to benefit rehabilitation patients considerably. There are four primary areas in which TATs could help in rehabilitation settings: 1) Improving toileting independence, 2) improving hygiene, 3) reducing burden of care, and 4) improving psychosocial well-being.

### **2.3.1 Improving Toileting Independence**

For rehabilitation patients with medical conditions that impair their mobility, wiping oneself can often be a physically difficult task (Nusrat et al., 2012; Thomas et al., 2011; Wu et al., 2013; Nordenskiold, 1997). The wall-mounted remote control of TATs could allow patients to simply press buttons in order to clean themselves, thus avoiding issues relating to inability to reach, lean over, or lack of strength. For those who have difficulty with balance, requiring less movement for cleaning could reduce the risk of falling off of the toilet. It is unclear whether dementia patients would be capable of learning how to use the TAT, but the remote control is often simple, and could be easier to manage than wiping normally. The simplified motion of using a remote control rather than wiping could greatly increase geriatric rehabilitation patients' ability to clean themselves.

In order to be fully independent while toileting, there are more issues to consider than hygiene. Rehabilitation patients must endure other toileting issues, such as incontinence, inability to get to the bathroom, difficulty transferring, and inability to dress and undress. TATs are not able to enhance independence when facing these tasks, but there are other assistive devices that can be helpful. Commodes, grab bars, bedpans, and raised toilet seats are examples of commonly used toileting devices. There is still a lack of effective devices to improve rehabilitation patients' ability to provide their own hygiene, making TATs an important device to investigate. TATs, when used in combination with these other assistive devices, could be a reliable tool to improve toileting ability.

### **2.3.2 Improving Toileting Hygiene**

The specialized functions of TATs could allow rehabilitation patients to achieve greater levels of hygiene than they could by wiping themselves without assistance. By using a stream of water that can be adjusted for position, temperature, pressure, and width of the stream, it is likely that geriatric

rehabilitation patients would be able to clean themselves more thoroughly and effectively when using a TAT.

Poor toileting hygiene is associated with increased frequency of rashes, skin breakdowns, and infections (Colling 2003). If TATs are able to provide a superior level of hygiene, there could be a considerable reduction in these clinical issues, meaning that TATs could have direct health benefits for users. This could be particularly important for community-dwelling elderly adults who do not have nurses to ensure that they are completely clean after going to the bathroom.

### **2.3.3 Reducing Burden of Care**

Improved independence and hygiene would lead to reduced burden of care for rehabilitation patients, which would be a considerable benefit both in hospital and at home. In some cases, this could make it easier for patients to be discharged back to their homes, thereby reducing patient stay time in hospitals. Less assistance for toileting would mean more time for nurses and family caregivers to focus on other tasks. Toileting in particular is seen as an unpleasant activity of daily living for caregivers (Clark & Rugg, 2005; Siviter, 2013), and a reduction in the need for caregiver assistance could lead to improved relationships between caregivers and their patients.

### **2.3.4 Improving Psychosocial Well-being**

Toileting is a heavily stigmatized activity for both patients and caregivers due to the intimate and private nature of going to the bathroom. It is one of the earliest things we learn to do on our own, which can make the sudden reliance on assistance for a bowel movement harmful to a patient's self-esteem. This stigma can lead to caregivers neglecting to talk to their patients about their toileting needs (Clark & Rugg, 2005) and failing to give proper toileting assistance due to the activity being seen as undignified by healthcare staff (Siviter, 2013). It is clear that relying on assistance to go to the bathroom can be deeply

damaging to a patient's sense of dignity and well-being. If TATs can improve independence and hygiene and lower the need for assistance from a caregiver, users of these devices might have a greater feeling of capability and self-esteem, which can be critical when recovering from or coping with an illness.

## **2.4 Interdisciplinarity of TAT Research**

In an article which described a shift in the mentality of a biology department in Arizona, Collins defined an interdisciplinary program as "teaching, learning, research, or problem solving that integrates several disciplines to create a unified outcome" (Collins, 2002). This section will demonstrate the interdisciplinarity toileting and TAT research. Toileting is a topic which is relevant to many aspects and disciplines within health care and medicine, and studying TATs in an effort to improve toileting independence requires the contributions of professionals from several related but separate disciplines.

Toileting is an issue that can affect patients and elderly people with a wide range of medical conditions and impairments. Whether a person is in hospital, in a nursing home, or living at home, they are likely to require assistance for their toileting hygiene. This makes TAT research applicable to nearly every sector of medicine and health. Patients with acute or chronic illness, physical or cognitive impairments, and patients with disabilities at any age could be helped by access to TATs.

Beyond the patients themselves, information concerning the use of TATs is relevant to many types of healthcare staff. Primary caregivers, such as nurses or family caregivers, could be impacted by having their patients use TATs. Physiotherapists and occupational therapists could incorporate TATs as an option for their rehabilitating patients. Physicians can also view TATs as an option for the proper care of their patients. The applicability of these devices to so many spheres of medicine demonstrates the Interdisciplinarity of TAT research.

In addition to the relevance of the results, carrying out TAT research requires a fully interdisciplinary approach. While working to recruit patients and collect data, collaboration and input is required from nurses, occupational therapists, physiotherapists, physicians, and patients with a variety of disabilities. Without using the points of view from this range of disciplines, effective research on toileting would be impossible.

Finally, the outcomes being measured in these studies show interdisciplinarity. One side of this research is concerned with hygiene. This relates primarily to clinical medicine and rehabilitation of patients. Making activities of daily living independent is the fundamental concern for healthcare staff in rehabilitation programs. The second aspect of this research is to assess the psychosocial impact of toileting, and the affect that TATs can have on a rehabilitation patient's sense of well-being. This encompasses the more holistic view of medicine, in which a comprehensive approach that takes both physical and psychosocial health into account is used to care for a patient.

From the topic itself to the execution of TAT research and the impact of the results of these studies, the interdisciplinary relevance of toileting is clear. Toileting hygiene and independence is a medical factor that relates to all of the fundamental aspects of healthcare, and requires an approach that incorporates many voices and perspectives.

## **2.5 Anticipated Outcomes of this Project**

Whether TATs can provide better hygiene than regular toileting without assistance is a critical aspect of this research. If TATs cannot provide a satisfactory level of hygiene, they cannot be considered useful in a medical context. We anticipated that TATs would provide a higher level of hygiene than a standard toilet in geriatric rehabilitation, and that this increase would be found across patients with a variety of disabilities.

The second major outcome of this research was patient satisfaction while using the TATs. The Psychosocial Impact of Assistive Devices Scale (PIADS) is used to assess a patient's self-reported sense of competence, adaptability, and self-esteem when using an assistive device. We anticipated that participant PIADS scores for regular would reflect indifference due to the fact that many rehabilitation patients find toileting difficult on their own, but they currently do not have an alternative to help them clean themselves. Their PIADS scores after using the TAT, however, were expected to be considerably higher in all three aspects of the PIADS.

Research into the medical uses of TATs is new, and these devices were not initially designed for rehabilitation patients. In light of this, there may be certain features that do not fully fit the needs of patients in rehabilitation patients.

An additional aspect of investigating a device with the intention of having it integrated into medical systems and facilities is to evaluate the potential difficulties with the implementation of such devices. To assess this, we conducted a survey with healthcare professionals, with the expectation that they would see a potential benefit of TATs for their patients, but may be skeptical about its implementation due to costs and the fact that many patients would still require assistance in a bathroom with a TAT.

## **2.6 Summary of the Articles**

This thesis contains three manuscripts that have been submitted or accepted for publication, formatted for their respective journals. Each article is summarized below.

The first article, titled "Toileting difficulties in adults receiving physical rehabilitation services: A neglected topic", is a narrative review article designed to summarize the current literature relating to toileting in physical rehabilitation. This article focuses specifically on the aspects of toileting that are rarely discussed, such as hygiene, and does not fully cover widely discussed topics, such as incontinence.

It serves as both an insightful stand-alone review and an introduction to TAT research. This article was submitted to *Disability and Rehabilitation*.

The second manuscript is our first pilot study concerning TATs in stroke rehabilitation. It is titled “Technology-assisted toilets: Improving toileting independence and hygiene in stroke rehabilitation”, and it describes a study in which a small cohort of stroke rehabilitation patients tested the TAT. They were assessed for cleanliness after using the TAT, and answered the PIADS to determine their perception of regular toileting and TATs. A cohort of healthcare professionals were also surveyed to analyze whether they saw a potential benefit of TATs for their patients, and whether they could be easily integrated into medical systems. This article has been accepted for publication pending revision in the *Journal of Rehabilitation and Assistive Technologies Engineering*.

The third article, titled “Can Technology-Assisted Toilets Improve Hygiene and Independence in Geriatric Rehabilitation? A Cohort Study “, describes a follow-up study to our stroke rehabilitation pilot. In this study, geriatric rehabilitation patients were tested on both their regular toileting and TAT toileting to see if they would be able to achieve superior levels of hygiene with the TAT. They also filled out the PIADS for both regular and TAT toileting. This article is formatted for submission to *Disability and Rehabilitation: Assistive Technology*.

## **Article 1 - Toileting difficulties in adults receiving physical rehabilitation services: A neglected topic**

David Yachnin, Jeffrey Jutai, Hillel M. Finestone

### **Abstract**

**Purpose:** To synthesize the available information on toileting in rehabilitation populations and identify gaps in research concerning this neglected area.

**Materials and methods:** Articles were considered for inclusion if they were related to toileting in physical rehabilitation populations and included patients above the age of 45. Original research, review articles, opinion pieces, and clinical guidelines and resources were considered.

**Results:** 32 articles were included. Studies on toileting were found in populations with chronic low-back pain, hip fracture, rheumatoid arthritis, amputation, multiple sclerosis, stroke, traumatic brain injury, Parkinson's disease, spinal cord injury and dementia. Retained articles were divided into 1) prevalence of toileting difficulties, 2) assessment of toileting, 3) causes of toileting impairment, 4) psychosocial consequences of impairment, 4) interventions to enhance toileting independence, and 5) assistive devices for toileting.

**Conclusions:** Physical disabilities predominated over cognitive ones. No dedicated measures for toileting were found, but the Functional Independence Measure, a universally accepted measure of burden of care, has a toileting component. Patients and health care professionals are embarrassed to discuss toileting, and affected patients feel distress and loss of dignity. Although toileting impairment is a barrier to achieving independence, the rehabilitation literature on this topic is sparse.

Keywords: Toileting, Technology, Assistive Devices, Rehabilitation, Hygiene, Activities of Daily Living

## **Introduction**

Many adults receiving physical rehabilitation services are often not able to toilet themselves independently of assistance from another person, but there is no current data that indicates the prevalence of toileting difficulties in physical rehabilitation programs. Among adults aged 65 years or older the prevalence of toileting disability has been estimated to range from 6% for community-dwelling adults [1] to as high as 60% for nursing home residents [2]. Family members and caregivers must then provide assistance for this very personal activity [3]. Loss of privacy is a difficult transition for most people who rely on others for assistance with toileting. Patients have expressed that their dignity is encroached when they rely on others for toileting.

While incontinence is widely discussed in the scientific literature, information specific to toileting disability is scarce. The purpose of this narrative review is to identify the scientific literature on the difficulties associated with toileting and toileting assistance for adults receiving rehabilitation services, and to identify the areas which may be lacking in the literature. This review emphasizes toileting difficulties concerning the ability to use a toilet and to clean oneself, rather than the issue of continence. Physical toileting difficulties for rehabilitation patients may include the inability to: 1) remain balanced while sitting on a toilet, 2) lean over to wipe themselves, 3) reach down to wipe themselves, or 4) have sufficient strength and manual dexterity to wipe themselves effectively. Cognitive toileting issues, caused by conditions such as dementia, can include forgetting to go to the bathroom or forgetting the location of the bathroom, being unable to complete the actions of dressing or cleaning themselves, or resisting assistance from caregivers.

This review assessed the scope of available toileting research through the following research questions: 1) what are the prevalence and incidence of toileting difficulties in the population of adults receiving physical rehabilitation services? 2) How are toileting difficulties assessed? 3) What physical and cognitive impairments are most often associated with toileting difficulties? 4) What are the psychosocial consequences of toileting difficulties? 5) What are the most commonly used approaches to toileting assistance in rehabilitation settings? 6) What assistive devices are available for toileting? Addressing these fundamental, but infrequently asked questions will stimulate more discussion and research on the toileting care and dignity of patients served in our health communities.

### **Materials and methods**

The following databases for English-language articles on toileting in adults who are receiving physical rehabilitation services were reviewed: Cochrane Library, Ageline, CPIQ, CINAHL, Medline and PubMed. Ageline, CPIQ, CINAHL and Medline were searched through combined searches in Medline, while PubMed and Cochrane Library were searched separately. Search terms included “toileting”, “toilet”, “rehabilitation”, “assistive devices”, “dignity”, and “independence”, as well as varying combinations of these terms. MeSH headings were not used due to a lack of suitable headings for toileting. Articles between January 1990 and October 2015 were included. Clinical guidelines, relevant journals, and websites of health-related evidence-based practice centres were also searched. Diseases that are common in physical rehabilitation but were not found in previous searches, including arthritis, multiple sclerosis, traumatic brain injury, spinal cord injury, Parkinson’s disease and dementia, were searched in reference to toileting by combining search terms such as “toileting” and “dementia”. Both randomized controlled trials and nonrandomized, observational studies were included for possible evaluation,

as well as Research reports, opinion articles, review articles, and theoretical models. Published abstracts, conference proceedings, and non-English language articles were excluded. The primary author conducted the literature searches and selected the articles for inclusion, which were vetted and approved by the remaining authors.

Articles were considered if they included data or discussions concerning toileting specifically in physical rehabilitation settings. Articles were not included if they contained relevant information that was already addressed in other articles. Some articles that did not directly address toileting were included if they provided information relevant to the discussion of toileting. Articles concerning rehabilitation patients below the age of 45 were excluded in order to focus the review on toileting and rehabilitation in the context of aging.

## **Results**

A total of 31 articles were retained for this review. Some articles were included in more than one section of the review.

### ***a) Prevalence and Incidence of Toileting Difficulties***

No articles were found that indicated the overall presence of toileting difficulties in physical rehabilitation, but several studies showed prevalence within specific medical conditions. Six studies were included in this section. A systematic review of anorectal dysfunction in patients with multiple sclerosis showed that, in studies that detailed the kind of support needed, toileting care or perineal care was required in 28–48% of cases [3]. Thomas et al. [4] found that 51.6% of stroke survivors were functionally independent for toileting 1 month after discharge, and 16.4% remained dependent at 6 months. Almost one-third (31.9%) of patients who had sustained a hip fracture remained partially dependent on toileting assistance 1 month after hospital discharge, and 6.9% were completely dependent [5].

The prevalence of incontinence is well-documented. An estimated 40–60% of stroke inpatients have isolated urinary incontinence, [4] 8–30% have isolated fecal incontinence, [6,7] and up to 33% have double incontinence [7]. In a population-based survey of adults over the age of 18 in Canada, Italy, Germany, Sweden and the United Kingdom, urinary incontinence was reported in 13.1% of women and 5.4% of men [8]. While the scope of this issue is immense, incontinence research fails to capture all the medical, social and psychological issues surrounding the inability to toilet oneself.

### ***b) Assessment of Toileting Difficulty***

Eight articles were identified that described approaches to measuring toileting ability. Toileting is most commonly measured as part of a set of ADLs. When measuring the prevalence of incontinence, researchers often use a scale such as the Barthel Activities of Daily Living Index [6,7,9]. When identifying functional difficulties in rehabilitation, researchers tend to use the Functional Independence Measure (FIM), which includes an item concerning toileting ability [10]. The FIM defines toileting as “maintaining perineal hygiene and adjusting clothing before and after using a toilet, commode, bedpan, or urinal”, and distinguishes scoring categories by the amount of assistance required by the patient [11]. Transferring onto the toilet, bowel management, and bladder management are given separate items on the FIM. In one study the investigators analysed the predictive validity of the two-factor model of the FIM, which divides the FIM items into physical and cognitive factors to explain variance in FIM scores [12]. The investigators divided the FIM items into three factors — self-care, cognitive functioning, and toileting — which they argued could account for a significantly greater degree of variance than the standard two-factor model. Mauthe et al. [13] looked at the ability of FIM items to predict discharge location for patients who had had a stroke. The toileting score was one of six items that

could individually predict the discharge location with 70% accuracy. These analyses show the importance of toileting as an aspect of functional independence.

We found only one scale that focuses exclusively on toileting. The Profile of Toileting Issues is a checklist scale designed to identify toileting problems in people with intellectual impairment or behavioural disorders [14]. This tool contains a few questions concerning the physical aspect of toileting.

### ***c) Physical and cognitive impairments***

#### ***i. Physical Impairments***

Physical impairments refer to any physical disability which causes the patient to require toileting assistance. Eight articles dealing with toileting difficulties due to physical impairments were retained for review. Difficulty may result from several types of disability. Lack of balance can make it difficult to successfully use or remain seated on the toilet, while lack of mobility can impair the ability to clean oneself. In patients with rheumatoid arthritis, reduced grip force and increased hand pain can impair activities of daily living (ADLs), such as toileting [15]. Impairment of wrist flexion in conditions such as rheumatoid arthritis (deficit in range of motion) or stroke (weakness) can make the required wiping motions impossible. Furthermore, pain or restriction of range of motion to the elbow or shoulder owing to injury or disease can make reaching the perineal and periurethral regions difficult. In these instances the affected person can no longer use a toilet without assistance.

Kolakowsky-Hayner et al. [16] followed patients with traumatic brain injury for 10 years and found that the number of patients who required toileting assistance increased significantly with increasing age in those aged 45 or more at the time of injury. Ashraf et al. [17] analysed the relationship between pain and ADLs in people with bilateral lower-limb amputation and found

that thoracic pain, lower cervical pain, lumbosacral pain and spinal cord pain were all significantly related to dependency in toileting.

Inability to toilet independently can persist long after hospital discharge. Lackie and Bisset [18] reported the case of an 81-year-old woman undergoing rehabilitation for chronic low back pain who required 12 weeks of home rehabilitation following 4 weeks of in-hospital rehabilitation to be able to toilet without assistance. Thomas et al. [4] showed among stroke survivors, toileting dependence remains high 6 months after discharge from hospital. Wu et al. [5] found similar results among hip fracture patients.

Skin conditions in the perineal and periurethral regions may be related to poor toileting hygiene. A study of behavioral treatment programs for urinary incontinence showed a significant decrease in the number of skin rashes in the group that received treatment, while the nontreated group showed a nonsignificant increase [19]. The treatment group also showed a decrease in the rate of skin breakdown, but the control group did not have enough participants with skin breakdown at the beginning of the study to compare the two groups. An article which reviewed literature concerning prevalence and management of hemorrhoids and fistulas described improper toileting practices, such as spending a long period of time sitting on the toilet and excessive wiping, as counterproductive activities that can exacerbate hemorrhoids or cause additional skin breakdowns [20].

#### *ii. Cognitive impairments*

Two articles dealing with cognitive problems were retained for review. There is less focus on toileting issues related to cognitive impairment as compared to physical impairment in the literature. In a qualitative study, Drennan et al. [21] reported that home caregivers for patients with dementia described the situation surrounding incontinence and toileting as difficult owing to

attempts to maintain the patient's dignity and to the patient's inability to understand and follow through with toileting interventions. The caregivers in this study reported various issues associated with toileting for dementia patients, including the inability to locate and use a toilet, inability to dress and clean themselves, improper management of soiled clothing, and resistance to receiving assistance from their caregiver.

Cognitive impairment also affects toileting in less obvious ways. Like driving, toileting is an automatic or well-rehearsed ADL. Impaired cognition may or may not affect one's ability to toilet oneself. Patients with severe dementia forget to toilet or ignore their body's toileting signals, but less cognitively impaired patients may be able to manage. Poynter et al. [9] studied participants with various cognitive disabilities who underwent rehabilitation to improve ADLs and found that all but the most impaired group benefitted significantly from rehabilitation for toileting.

#### ***d) Negative psychological consequences of toileting dependence***

We retained for review six articles dealing with the consequences of toileting disability on dignity and independence. The inability to toilet oneself affects psychological well-being. Several qualitative studies and opinion pieces discuss the importance of toileting independence to patient dignity. Tutton et al. [22] emphasized the need for patients to be able to return to normalcy and to complete all their daily activities independently. Clark and Rugg [23] noted that being able to toilet independently was critical to dignity and self-esteem, and Siviter [24] stated that making patients wait to use the toilet is a fundamental failure of dignity. According to the Activity Restriction Model of Depressed Affect, inability to engage in valued activities because of a recent injury or disability can have a negative effect on a patient's psychological well-being [10,25].

The topic of toileting is surrounded by a large amount of stigma. In a qualitative study of stroke survivors, the researchers, who are occupational therapists, discussed problems in toileting assistance [23]. Toileting was considered such a private activity that caregivers were hesitant to ask their patients about it, and patients stated they were reluctant to ask for assistance owing to their own embarrassment. In some cases hospital caregivers consider toileting assistance to be an undesired task that is not fit for someone in their position and are reluctant to assist those in their care [24]. In 2011, the UK Patients Association, which offers a helpline to give patients information and to collect their views on the care they receive, reported a 37% increase in telephone complaints, one-third of which were related to inadequate toileting assistance [26].

#### *e) Current toileting interventions*

Three articles concerning toileting interventions were retained for review. In a recent review of toileting intervention strategies the authors discussed two primary strategies for managing incontinence [27]. The first method involves fixed voiding intervals: the caregiver prompts the patient to use the toilet at arbitrarily set intervals. A concern with this intervention is the potential alteration of the patient's regular voiding habits. With the second intervention the patient's voiding pattern is identified, and a caregiver prompts the patient to use the toilet before the voiding time. With both these methods, physical assistance is to be provided when necessary. A strategy that can be added to either intervention is to use positive or neutral reinforcement to motivate patients to identify their own continence needs and difficulties and to seek assistance when necessary. The review did not focus on toileting problems beyond incontinence.

Leahy et al. [28] wrote a book which described techniques for providing health care at home, and included recommended procedures for assisting people with disabilities with toileting.

The guidelines focus on assisting transfer onto the toilet. No mention is made of perineal cleaning and hygiene of the area, which are important to the dignity of patients undergoing physical rehabilitation.

Drennan et al. [21] discussed the strategies of home caregivers of dementia patients in relation to toileting. A recurring theme among those interviewed was that the caregivers, who were primarily family members, did not seek advice from health care professionals on managing toileting in order to protect the dignity of the patient, and those that did seek help were given unhelpful responses. Some caregivers reported that their patient's toileting was worse after release from hospital than upon admission. The authors only briefly mentioned assistance for hygiene, stating that it was often a challenge for the caregiver.

#### *f) Assistive devices for toileting*

Three articles were located that examined assistive devices for toileting.

Many elderly people require assistive devices related to toileting in order to be functional at home. Stroke Engine, a website designed to provide information for stroke survivors and health care professionals, lists the following assistive devices for toileting: urinals, bedpans and commodes for those who cannot travel to the bathroom; grab bars and toilet frames for transferring; raised toilet seats and seats with handles for those with difficulty remaining seated; and wet wipe sheets, bidets and bidet-toilets for those who cannot wipe themselves [29]. This shows the number of difficulties in independent toileting for the stroke survivor. Additionally, some devices, such as patient lifts, can be used to reduce caregiver burden by reducing the effort needed to transfer a patient, but these devices do not improve a patient's ability to toilet on their own.

In a meta-analysis of six national surveys in the United States, Cornman et al. [30] looked at the prevalence of assistive devices for various ADLs in the general population and found that 3–5% of people aged 65 or more require assistive devices for toileting; among those over the age of 85 the proportion was 8–15%. The authors considered devices for bathing and transferring separately from those for toileting.

One relatively new technology, the bidet-toilet (or “smart toilet”), has the potential to become an assistive device for toileting. This device is a toilet seat that incorporates a gentle stream of water to clean the perineal and/or periurethral regions; fan drying is also available if desired. Although popular in some countries, such as Japan and South Korea, bidet-toilets are uncommon in North America, and their potential use in rehabilitation populations has not been thoroughly examined. Cohen-Mansfield and Biddison [31] installed bidet-toilets in the bathrooms of female nursing home residents and compared the findings to those for control subjects who used regular toilets. Outcome measures were primarily qualitative. Approximately half of the residents and nursing home staff reported the device had positive effects. An analysis of urine bacterial content showed a decrease in bacteria in the experimental group only. Staff reported that the device cleaned, although not completely, but the researchers failed to assess the control group for cleanliness. Other problems with this study included leaks owing to improper installation, which led some participants to rate the device negatively, and inconsistency on the part of nursing staff in completing the toileting logbooks that were being used to assess cleanliness.

## **Discussion**

Being able to toilet without assistance is an aspect of daily living that is usually taken for granted but becomes an important challenge when one is faced with disability. In physical

rehabilitation settings, improving toileting is a critical step in making patients able to live independently. The amount of available data on toileting is low considering the fact that it is a fundamental requirement for independent living. Most of the studies referenced in this paper mention toileting only among a list of other ADLs and do not thoroughly discuss the implications of the findings, whereas qualitative studies show the importance of toileting to those who cannot use a toilet without assistance. Clearly, more studies focusing exclusively on toileting in rehabilitation populations are required.

By scoping the available literature surrounding toileting in rehabilitation, we have identified certain aspects of toileting that are well-studied, while others are severely lacking in available information. The subjects of the prevalence and management of incontinence are prominent in rehabilitation literature, as well as thorough discussion of the issue of dignity in toileting disability and the measurement of toileting ability. Data on overall prevalence of other toileting impairments, such as inability to clean oneself, are not available, but some statistics concerning rates of dependence on toileting assistance can be found for specific medical conditions. Information on the physical impairments associated with toileting in various medical conditions is available, but studies that focus on these toileting impairments and discuss them in detail are few. The impact of cognitive impairments on toileting ability is not well-documented. Concerning the use of assistive devices for toileting, current information on prevalence of assistive device use is available; however we could not identify any studies on the effectiveness of those devices, which is a gap, compounded by the lack of available guidelines and methods for improving the toileting ability of rehabilitation patients.

An additional problem lies in the definition of both toileting and incontinence. When research discusses toileting, it could be referring to transfers onto the toilet, undressing to use the

bathroom, toileting hygiene, or incontinence. Incontinence can be used to indicate patients who are unable to control their voiding, but it can also be used in cases in which a person is aware that they need to use the bathroom, but due to other impairments they are not able to get to the bathroom in time. There are some standard definitions for toileting, but they are not consistently used. The Centers for Medicare and Medicaid Services, for example, uses the FIM definition of toileting in their Inpatient Rehabilitation Facility Patient Assessment Instrument [11]. A lack of concrete definitions and uses for these terms can make it difficult to know what an article is discussing.

Due to the lack of studies that focus on the scope of impairments in toileting beyond mobility and incontinence, it is difficult to get a reliable sense of the scope of these issues. An important avenue for future research would be to conduct a widespread survey that would identify the frequency of toileting impairments, and the medical conditions that they may be causing the impairments. A study of this nature would allow researchers and clinicians to have a greater understanding of the severity of toileting issues and their potential causes, which could provide insights into ways to improve toileting independence.

No standard outcome measures dedicated primarily to toileting were found in the scientific literature. The creation and validation of such scales analysing the physical, cognitive and psychological aspects of toileting could be useful in quantifying toileting in rehabilitation populations. Furthermore, no measurement tool designed to identify only the physical problems involved with toileting in rehabilitation populations was found. Given the importance of toileting identified in the FIM analyses, [12,13] a questionnaire of this nature could be a useful tool for clinicians and researchers. Without a standard measurement tool with detailed information about toileting, it is difficult for toileting information to be communicated clearly and effectively. With

the currently available measurement tools, multifaceted toileting impairments are simplified to levels which do not give a complete picture of a patient's toileting ability. The FIM reduces toileting to a single score which rates ability to dress and wipe independently, with additional scores for cleanliness. A more detailed measure could include aspects such as areas that a patient is not able to clean, technique used for cleaning, level of cleanliness, and the cause of the patient's toileting impairment.

The authors of this article have designed a 4-point scale which could be used to assess toileting hygiene, but it has not yet been validated. It is designed to be filled out by a researcher or healthcare worker after giving the subject a visual inspection after using the bathroom. The scale includes separate scores for genital and perineal hygiene, as well as a section for the person making the assessment to describe the areas that were unclear, and a section to indicate what may have impacted the subject's ability to clean themselves. We recommend that a study be carried out to assess the validity of this scale in which two different nurses, or other primary care workers, would give their patients independent ratings of cleanliness after having a bowel movement. The scores could be compared to indicate whether there is consistency between raters and whether the scale reliably shows sensitivity to different levels of hygiene.

Some types of physical impairment that commonly affect toileting ability are stroke, multiple sclerosis, hip fracture, and traumatic brain injury. Dementia was found to be a cognitive impairment that can often reduce a person's toileting ability. It is likely that toileting affects a wider range of impairments that are found in rehabilitation, but the limited range of available information lowered the number of impairments represented in this review. The high prevalence of toileting difficulties suggests that toileting is an issue that requires more attention in physical rehabilitation. Ideally, for each medical condition associated with toileting, research would

include the prevalence of toileting impairments, the causes of toileting difficulty, the severity of toileting impairments, and methods for managing toileting impairments and improving toileting independence for rehabilitation patients.

A primary issue that needs to be addressed is the stigma surrounding the topic of toileting. Discussions with patients and medical staff show that both groups are reluctant to talk about toileting. For rehabilitation staff, assisting someone with their bowel movements can be considered undesirable and undignified, which in some cases results in patients' being neglected when they are in need. The negative psychosocial consequences of toileting could have a large impact on the effectiveness of physical rehabilitation programs. This indicates that more attention should be paid to finding ways to maintain patient dignity when giving toileting assistance.

While there are several studies that identify toileting as a critical issue for patient dignity and self-esteem, there is little in the way of recommendations for handling toileting in a sensitive way. Future studies could use mixed-methods design to assess this issue. Interviews could be conducted to closely examine what aspects of toileting assistance patients find particularly intrusive, and if there were certain methods used by staff that alleviated the embarrassment felt by their patients. This could be combined with quantitative questionnaires that assess the psychosocial impact of particular healthcare processes, such as the Psychosocial Impact of Assistive Devices Scale (PIADS). A series of studies could compare methods used in different medical institutions to assess which procedures are most effective at maintaining patient dignity.

The lack of information concerning how toileting is handled by caregivers is an issue in the current scientific research. A research project that identifies the strategies used by occupational therapists and other health care professionals to manage and improve toileting

beyond incontinence issues and evaluated the success of various strategies could be useful in improving toileting care. Our review of the existing literature suggests that strategies for managing incontinence are well-studied, but other areas, such as hygiene, could benefit from additional research. There also appears to be a pattern of health care professionals providing insufficient care or advice for home caregivers which should be thoroughly investigated.

Assistive devices for toileting are still fairly basic and in many cases are not sufficient to enable patients with disabilities to easily use a toilet or be able to clean themselves properly. Further research into the physical difficulties associated with toileting and the prevalence of toileting problems could lead to the development of better assistive devices, allowing for greater independence for patients receiving physical rehabilitation, which would make discharging patients from rehabilitation programs easier. The bidet-toilet is one relatively new technology that could greatly improve toileting independence and hygiene. There is little current research on bidet-toilets, but their remote-controlled cleaning functions could make toileting much easier for rehabilitation patients. If they improve hygiene and independence, there would be a reduced burden of care for patients using these devices, as well as a reduction in infections and skin problems associated with poor toileting hygiene.

While there are many assistive devices that improve mobility of rehabilitation patients and their ability to transfer onto the toilet, for many patients being discharged to their homes there can be other architectural barriers to toileting. It is often the case that in order for these patients to be able to use the bathroom at home, various devices need to be installed, such as grab bars or raised toilet seats, in order to transfer and remain balanced. Home bathrooms that are too small to accommodate a wheelchair can also make returning home difficult. Adjusting to these

barriers can be a large financial burden, or can make discharging a patient to their home impossible.

Commodes are a commonly used device which can address certain issues, such as toilet height, and problems with bathroom accessibility and incontinence. Due to the fact that they are portable and can be kept in the bedroom, they are effective for rehabilitation patients who may not be able to get to the bathroom in time, or are unable to get a wheelchair into their bathroom at home.

In conclusion, toileting in rehabilitation populations needs to be better addressed. Limited research indicates that toileting self-management is a problem in physically and cognitively affected populations. Clinicians need to ask and educate their patients/clients about this sensitive area, as maintaining independence in toileting can improve patient's quality of life. More research to delineate the extent of the problem and identify technology related and other solutions will be the focus of our future research.

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### **Declaration of Interest**

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**Table 1:** Publications concerning prevalence of toileting impairments

Publication	Population	Study type/focus	Outcome measures	Findings
Harari et al., 2003 [6]	Stroke in- and outpatients n = 1563	Observational study Examined prevalence, natural history, associations and impact of new-onset fecal incontinence after stroke	Barthel Index, South London Stroke Register	Prevalence of fecal incontinence was 30% at 1 wk, 11% at 3 mo, 11% at 1 year, 15% at 3 yr
Irwin et al., 2006 [8]	Adults aged $\geq 18$ yr in 5 countries n = 19,165	Population-based survey Examined prevalence of lower urinary tract symptoms	Computer-assisted telephone interviews	Urinary incontinence reported in 13.1% of women and 5.4% of men
Kovindha et al., 2009 [7]	Stroke inpatients n = 185	Observational study Examined prevalence of urinary and fecal incontinence	Barthel Index	Prevalence at admission: urinary 12.4%, fecal 7.6%, double 33% Prevalence at discharge: urinary 8.1%, fecal 4.9%, double 15.1%
Nusrat et al., 2012 [3]	Patients with multiple sclerosis	Systematic review Summarized literature on anorectal dysfunction	n/a	Toileting or perineal care needed in 28–48% of cases
Thomas et al., 2011 [4]	Stroke inpatients n = 780	RCT Analysed feasibility of large RCT for urinary continence interventions	International Consultation on Incontinence Questionnaire, Incontinence Quality of Life Instrument	40–60% of stroke survivors had isolated urinary incontinence

Wu et al., 2013 [5]	Elderly community- dwelling patients with hip fracture n = 116	Observational study Assessed home care needs and task difficulty	Physical function status scale developed by Williams et al., questionnaire of care needs (Chinese version revised by Chiu [1998])	Partially dependent on toileting assistance: 56.0% at discharge, 50.0% at 1 wk, 31.9% at 1 mo Completely dependent: 25.9% at discharge, 13.0% at 1 wk, 6.9% at 1 mo 87.1% of caregivers stated that patients needed toileting assistance Difficulty of administering assistance scored 1.8 out of 5 (not very difficult)
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**Table 2:** Articles dealing with approaches to measuring toileting ability. Articles included in this section that were included in a previous table have not been repeated.

Publication	Population	Study type/focus	Outcome measures	Findings
Cavanagh et al., 2000 [12]	In- and outpatients with ischemic stroke diagnosis from urban rehabilitation centre n = 2303	Factor analysis Analysed multidimensional nature of FIM for patients with stroke Not specific to toileting	FIM administered at admission and discharge	Grouped FIM scales into 3 major categories: self-care, cognitive functioning and toileting Argued that this grouping would lead to better monitoring of patient improvement and better rehabilitation
Matson et al., 2011 [14]	Patients in developmental centres with intellectual disability n = 108	Methods paper Tested reliability of new measure for screening for toileting issues and for identifying potential functions to target in treatment Specific to toileting	Profile of Toileting Issues	Internal consistency of the tool was sound ( $\alpha = 0.83$ ); interrater reliability was significant
Mauthe et al., 1996 [13]	In- and outpatients with acute stroke n = 279	Factor analysis Analysed ability of FIM to predict discharge location Not specific to toileting	FIM	Toileting was among 6 FIM measures that predicted discharge location with 70% accuracy; prediction could be made independently of other measures
No Author, 2004 [11]	n/a	Manual provided by the Centers for Medicare and Medicaid Services which provides FIM definitions and instructions on how to administer the FIM	n/a	Provides a standard definition for toileting and explains how toileting and other FIM items are scored.

**Table 3:** Articles concerning toileting difficulties due to physical impairments. Articles included in this section that were included in a previous table have not been repeated.

Publication	Population	Study type/focus	Outcome measures	Findings
Ashraf et al., 2012 [17]	Patients with war-related bilateral lower limb amputation n = 335	Observational study Investigated impact of pain in vertebral column on ADL	ADL	Thoracic pain, lower cervical pain, lumbosacral pain and spinal cord pain were significantly related to dependency in toileting
Colling et al., 2003 [19]	Elderly community-dwelling people n = 78 caregiver-care recipient pairs	RCT Tested effects of patterned urge-response training	Short Portable Mental Status Questionnaire, Katz ADL Index, Hadley, Wood, McCracken (HWM) Behavioral Capabilities Scale for Older Adults	Significant decrease in skin rashes and skin breakdown in treatment group Skin breakdown could not be analysed in control group because too few participants had this condition at baseline
Kolakowsky-Hayner et al., 2012 [16]	Patients with traumatic brain injury, followed over 10 years n = 478	Longitudinal cohort study Analysed changes in function over time	FIM, Disability Rating Scale, Supervision Rating Scale, Glasgow Outcome Scale	No. of patients requiring toileting assistance increased with increasing age when injury occurred at age 45 or more
Lackie et al., 2012 [18]	81-year-old woman undergoing rehabilitation for chronic low back pain as in- and outpatient	Case study Compared inpatient rehabilitation to home rehabilitation Not specific to toileting	Modified Barthel Index, Modified Elderly Mobility Scale	Patient's condition improved significantly only at home Required 12 wk of home rehabilitation (after 4 wk as inpatient) to toilet

				independently
Nordenskiöld, 1997 [15]	Female in- and outpatients with rheumatoid arthritis or fibromyalgia, healthy control subjects n = 87 experimental group, 187 control group	Nonrandomized controlled trial Analysed difficulties in ADL and relationship between grip force and ADL Not specific to toileting	Grip force as assessed with Grippit, Health Assessment Questionnaire, Evaluation of Daily Activity Questionnaire	Reduced grip force and increased pain in patients with rheumatoid arthritis causes difficulty in ADL, including toileting Difficulty can often be lessened with use of assistive devices
Rakinic & Poola 2014 [20]	Patients with hemorrhoids and fistulas	Systematic review of current problems in management and treatment of hemorrhoids and fistulas	n/a	Improper toileting practices can exacerbate anorectal discomfort and can cause additional skin breakdowns due to patients sitting on the toilet for too long or wiping excessively
Note: ADL = activities of daily living; RCT = randomized controlled trial; FIM = Functional Independence Measure.				

**Table 4:** Articles concerning toileting difficulties due to cognitive impairments. Articles included in this section that were included in a previous table have not been repeated.

Publication	Population	Study type/focus	Outcome measures	Findings
Drennan et al., 2011 [21]	Family caregivers of patients with dementia n = 32	Qualitative study Carers' perceptions of incontinence problems and management strategies	n/a	Care is difficult owing to need to maintain patient's dignity Patients have trouble understanding and carrying out toileting interventions
Poynter et al., 2013 [9]	Patients with cognitive disabilities due to various causes undergoing in-hospital rehabilitation n = 241	Observational study Examined whether patients could benefit from rehabilitation for ADL Not specific to toileting	ADL, Mini-Mental Status Examination	Only most cognitively impaired participants could not benefit

**Table 5:** Articles concerning psychosocial consequences of toileting disability. Articles included in this section that were included in a previous table have not been repeated.

Publication	Population	Study type/focus	Outcome measures	Findings
Clark et al., 2005 [23]	Patients admitted to stroke unit in acute care hospital n = 13	Discussed the importance of independence in toileting for stroke survivors Specific to toileting	n/a	There is stigma around discussing toileting; toileting not really discussed by patients or staff because it is considered very private activity Patients are afraid to ask about toileting because they are embarrassed and feel it is not dignified Patients felt that being independent in toileting was critical for morale and self-esteem
Dean, 2012 [26]	n/a	Discussed inadequacy and stigma surrounding toileting assistance Specific to toileting	n/a	In 2011 UK Patients Association reported 37% increase in telephone complaints, one-third of which concerned toileting assistance Emphasized issue of inadequacy in toileting assistance and unwillingness of some nurses to carry out toileting assistance owing to stigma
Egan et al., 2014 [10]	Adults who had been discharged from hospital after their first stroke n = 67	Observational study Explored reciprocal effects between participation and emotional and physical well-being during first 2 years after	Reintegration of Normal Living Index, General Well-Being Schedule, General Self-Rating of Health Question, Discharge FIM	Participants who engaged in activities of value to themselves showed improved psychological well-being

		stroke Not specific to toileting		
Siviter, 2013 [24]	n/a	Discussed necessity for nursing staff to treat residents with dignity and respect Not specific to toileting	n/a	Making a resident wait to use toilet is failure of dignity
Tutton et al., 2012 [22]	Patients and staff at stroke unit n = 10 patients, 10 staff members	Examined concept of hope for stroke survivors Not specific to toileting	n/a	Patients struggle with keeping hope Desire to recover and return to normalcy is critical to maintaining hope Immediate dependency for simple tasks like toileting can be very damaging
Williamson et al., 2000 [25]	n/a	Described theory of Activity Restriction Model of Depressed Affect Not specific to toileting	n/a	According to theory, inability to participate in valued activities because of recent injury or disability can result in depressed affect

**Table 6:** Articles concerning current toileting interventions. Articles included in this section that were included in a previous table have not been repeated.

Publication	Population	Study Type/Focus	Outcome Measures	Findings
Leahy et al. 2004 [28]	n/a	Non-academic textbook for aides who are providing home care.	n/a	Provides instructions for assisting patients at home with toileting care. Focuses on transferring, does not mention hygiene or perineal care.
Ostaszkiwicz et al. 2013 [27]	Adults who have difficulty with incontinence	Systematic review  Discussed current methods used for managing incontinence in adults.	n/a	Described fixed voiding intervals, identification of the patient's regular voiding patterns, and use of reinforcement in both cases as the current methods of incontinence intervention.

**Table 7:** Articles concerning assistive devices for toileting. Articles included in this section that were included in a previous table have not been repeated.

Publication	Population	Study type/focus	Outcome measures	Findings
Cohen-Mansfield et al., 2005 [3]	Female nursing home residents n = 22 residents, 27 nursing staff members	RCT Analysed toileting experience with bidet-toilets Specific to toileting	Toileting Experiences Questionnaire, Toilet Reaction Questionnaire, use logs, Minimum Data Set information, Mini-Mental State Examination, urine cultures	About half of residents and staff reported bidet-toilet as having positive effect Positive trend in resident affect in experimental group only Staff members noted that toilet cleaned, but not completely Did not mention cleanliness of control group Bacterial urine content lower in experimental group
Cornman et al., 2005 [30]	Community-dwelling adults $\geq 65$ yr of age	Systematic review of approaches that national surveys have used to measure use of assistive devices Used cross-sectional data from 6 US surveys to compare rates of assistive device use and disability Not specific to toileting	n/a	3.2–4.9% of those aged $\geq 65$ and 8.0–15.0% of those aged $> 85$ used assistive devices for toileting Transferring and bathing considered separately Including device users who report no difficulty would significantly increase prevalence estimates of

				device use and disability
Stroke Engine [29]	n/a	Non-academic website which provides information for stroke survivors and their caregivers	n/a	Provides a list of available assistive devices for toileting in stroke rehabilitation.

## **Article 2 - Technology-assisted toilets: Improving independence and hygiene in stroke rehabilitation**

David Yachnin, Georges Gharib, Jeffrey Jutai, Hillel Finestone

### **Abstract**

**Background and Purpose:** Dependence on assistance for toileting is widespread problem for persons receiving healthcare. Technology-assisted toilets (TATs), which hygienically wash and dry the perineal region, are devices that could improve toileting independence in a variety of patients. The objective was to investigate whether TATs improve toileting independence, quality of life, and whether TATs can provide sufficient toileting hygiene in stroke rehabilitation.

**Methods:** This pilot study was carried out in a stroke rehabilitation unit. 30 participants were recruited. Participants had a bowel movement and cleaned themselves using the TAT on one to three occasions. Participants rated their toileting before using the TAT and after each TAT use with the Psychosocial Impact of Assistive Devices Scale (PIADS). After each session, participants were rated for cleanliness.

**Results:** PIADS scores were analyzed from eight individual participants, five of whom completed the full protocol. PIADS scores were significantly higher with the TAT than with the participants' regular toileting routine ( $p < 0.05$ ). TATs cleaned effectively in 73% of cases (16/22,  $p < 0.05$ ).

**Conclusion:** TATs improved stroke patients' psychosocial outcomes compared to standard toileting and completely cleaned participants in the majority of cases. A larger study should confirm TAT's benefit in stroke rehabilitation through improved independence and hygiene.

### **Keywords**

Toileting, stroke rehabilitation, assistive technology, hygiene, activities of daily living (ADL)

## Introduction

Many adults with disabilities and geriatric patients have great difficulty with toileting (i.e. urination and defecation) or are unable to toilet themselves independently. Among adults aged 65 years or older the prevalence of toileting disability has been estimated to range from 6% for community-dwelling adults<sup>1</sup> to as high as 60% for nursing home residents.<sup>2</sup> Health professionals and caregivers must then provide assistance for this very personal activity.<sup>3</sup> While incontinence is widely discussed in the scientific literature, information specific to toileting disability due to a person's inability to effectively cleanse the anal and perineal skin areas is scarce. The high prevalence rates for toileting impairment show the importance of proper toileting assistance, but there is very little research that focuses on improving the capability of those who cannot toilet independently. The purpose of this project was to focus on these toileting concerns and determine the effectiveness of Technology-Assisted Toilets (TATs) and their impact on psychosocial outcomes.

Stroke patients experience disability related to brain injury and its physical, perceptual, and cognitive consequences. Each of these deficits may contribute to difficult-to-perform, incomplete and unhygienic toileting. An estimated 40–60% of stroke inpatients have isolated urinary incontinence,<sup>4</sup> 8–30% have isolated fecal incontinence,<sup>5,6</sup> and up to 33% have double incontinence,<sup>5</sup> giving prominence to the issue of effective toileting. One study showed that in stroke patients being discharged from hospital, only 51.6% were functionally independent for toileting one month following discharge, and 16.4% remained dependent after six months.<sup>4</sup>

Toileting care places a physical and psychological burden on both the caregiver and the recipient of care,<sup>7</sup> and together with bathing help, it ranks among the most burdensome of care tasks. It can also present obstacles that make the discharge of patients to their homes unfeasible.<sup>8-</sup>

<sup>10</sup> Therefore, the establishment of toileting independence is a critically important issue for stroke rehabilitation patients. Our study investigated whether Technology-assisted toilets (TATs) could be a useful device to assist stroke rehabilitation patients with toileting.

TATs are commercially available toilet seats that clean the user with a stream of water (**Figure 1**), and dry the perineal area with a fan. Additional controls allow the user to adjust water pressure, water temperature, dryer strength, and adjust the position of the stream. They are controlled by a wall-mounted remote which can be accessed by the patient or caregiver (**Figure 2**). These toilets are extremely common in countries such as Japan, but are available in many North American and European countries, usually as a luxury item. Their use in medicine, however, has not been well documented. TATs have the potential to eliminate the need for wiping, an activity of daily living (ADL) that is often difficult or impossible for stroke rehabilitation patients. Wiping can be hindered as a result of hemiparesis, which causes sensory and motor losses of the upper extremity and loss of balance,<sup>11</sup> as well as visuo-spatial and cognitive difficulties.<sup>12</sup> The authors hypothesized that if they are effective, TATs could increase stroke patient independence, reduce burden of care, and improve toileting hygiene.



**Figure 1.** A TAT attached to a standard toilet with the wand extended for spraying. When the cleaning functions of the TAT are not being used, the wand retracts into the toilet seat.



**Figure 2.** A remote control which would be used to operate a TAT. This remote would be mounted on the wall beside the TAT. The front panel opens to access additional features, such as temperature control.

Only one previous study was found that considered the possible benefits of TATs.<sup>13</sup> This study installed TATs in a nursing home for elderly women, and had them use the toilets over an extended period of time. Approximately half of the participants using TATs reported them as being positive, but the study had several methodological issues. Many of the residents who rated the TAT negatively were concerned about technical issues, such as improper installation causing leaks in the participant's bathroom, which made them apprehensive about using the TAT. While the authors reported that patients were not fully clean after using the TAT, they did not compare TAT users with the control group of patients to assess effectiveness.

The objective of this project was to investigate the potential use of TATs by stroke patients to:

- (a) provide adequate toileting hygiene;
- (b) improve quality of life;
- (c) be accepted by users;
- (d) to assess the feasibility of conducting larger-scale studies on TATs;
- (e) to ascertain whether health care professionals (HCPs) would think that TATs could have clinical benefits.

## **Methods**

### *Population*

A convenience sample of 30 participants was recruited from the stroke rehabilitation in-patient (20-bed dedicated regional unit) and out-patient programs at the Elisabeth Bruyère Hospital, a division of Bruyère Continuing Care, in Ottawa, Ontario.

Stroke rehabilitation English- or French-speaking in-patients and out-patients were included if they had a stroke within the last 4 years and were still impaired due to the stroke, had sufficient balance to be able to sit independently on the toilet seat, enough manual dexterity to use the remote control, and the ability to give informed consent, which was assessed using the Evaluation to Sign Consent.<sup>14</sup>

Participants were excluded if they showed no sign of disability post stroke, were physically unable to sit on the toilet without assistance, were under isolation precautions, could not use the remote control device for the toilet, or required a commode to use a toilet.

A convenience sample of 12 health care professionals (HCPs), including nurses, physiotherapists, occupational therapists and social workers, were also recruited for this study. HCPs were included if they were employed at Bruyère Continuing Care, were English-speaking, and worked frequently with stroke rehabilitation patients.

This study was approved by the Bruyère Research Ethics Board, and all participants gave written informed consent before being enrolled. All procedures followed were in accordance with Bruyère Continuing Care institutional guidelines.

### *Outcome Measures*

The primary outcome measure used in this study was the Psychosocial Impact of Assistive Devices Scale (PIADS), a validated questionnaire designed to assess a user's feelings of competence, adaptability, and self-esteem when using an assistive device.<sup>15-17</sup> This questionnaire was used to assess the participants' self-reported sense of their quality of life when using the device. Positive PIADS scores show that a user feels an improvement when using a

device. A score of 0 indicates that the user is indifferent towards the device. A negative score means the user feels worse when using the device than without the device.

The secondary outcome measure assessed perineal cleanliness. The cleanliness scale, which was designed for this study due to no equivalent scale existing in the scientific literature, is a four-point scale in which a score of 0 indicates that the person is completely clean and a three indicates that they are severely soiled. A score of one indicates “mostly clean, but some remaining smears or spots of urine/feces” and a score of two indicates “mostly soiled, but some clear evidence of cleaning”. It was designed to be used by an investigator or caregiver after visually inspecting the perineal area.

### *Intervention*

Participants were divided into two groups; the bowel movement (BM) group and the dry run (DR) group. Participants in both groups engaged in three separate testing sessions. During each session, the participant was brought to a bathroom and used the TAT. Patients in the BM group were given a visual inspection for cleanliness prior to going to the bathroom. After having a BM, and cleaning themselves using the TAT, they received a second visual inspection. For each session, they were given pre-BM and post-cleaning scores for cleanliness based on the visual inspections. DR participants tried the TAT cleaning functions without having a BM, and did not receive visual inspections. After each session, both groups answered the PIADS to assess their experience using the TAT. Before any testing sessions were held, each participant answered the PIADS in reference to their standard toileting, in which they use a standard toilet and toilet paper to clean themselves.

All participants received a training session on how to use the TAT immediately prior to their first testing session. Training involved an explanation of which buttons to use on the remote control to begin washing, stop washing, and drying. Participants were not instructed on how to adjust water pressure, temperature, dryer strength, and stream position. All of these functions were set to medium levels before each test. After training, the participants operated the TAT without assistance. The TAT used for this study was the TOTO Washlet S350e.

HCPs used the TAT once and answered the PIADS in reference to how they thought a stroke rehabilitation patient would be affected by the experience of using a TAT.

### *Statistical Analyses*

Two sets of analyses were conducted on PIADS scores, one to examine differences between baseline and the first TAT trial score, and one to investigate changes in scores over repeated TAT trials.

In order to compare participant satisfaction when using the TAT to regular toileting, we used a repeated measures ANOVA using the PIADS scores of participants in the BM group who completed both the baseline PIADS and at least one BM trial (n=8). Scores are divided into three PIADS subscales of competence, adaptability, and self-esteem.

To test whether PIADS scores changed after several uses of the TAT, we conducted a repeated measures ANOVA using the PIADS scores of BM group participants who completed the baseline PIADS and all three BM trials (n=4). Scores were analyzed using the three PIADS subscales.

To analyze cleanliness scale data, we used a binomial test<sup>18</sup> to compare the frequency of participants being completely clean to the frequency of participants remaining unclean

(cleanliness scale scores of one to three). We used cleanliness data from every BM trial that was conducted (n=22). We also conducted a one-sample t-test to look for agreement between tests. A Friedman test<sup>19</sup> was used to investigate whether there was a difference in cleanliness scores over the three BM trials.

To identify differences between the BM, DR, and HCP groups, we compared the first TAT trials from the BM and DR groups and the single TAT trial from the HCP group using a repeated measures ANOVA.

## **Results**

### *Population*

Of the 30 total recruited participants, five participants completed the full protocol and 15 completed part of the protocol as they were discharged from the hospital prior to completing the full study. One participant withdrew from the study due to concerns that it would affect his BM routine and nine participants were discharged before they could complete any part of the study. For each participant, testing was attempted until they were discharged from hospital or finished their outpatient rehabilitation program. For inpatients, this meant that testing was usually completed in less than one month. For outpatients, data collection could occur over a span of a few months. All 12 HCPs completed the full protocol. Eleven of the HCPs were female. The HCPs included three nurses, two occupational therapists, one physiotherapist, one clinical professor, and five nursing students.

Demographic information was collected for the 20 participants who completed all or part of the protocol. Eleven were female and nine were male. The average age of participants was 64,

with a range from 50-87. Only one participant had suffered more than one stroke. The average time between the most recent stroke and assessment was 57 days.

Common physical impairments that made toileting difficult for the participants included hemiparesis, inability to transfer onto the toilet independently, difficulty remaining balanced while seated, impaired mobility which made leaning over and reaching to wipe difficult, and reduced hand grip and strength. While most patients did require some assistance to go to the bathroom, some were completely independent at the time of the study. No patients with major cognitive impairments were included, but some patients experienced minor memory and language deficits.

### *Toileting Hygiene*

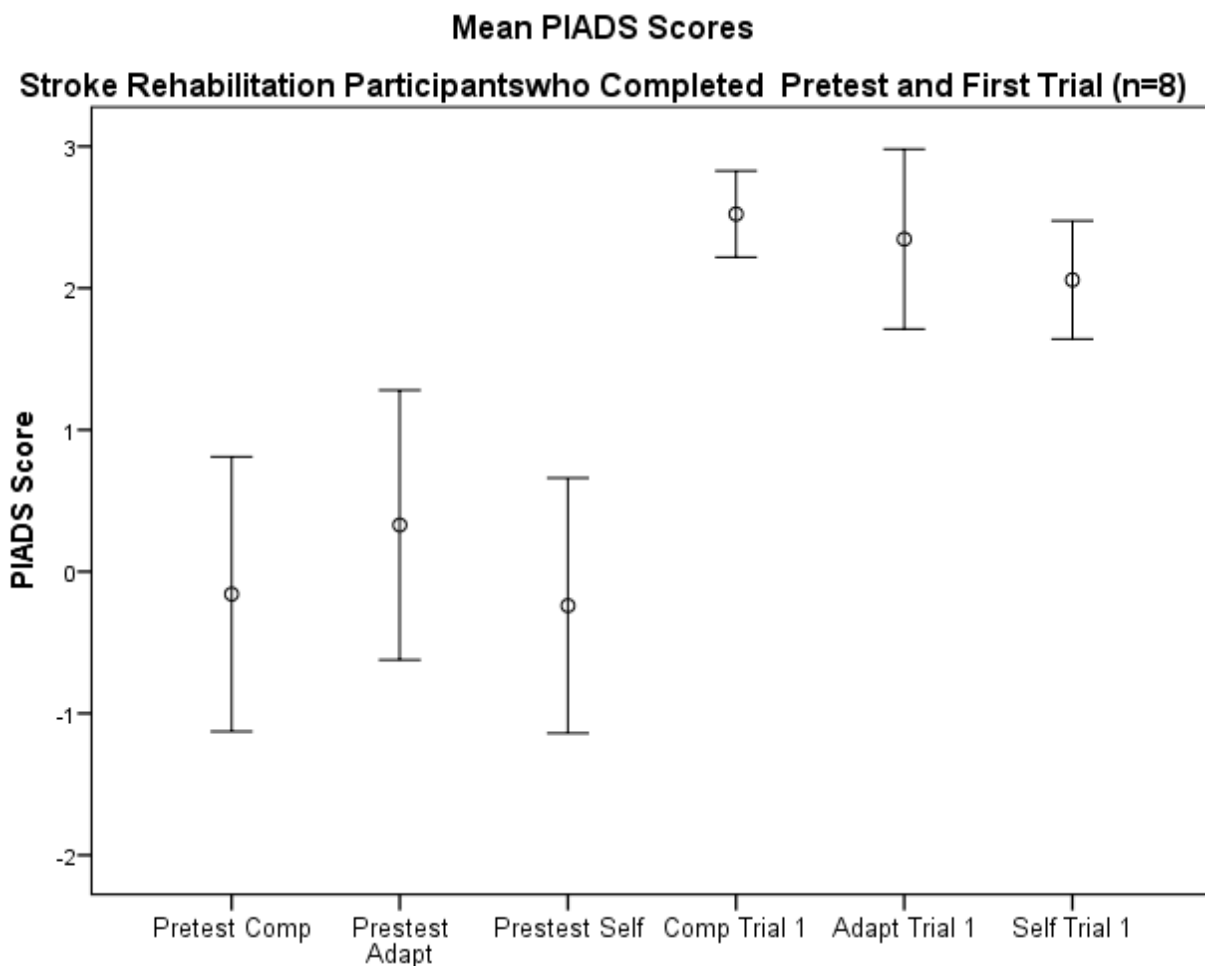
Of the 22 total BM trials, 16 (73%) resulted in a score of 0, meaning the participants were completely clean. Five trials resulted in a score of one, and one trial resulted in a score of two. No participants received a score of three with TATs.

The binomial test showed that participants using the TAT were significantly more likely to be completely clean than to not be clean ( $p=0.050$ ). The one-sample T-test confirmed that there was a significant difference in the frequency of clean and unclean BM trials ( $p<0.05$ , 95% CI = 9.3, 13.7). The Friedman test showed that there was no significant difference in the frequency of unclean BM trials over the three trials.

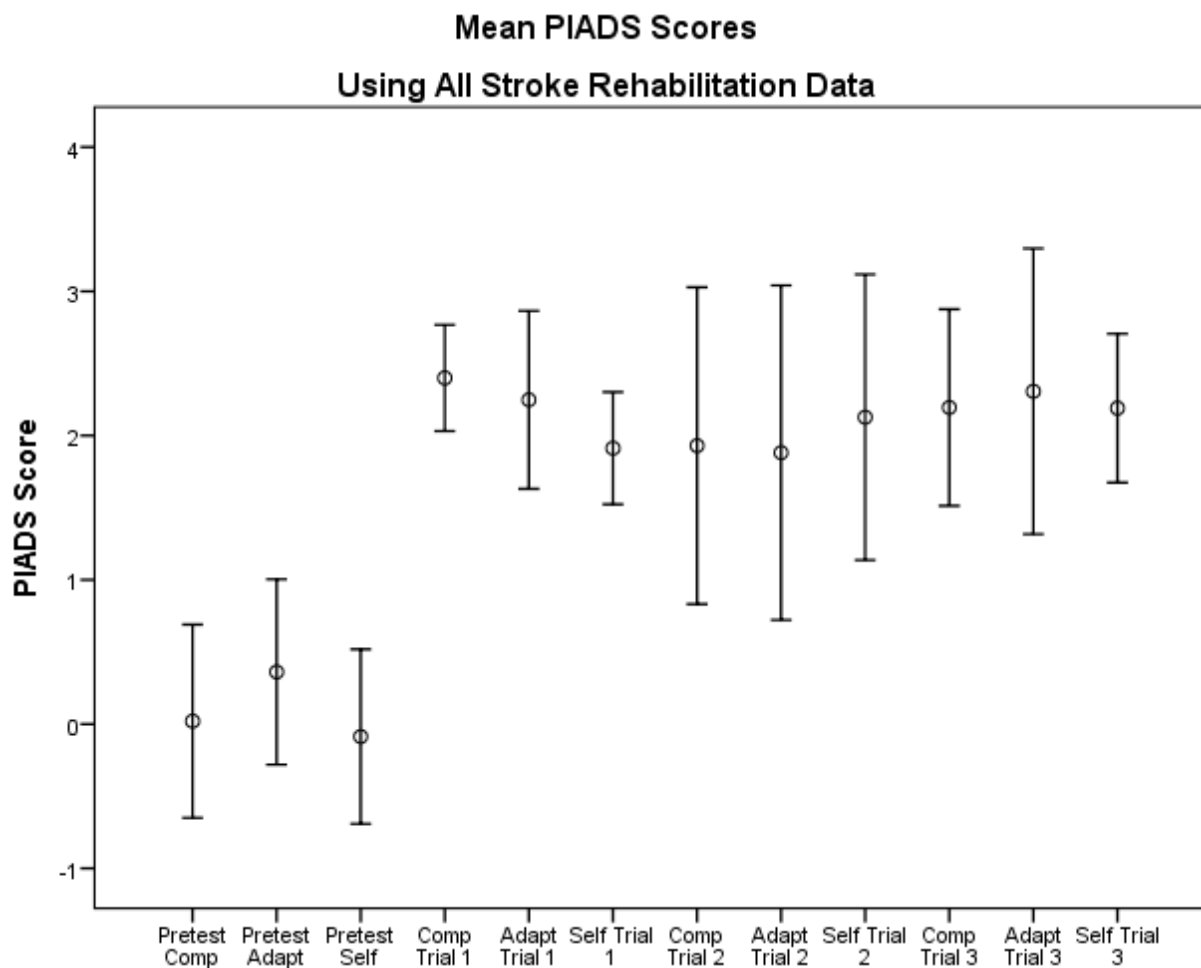
### *PIADS Data*

A repeated measures ANOVA revealed a significant main effect of session (PIADS scores significantly increased from baseline to first TAT trial in the BM group) ( $F(1,7)=13.164$ ,  $p<0.01$ .) for all three PIADS subscales (Figure 3). There was also a significant interaction

between session and PIADS subscale ( $F(2,6)=6.453, p<0.05$ ). Pairwise comparisons of PIADS subscale scores for each session suggested that the largest differences between session occurred for the Competence and Self-esteem subscales. The ANOVA performed for the three BM trials revealed similar results, but they were not statistically significant (Figure 4). No differences were found when comparing BM, DR, and HCPs PIADS scores (Figure 5). Previous PIADS studies have indicated that scores higher than one indicate that the user of the device is likely to continue using the device voluntarily.<sup>15-17</sup> Average PIADS scores after using the TAT were close to two, which indicates strongly that the participants would not abandon use of the TAT over time.

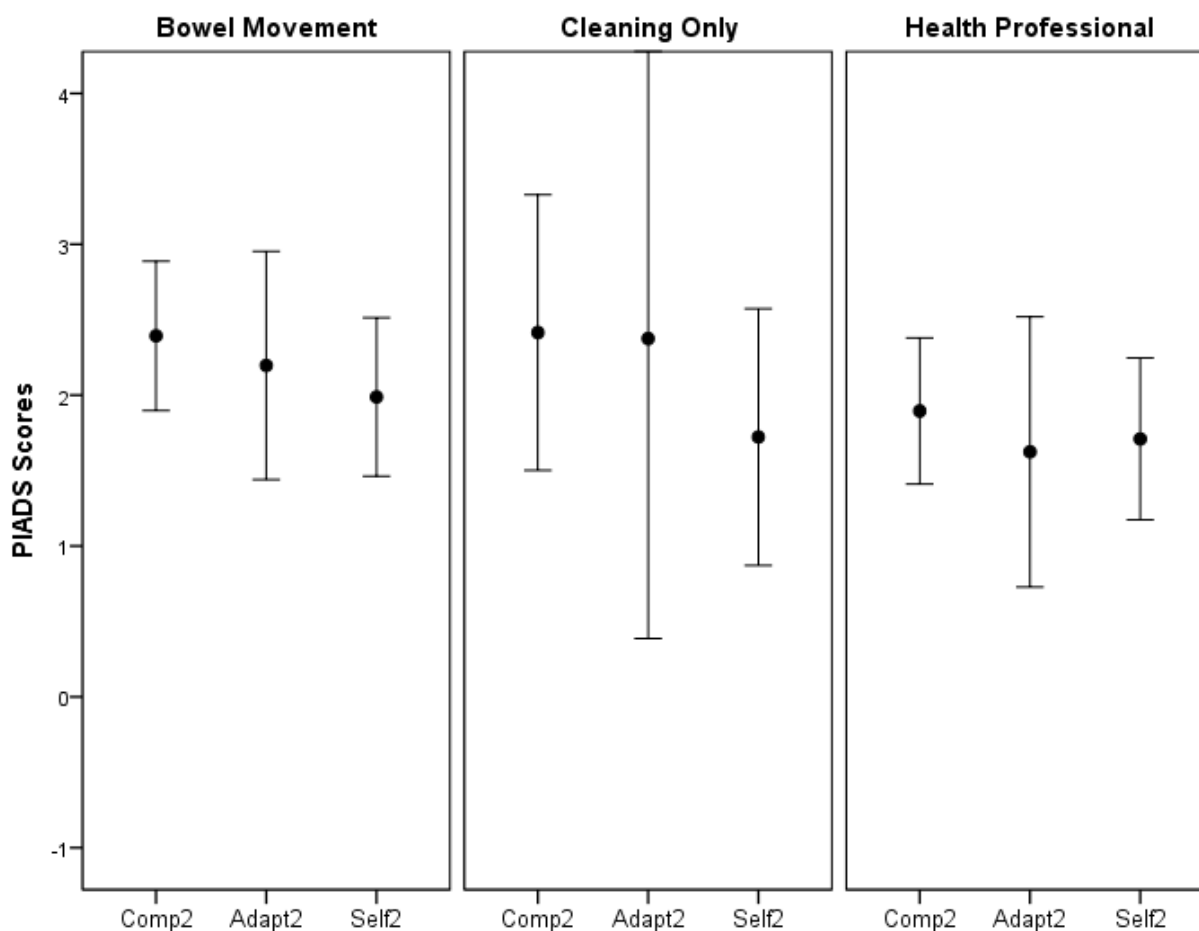


**Figure 3.** Psychosocial Impact of Assistive Devices Scale (PIADS) scores for participants who completed pretest and at least 1 bowel movement trial. Error bars indicate 95% confidence interval. 'Comp' indicates competence subscale. 'Adapt' indicates adaptability subscale. 'Self' indicates self-esteem subscale. A score of 3 shows a strong positive result, 0 shows indifference towards the device, and a score of -1 or lower indicates that participants dislike the device.



**Figure 4.** Psychosocial Impact of Assistive Devices Scale (PIADS) scores for all stroke rehabilitation participants. Each trial is divided into competence, adaptability, and self-esteem subscales. Error bars indicate 95% confidence interval. 'Comp' indicates competence subscale. 'Adapt' indicates adaptability subscale. 'Self' indicates self-esteem subscale. A score of 3 shows a strong positive result, 0 shows indifference towards the device, and a score of -1 or lower indicates that participants dislike the device.

### PIADS Scores for BM Group, Clean Only Group, and Health Professionals



**Figure 5.** Psychosocial Impact of Assistive Devices Scale (PIADS) scores for first TAT trial in three groups. Error bars indicate 95% confidence interval. 'Comp' indicates competence subscale. 'Adapt' indicates adaptability subscale. 'Self' indicates self-esteem subscale. A score of 3 shows a strong positive result, 0 shows indifference towards the device, and a score of -1 or lower indicates that participants dislike the device.

### Discussion

Our results show that when using a TAT, stroke rehabilitation in- and out-patients were able to clean themselves thoroughly without assistance almost three quarters of the time. They felt that they had a greater degree of competence, adaptability, and self-esteem when compared to their regular toileting. These findings suggest that TATs can provide adequate toileting

hygiene, and use of TATs could benefit the well-being of stroke rehabilitation patients by improving their independence in the bathroom. Data from HCPs indicates that those working directly with stroke rehabilitation patients believe that TATs could prove useful in a clinical setting, and could reduce the burden of care necessary for stroke rehabilitation patients.

The results from the PIADS questionnaire show a dramatic increase in the participants' sense of well-being and quality of life when using the TAT. The participants felt that there was a large increase in their ability to toilet on their own, that there was a large reduction in feelings of frustration and embarrassment, and that they would be able to carry out their activities of daily living more easily if they had regular access to a TAT.

The number of participants who completed multiple BM trials was low, but there was no evidence to suggest that participants felt more comfortable using the TAT more or were more effective at using the TAT over multiple uses. This suggests that using a TAT is fairly simple, and does not require a significant amount of practice to use properly.

There were no safety issues related to this study. TATs do not contain many risks that are not found in a regular toilet, but there is still potential for falls when using the TAT. Most models have a seat heater that could cause discomfort or burns, but that feature was turned off for this study. None of the participants in this study had urinary tract infections, burns, or skin breakdowns as a result of using the TAT, however the participants only used the TAT in a few instances. Regular use of TATs would reveal more information on complications such as infection.

Most models of TAT range in price between \$400 CAD to \$2,500 CAD, making them an affordable assistive device. The price varies depending on brand and number of features, but this

study used only the most basic functions of TATs which are common to all models. After installation, the TATs did not malfunction and required no further maintenance beyond regular cleaning.

### *Limitations*

Although this study found promising results, there were a number of limitations affecting the project. The first issue is that we had a small sample size and a low rate of completion for our participants. The investigators quickly found out that successfully completing BM trials is challenging. In order to successfully carry out a trial, the researchers needed to be present at the same time as the participant needed to have a BM, which was difficult to predict. This led to many participants being discharged from hospital before completing the full 3 trials. Despite the low sample size, we were still able to demonstrate statistically and clinically important improvement when using the TAT. An alternative design for a study of this nature could be to use the nursing staff in the unit as the primary data collectors, but this requires more commitment from the institution in which research is being conducted.

Another limitation was that we were unable to recruit a large enough number of stroke rehabilitation out-patients to analyze them as a separate group. TATs may have a larger benefit to community-dwelling adults by increasing independence and reducing the need for assistance at home. Future studies should target community-dwelling adults.

Out-patients that we attempted to recruit showed considerable reluctance to participate in the study. They expressed concerns about having a BM at the hospital, and seemed more uncomfortable with the visual cleanliness inspections than the in-patients. In general, in-patients were more eager to participate, and comfortable with answering personal questions

about toileting and being inspected after having a BM. Toileting is an intensely private matter and subjects were reluctant to participate in the study while at the same time indicating that they recognized its potential importance.

The cleanliness scale that we created is not yet validated and its reliability is thus unknown. No scale currently exists for quantitatively measuring perineal cleanliness, which is a gap that needs to be addressed. We will be conducting another TAT study in which we will also test the validity of our cleanliness scale. Nurses noted to the study authors that the scale created was practical and sensible.

This was a pilot study, and therefore one of our goals was to investigate whether studying TATs was feasible. Although we had difficulty getting participants to complete the full study, we were able to test enough participants to conduct meaningful analyses of our results. This indicates that conducting TAT studies in which participants are measured on multiple occasions may be challenging, but that studying TATs is feasible and worthwhile.

## **Conclusions**

This study shows that TATs have the potential to be beneficial in stroke rehabilitation. It is likely that the benefits of TATs could be extended to elderly adults with a wide variety of disabilities that prevent them from toileting independently. Further research should be conducted to establish the extent to which TATs could be helpful, and which groups benefit the most from this device.

## Acknowledgements

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## Declaration of Conflicting Interests

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## Article 3 - Can Technology-Assisted Toilets Improve Hygiene and Independence in Geriatric Rehabilitation? A Cohort Study

David Yachnin, Hillel Finestone, Ami Chin, Jeffrey Jutai

### Abstract

*Purpose:* To investigate whether Technology-Assisted Toilets (TATs) could be used to improve toileting hygiene and independence for geriatric rehabilitation patients. TATs are commercially available toilet seats that use a stream of warm water to clean the user, have a fan for drying, and are operated by a remote control.

*Materials and Methods:* 25 Geriatric rehabilitation in-patients were recruited, 6 completed the study and 7 partially completed the study. Each participant had two trial bowel movements. One trial involved cleaning themselves with toilet paper; the other involved cleaning themselves with the TAT functions. After each trial, participants received a visual inspection for cleanliness and answered the Psychosocial Impact of Assistive Devices Scale (PIADS), a validated scale, to assess their sense of competence, adaptability, and self-esteem in the bathroom. A toileting cleanliness scale, designed for this study, was completed by a nurse after TAT usage. Participants received a score from 1 (completely clean) to 4 (completely soiled) based on a visual inspection after cleaning.

*Results:* TAT and toileting cleanliness scores were similar. PIADS scores showed a trend towards higher scores when using the TAT, but results were not statistically significant.

*Conclusions:* TATs cleaned as well as standard toileting in geriatric rehabilitation inpatients. Participants indicated that TATs improved their sense of competence, adaptability, and self-esteem. Geriatricians and rehabilitation professionals should consider prescribing TATs in their practice as an assistive device in order to promote patient independence and dignity and reduce the burden of care for patients requiring toileting assistance.

Keywords: toileting, assistive technology, rehabilitation, hygiene, independence

Clinical Trial Registry: This study is registered on [clinicaltrials.gov](https://clinicaltrials.gov) under the reference number NCT02518321.

Word Count: 4782

## Introduction

Many geriatric rehabilitation patients have great difficulty with toileting or are unable to toilet themselves independently. Among adults aged 65 years or older the prevalence of toileting disability has been estimated to range from 6% for community-dwelling adults [1] to as high as 60% for nursing home residents [2]. Health professionals and caregivers must then provide assistance for this very personal activity [3]. While incontinence is widely discussed in the scientific literature, information specific to toileting disability is scarce. The high prevalence rates for toileting disability show the importance of proper toileting assistance, but there is very little research that focuses on improving the capability of those who cannot toilet independently. The purpose of this study was to investigate the potential for technology-assisted toilets (TATs) to improve the ability of geriatric rehabilitation patients to toilet themselves without assistance.

Physical difficulties in toileting can be caused by several aspects of disability. Lack of balance can make it difficult to successfully use or remain seated on the toilet, while lack of mobility can impair the ability to clean oneself. Impairment of wrist flexion in conditions such as rheumatoid arthritis (deficit in range of motion) or stroke (weakness) can make the required wiping motions impossible, and pain or restriction of range of motion to the elbow or shoulder owing to trauma or disease can make reaching the perineal and periurethral regions difficult. In these instances the disabled person can no longer use a toilet without assistance.

Requiring assistance for a private and personal activity such as toileting can be detrimental to a person's self-esteem and sense of well-being, and may contribute to depression. Several qualitative studies and opinion pieces discuss the importance of toileting independence to patient dignity. Tutton et al [4] emphasized the need for patients to be able to return to

normalcy and to be able to complete all of their daily activities independently. Clark and Rugg [5] noted that being able to toilet independently was critical to dignity and self-esteem, and Siviter [6] stated that making patients wait to use the toilet is a fundamental failure of dignity. The negative psychosocial impact of toileting dependence demonstrates the need for methods that can increase patient independence.

We use the term TATs to refer to toilet seats that clean the user with a stream of water, have a fan for drying the user, and are operated with a wall-mounted remote control. We developed the term “TAT” to refer to this type of device while avoiding any branding associated with a specific manufacturer of these devices. The user is able to adjust the stream position, water pressure, water temperature, and dryer strength with the remote. These toilets are extremely common in countries such as Japan and are commercially available, but their use in rehabilitative care has not been well-documented. TATs have the potential to eliminate the need for wiping; an activity of daily living that is often difficult or impossible for geriatric patients. TATs could increase patient independence and dignity, and thereby help reduce depression associated with loss of independence. They could also reduce burden of care and improve toileting hygiene.

Although TATs are not a new technology, only one previous study was found that investigated their use in health care. Cohen-Mansfield and Biddison [7] conducted a randomized control trial in which they installed TATs in the bathrooms of female nursing home residents and compared the findings to control subjects who used regular toilets. Approximately half of the residents and nursing home staff reported the device had positive effects, including physical and mental relief, a decrease in negative affect, adequate hygiene. Participants using the TAT also showed a reduced rate of urinary bacterial growth. An analysis of urinary bacterial content

showed a significant decrease in bacteria in the experimental group only. Staff reported that the device did not completely clean the participants, but the researchers failed to assess the control group for cleanliness in order to compare hygiene. Other problems with this study included leaks from the toilet owing to improper installation, which led some participants to report dissatisfaction with the TATs, and inconsistency on the part of nursing staff in completing the toileting logbooks which were being used to assess cleanliness. Despite these shortcomings in the study's results, the TAT showed potential to be of benefit to this population.

We conducted a pilot study in elderly stroke rehabilitation in- and out-patients to investigate whether TATs could provide an acceptable level of hygiene, whether they would improve the participants' sense of well-being, and whether it would be feasible to conduct larger-scale studies on TATs [8]. 30 Participants from a stroke rehabilitation program rated how they felt about their regular toileting routine, and then used the TAT for a bowel movement (BM) on up to three occasions. After each trial, they rated their experience and were inspected for cleanliness. Out of 22 total BM trials, which includes multiple trials from participants who completed more than one trial, 16 resulted in the participant being completely clean, and there was a significant increase in participant ratings of their toileting experience after using the TAT. These results are encouraging, and indicate that TATs could be used as an effective assistive device in stroke rehabilitation.

The purpose of this follow-up study was to examine the effectiveness of TATs in geriatric rehabilitation, where we may expect a wider range of impairments and disabilities because of a wider range of causes for admission into a geriatric rehabilitation program. The objectives of this project were to 1) assess the effectiveness of TATs compared to standard

toileting care for cleaning following a bowel movement in geriatric patients, and 2) assess patient psychosocial outcomes with the TAT in comparison with standard toileting.

## **Methods**

### ***Population***

A convenience sample of 25 participants was recruited from the geriatric rehabilitation in-patient program at the Elisabeth Bruyère Hospital in Ottawa, Ontario. The criteria for admission into the geriatric rehabilitation program were that the patient was over the age of 65 and recovering from a recent illness, injury, surgery, or other condition resulting in loss of autonomy. Additionally, they were well enough and had sufficient energy to participate in an one-hour physiotherapy and occupational therapy sessions each day, able to learn and retain new information, and motivated to participate in the program. There were a total of 50 beds in the in-patient unit.

Participants were included if they 1) were over the age of 65 and were inpatients in the Geriatric Rehabilitation Unit of the Elisabeth Bruyère Hospital, 2) could communicate effectively in English or French, 3) were able to remain balanced independently while sitting on a toilet, 4) are able to operate the remote control, and 5) were able to wipe themselves, but they did not need to be able to wipe themselves effectively.

Participants were excluded if they 1) were cognitively unable to provide informed consent, 2) were severely aphasic or could not speak English or French, 3) were undergoing treatment that interfered with toileting, 4) had any conditions that increase perineal sensitivity such as ulcers, wounds, or infections, 5) required more than one person to assist them in transferring to and from the toilet, or 6) could not sit on a standard-height toilet safely.

In order to describe the functional mobility of the participants, we collected the Physiotherapy Functional Mobility Profile (PFMP) [9] scores from participant medical records, which was administered when each patient is admitted to, and discharged from, the geriatric rehabilitation unit. Only admission PFMP scores were collected.

This study was approved by the Bruyère Research Ethics Board, and all participants gave written informed consent before being enrolled. All procedures followed were in accordance with Bruyère Continuing Care institutional guidelines.

### ***Intervention***

Each participant was tested on two separate occasions. During one testing session, participants had a bowel movement and cleaned themselves using standard wiping methods.

During the second session, participants had a BM and used the cleaning functions of the TAT. The order of testing sessions was counterbalanced such that some patients used the TAT first, and others used standard toileting first. During both testing sessions, participants received a visual inspection of the perineal and periurethral areas from a nurse after they had finished cleaning to assess their level of cleanliness. Participants then filled out a questionnaire to assess the psychosocial impact of each toileting method. The same bathroom was used for both testing sessions.

Participants who were likely to be discharged from hospital before being able to carry out a successful BM session tried cleaning themselves with toilet paper or with the TAT and filled out the questionnaire regarding their experience, but were not assessed for cleanliness.

Prior to testing, each participant received a training session on how to use the TAT. Patients were shown how to start and stop the stream of water and the dryer. They were not

instructed on how to adjust pressure, water temperature, stream position, or dryer strength. All of these variables were set to medium levels before the participant entered the bathroom.

Participants were not given direction on how long to let the TAT run before stopping the stream of water.

The model of TAT used for this study was the TOTO Washlet S350e. Only the most basic functions of the TAT were used, which are standard for the majority of TAT models.

### ***Outcome Measures***

After each testing session, participants filled out the Psychosocial Impact of Assistive Devices Scale (PIADS) [10], which is a self-reported questionnaire that assesses the psychosocial impact of using an assistive device. Scores from the PIADS can be broken down into three subscales; competence, adaptability, and self-esteem. The Competence subscale measures feelings of competence and efficacy. It is sensitive to the perceived impacts of an assistive device on performance and productivity. The Competence subscale (12 items) includes questions on topics such as competence, productivity, usefulness, performance, and independence. The second subscale, Adaptability (6 items), indicates a willingness to try out new things and to take risks. It is sensitive to the enabling and liberating aspects of an assistive device that might be expected if the device enhanced participation as defined in the WHO International Classification of Functioning, Disability and Health. The Adaptability subscale includes questions on topics such as ability to participate, willingness to take chances, eagerness to try new things, and the ability to take advantage of opportunities. The third subscale, Self-esteem (8 items), indicates feelings of emotional health and happiness. It is sensitive to the perceived impact of an assistive device on self-confidence and emotional well-being. The Self-esteem subscale includes questions on

topics such as self-esteem, security, sense of power and control, and self-confidence. Scores can range from  $-3$  (maximum negative impact) through zero (no perceived impact) to  $+3$  (maximum positive impact). Research has shown that PIADS scores can predict the continuance and discontinuance (abandonment) of assistive devices [11,12]. After completing the PIADS, participants were asked for any additional feedback they had on the trial.

Cleanliness was assessed through visual inspections by a nurse who gave the participant a score on a 4-point cleanliness scale which was designed for this project (Appendix A). This scale needed to be designed because no adequate measurement tool for toileting hygiene was found in the scientific literature. The scale includes a separate score for cleanliness in the genital region and perineal region, as well as a section for the person making the assessment to indicate which areas remained unclean and what factors may have impeded the patient's ability to clean effectively. A score of 1 indicates that the person being assessed is completely clean, and a score of 4 shows that subject is completely soiled. This scale has not yet been validated.

## **Results**

### ***Population***

The average age of all participants was 80 years old ( $SD = 7.3$ , Range = 69-97). Fifteen participants were female and ten were male. The most common reason for admission to the geriatric rehabilitation program was due to sustaining a hip fracture ( $n=9$ ). Two participants were recovering from surgical hip treatments. No other single reason for admission was shared by 2 or more participants. Other conditions included recovery following a left shoulder arthroplasty, vertebral fracture, lower limb cellulitis with sudden-onset lower limb weakness, humeral fracture, deconditioning, ankle fracture, lower limb neuropathy, general weakness and functional

decline, renal failure, lower extremity hemiplegia, and chronic obstructive pulmonary disease exacerbation. Some participants were admitted with more than one of the conditions above.

The majority of participants had multiple comorbidities. Common additional medical conditions included osteoporosis, osteoarthritis, rheumatoid arthritis, atrial fibrillation, hypertension, diabetes, congestive heart failure, hypothyroidism, and spinal stenosis.

PFMP scores are based on 9 separate functional mobility assessments that are each given a score out of 7, yielding a total PFMP score of 63. The average PFMP score among participants was 30 (SD = 8.4, Range = 19-48).

Of the 25 total participants, 6 participants successfully completed both the wiping and TAT trials after having a BM, but several participants completed part of the protocol. Table 1 shows the number of participants that completed each trial.

[Insert table 1 here]

### ***Toileting Hygiene***

There were no discernable differences in cleanliness scores between wiping and TAT trials. The average perineal hygiene score was 1.78 when using the TAT and 1.83 when wiping (figure 1). The average genital hygiene score was 1.22 when using the TAT and 1.17 when wiping. 33% of trials for both TAT cleaning and wiping resulted in a score of 1 (completely clean) for perineal hygiene.

[Insert figure 1 here]

For each trial that did not result in the participant being completely clean, the reason that that participant was unable to clean themselves was noted. Out of the six TAT trials that resulted

in a cleanliness score greater than 1, three were due to skin folds or obesity, two were due to participants stopping the TAT stream too quickly, and one was due to the TAT stream not having enough pressure and being aimed improperly. For the four wiping trials that resulted in a score greater than 1, two were due to poor upper limb mobility and lack of strength, one was due to only poor upper limb mobility, and one was due to obesity or skin folds.

### *Psychosocial Outcomes*

PIADS scores on all 3 subscales (competence, adaptability, self-esteem) showed higher scores after TAT toileting than after wiping, but the difference was not great enough to achieve statistical significance (figure 2).

[Insert figure 2 here]

Participants' feedback on the TAT was mixed. Some positive comments included:

“[the TAT] was very helpful. It does the work for me”,

“it washed well, I would love to have one at home”, and that the TAT was

“not difficult to use, everything was set up perfectly.”

Participants tended to be more constructive in their negative feedback, saying that

“the water was not hitting the right spot and the controls were hard to reach”,

“it is necessary to have toilet paper as well”, and that

“it could use more pressure to reach deeper, the dryer was not strong enough, and I had to move around to get the stream everywhere”.

In some cases, participants were ambivalent about the TAT. One participant mentioned that they “like the newer toilet, but it’s too expensive”. Another felt unable to give proper feedback, saying that “it’s hard to judge the features with just one use”.

### ***Relationship between Cleanliness and Psychosocial Outcomes***

The correlations between each PIADS subscale and cleanliness scores showed no significant relationships (table 2), but the majority of the correlations indicated that participants who were cleaner after each trial had higher PIADS scores. The strongest correlations were between perineal cleanliness after wiping and each PIADS subscale. Figures 3-6 show the distribution of cleanliness scores with each PIADS subscale for the 6 participants who completed both trials after having a BM. These figures demonstrate that for both TAT and wiping, there is a greater distribution in the level of perineal cleanliness than genital cleanliness, with genital cleanliness scores being zero in almost every case. Figures 3-6 also show a greater variability in PIADS scores in the wiping condition, but no discernible difference in cleanliness scores between the two conditions.

[Insert table 2 here]

[Insert figures 3-14 here]

### **Discussion**

The results from this pilot study of TAT use in geriatric rehabilitation shows that TATs do have the potential to improve patient independence in toileting and quality of life. Although the current results are not strong enough to suggest that TATs should be used in the geriatric rehabilitation population there is evidence to support further research in this area. While the

cleanliness scores for after TAT use were no better than after wiping, the fact that the scores are similar indicates that TATs are able to provide the same level of hygiene as regular toileting.

It is important to note some aspects of the methodology that may have negatively impacted participants' ability to use the TAT effectively. The participants only used the TAT on one occasion, meaning they did not have repeated uses to familiarize themselves with the device. It is possible that some participants would show greater levels of hygiene after using the TAT several times which would improve user competence.

As the participants were using the TAT device for only one trial, they were only shown how to start and stop the stream of water and the dryer. Additional features, such as the ability to adjust the stream position, water temperature and pressure, and dryer strength, were not used for this study. The ability to adjust the stream position and pressure could allow users to apply the stream to a larger area and thus make it easier for those with reduced mobility to clean themselves thoroughly. Use of these advanced features could have resulted in superior cleanliness scores as well as user satisfaction, but these features were avoided due to concerns that the extra controls may have been difficult for the participants to master with only a single TAT trial. Furthermore, using only the basic features reduced the amount of variability from one participant to the next, and makes these results generalizable to different models of TATs, which all have the features used in this study.

PIADS scores after toileting with the TAT were higher than scores after wiping on the 3 subscales of competence, adaptability, and self-esteem, but the sample size was too small to reach statistical significance. This result indicates that using TATs could improve a geriatric rehabilitation patient's sense of independence and quality of life. Previous PIADS studies have

shown that a score higher than 1.5 indicates that the user of the device is unlikely to abandon using the device [12]. Mean TAT PIADS scores reached this threshold, while wiping PIADS scores did not, suggesting that participants would switch from wiping to TAT toileting if given the choice.

Although none of the correlations between cleanliness scores and PIADS subscales yielded significant results, the trends for this data mostly show the results that we anticipated. With a few exceptions, the correlations between cleanliness and PIADS scores were negative, indicating that when participants were able to clean themselves more effectively, their PIADS scores increased. The correlations were stronger when looking at perineal cleanliness as opposed to genital cleanliness. This met expectations due to the fact that the genital region is easier to clean, resulting in better cleanliness scores, and that the TAT cannot clean the genital area in men, meaning the TAT genital cleanliness scores had no real relation to the impressions of male participants.

The wiping trials showed a stronger correlation with PIADS scores than the TAT trial. This is likely due to the fact that when participants are wiping themselves, they are more aware of how clean they are. They are able to look at the toilet paper to see if they are clean. When using the TAT, the participants had no visual feedback regarding their own cleanliness, making them less aware of their own cleanliness level. If a person attempts to clean themselves and can see that they were not effective, it is not surprising that their feelings of competence, adaptability, and self-esteem would decrease, leading to stronger correlations in the wiping trials. This was particularly illustrated by a comment from one participant, who said “I am more sure that I’m clean after wiping, and I’m more confident.” It is likely that geriatric rehabilitation patients would feel more confident when using the TAT on multiple occasions, which could

result in an increase in PIADS scores and strengthen the correlation between high PIADS scores and effective TAT cleanliness.

With a small sample size, it is difficult to draw conclusions on whether the TAT is better suited to patients with certain impairments than others, but the diversity of admission diagnoses and patient comorbidities in the geriatric rehabilitation population could account for some of the distribution in PIADS and cleanliness scores. For example, participant G11, who was admitted with general deconditioning due to an upper gastrointestinal bleed, was better able to clean herself using the TAT, and gave much higher PIADS scores when using the TAT. Participant G11 had a PFMP score of 46, which was considerably higher than average (mean = 30, SD = 8.4), which illustrates that patients with higher functional mobility may be more able to use the TAT. Participant G05 suffered from a femoral neck fracture and had poor cleanliness scores when using the TAT, but gave the TAT high PIADS scores. Since her PIADS scores do not reflect frustration with the device, it is likely that she simply did not operate the TAT effectively, and may benefit from multiple uses of the TAT. Participants G03 (vertebral fracture) and G25 (hip fracture) both received a score of 2 for TAT perineal cleanliness, indicating that it is possible for patients with more severe mobility limitations to operate the TAT, but they may have difficulty using it effectively. PIADS and cleanliness scores for these patients can be found in figures 3-6.

When looking at the distribution of genital cleanliness scores (figures 3-6), it is clear that there is a floor effect. With the exception of one participant in each of the trials, all participants received a genital cleanliness score of 1 (completely clean). The genital region is much easier to reach for most geriatric rehabilitation patients than the perineal area, and after going to the bathroom for a bowel movement there is generally less to clean in the genital area. This likely

led to participants being able to completely clean themselves in the genital region in almost all trials.

The perineal cleanliness scores show a much wider distribution. Unlike the genital region, the perineal area is much more difficult to reach and is generally considerably more soiled after a bowel movement, leading to a greater number of participants in both trials who were unable to successfully clean the perineal area. This, combined with the floor effect of genital cleanliness scores, lends some validity to the cleanliness scale. As was expected, the results from the cleanliness scale reflected the greater difficulty in cleaning the perineal region.

In addition to the challenges already mentioned, there were considerable limitations to this study. Primarily, our sample size was small and the number of participants who successfully completed the study was low. Recruitment was more difficult for this study than anticipated, with many patients reluctant to discuss the topic with researchers, and others who did not wish to participate due to not being comfortable with being in a study concerning toileting, concerns about privacy, and lack of interest in trying a new type of toilet. We expected that successfully collecting data on participants having a BM would be challenging, but with a large patient pool we anticipated being able to recruit a much larger number of participants. Due to the small sample size, we were unable to effectively assess which medical conditions would be most affected by using the TAT, though our results show that there is likely some variability in which populations will benefit the most from the use of this toilet.

For this study, we were unable to embed researchers among the regular nursing staff, which meant that in order to collect data after a participant had a BM, the research staff was required to be present when the participant needed to go to the bathroom for a bowel movement.

This created significant challenges with gathering data, and led to many participants being discharged from hospital before the study could be completed. The average length of stay for a patient in the program over the course of the study was 26.9 days. The actual time to test participants was considerably lower than the full length of stay, due to the patients needing time to adjust to a new environment, be assessed by the treating team before we were able to approach the patient for recruitment. A more effective design for a future study would be to embed the researchers among the nursing staff, that way cleanliness data could be collected at any time.

Another limitation of this study was that participants were only using the TAT on one occasion. With multiple uses, participants would have the opportunity to become more familiar with the device and could become more skilled at using the TAT to clean themselves independently. A future study could investigate TATs by installing these toilet seats in a long-term care home and embedding researchers among the regular nursing staff. As patients reside permanently at long term care facilities, this would eliminate concerns for patients being discharged from the study prematurely, and allow participants to become habituated to the new device for more effective data collection. Furthermore, a study design that allowed for long-term use of TATs could yield information on whether TATs can reduce the rates of infections, rashes, skin breakdowns, and other conditions associated with poor toileting hygiene.

One goal of this study was to validate the cleanliness scale that the research team designed. The lack of a standardized tool for assessing toileting hygiene is concerning, and shows how toileting can often be neglected as a topic. The initial methodology for this project included having each participant assessed by two different nurses in order to test the scale for inter-rater reliability. This plan was abandoned due to the fact that patients were already reluctant to participate, and that having multiple people entering the bathroom to give a visual inspection

might be both physically and emotionally demanding for the participants. In the future, this scale should be investigated for its validity and reliability in order to fill the gap in assessment tools for toileting hygiene.

A point of concern that was raised by a number of participants and prospective participants for this study was the cost of TATs. This raises the importance of researching whether TATs are a cost-effective device. If TATs are able to make geriatric rehabilitation patients more independent in the bathroom, this could reduce the amount of care required both at home and within medical institutions. It is also possible that an improvement in hygiene would reduce complications that arise from improper toileting, such as infections [13]. These potential reductions in burden of care could result in savings for health care facilities and for community-dwelling elderly people. If TATs prove to be cost-effective, we suggest classifying TATs as assistive devices so that a portion of the costs associated with the installation of TATs could be publicly funded in order to alleviate the costs for patients.

At the beginning of this study, we predicted that TATs would provide a higher level of cleanliness than standard toileting, and that participants would rate the TAT much higher than standard toileting. While this study did not show the degree of positive results that we anticipated, there is reason to believe that TATs can be an effective assistive device for toileting hygiene. At this point, we cannot conclude that TATs provide a higher level of hygiene than standard toileting, but the results of this study demonstrate that TATs can provide equivalent hygiene when compared to using toilet paper. Despite the limitations of this study, there is still potential for these devices to improve hygiene and independence, and to give geriatric rehabilitation patients a higher quality of life.

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Table 1: Number and type of trials completed by each participant

Level of Study Completion	Number of Participants
Completed both trials	6
TAT BM trial only	3
Wiping BM trial only	3
TAT trials without BM	1
No trials complete	8
Withdrawn	4

Table 2 Correlations between cleanliness and PIADS scores. A negative correlation indicates that PIADS scores were higher when the participant was more effectively cleaned

		PIADS		
		Competence	Adaptability	Self-Esteem
Cleanliness	TAT Genital	0.175	-0.144	0.449
	TAT Perineal	-0.275	-0.39	-0.122
	Wiping Genital	-0.033	0.334	-0.049
	Wiping Perineal	-0.722	-0.487	-0.738

Figure 1. Cleanliness scores for participants who completed both TAT and Wiping conditions. N = 6

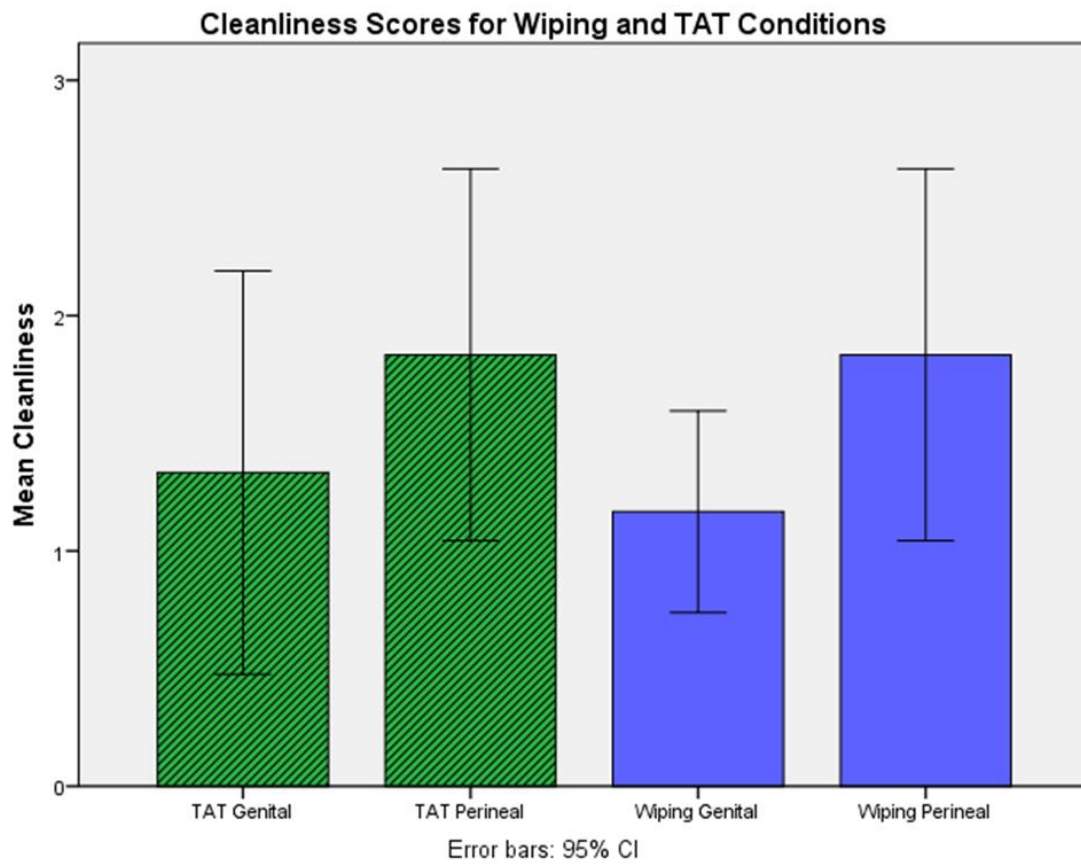


Figure 2. Mean PIADS scores by subscale for Wiping and TAT conditions. N = 7 for Wiping, N = 12 for TAT

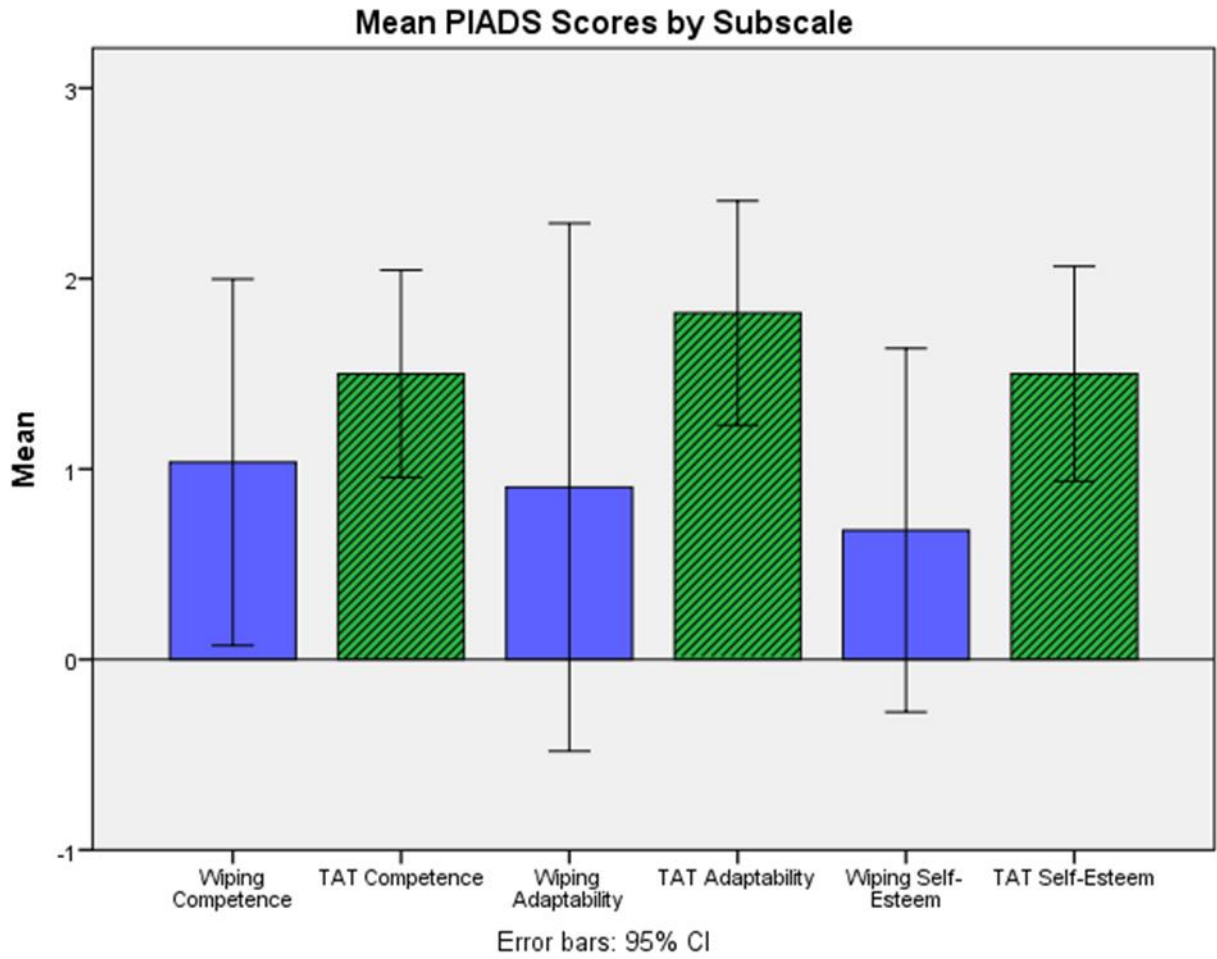


Figure 3. Distribution of TAT genital cleanliness and PIADS Competence scores. Includes participants who completed the full protocol. Labels identify participants

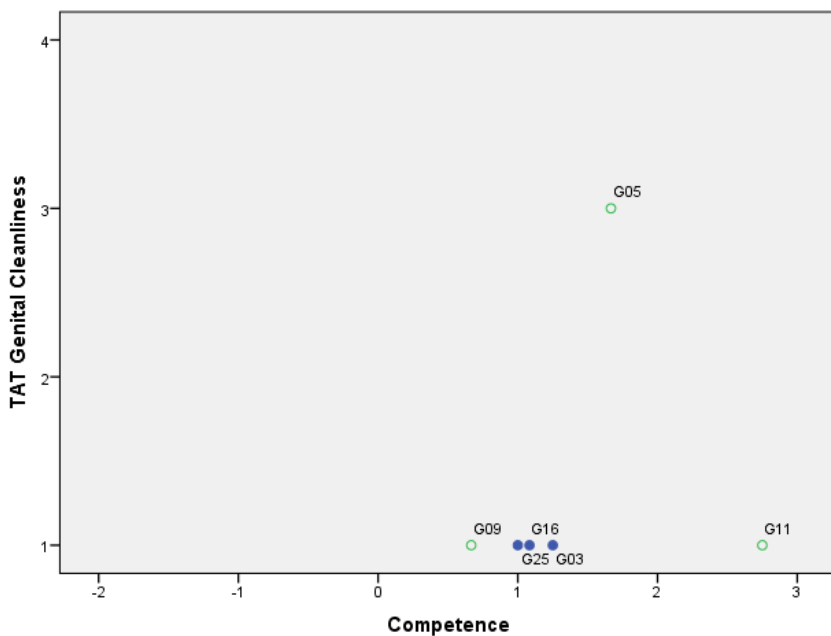


Figure 4. Distribution of TAT genital cleanliness and PIADS Adaptability. Includes participants who completed the full protocol. Labels identify participants

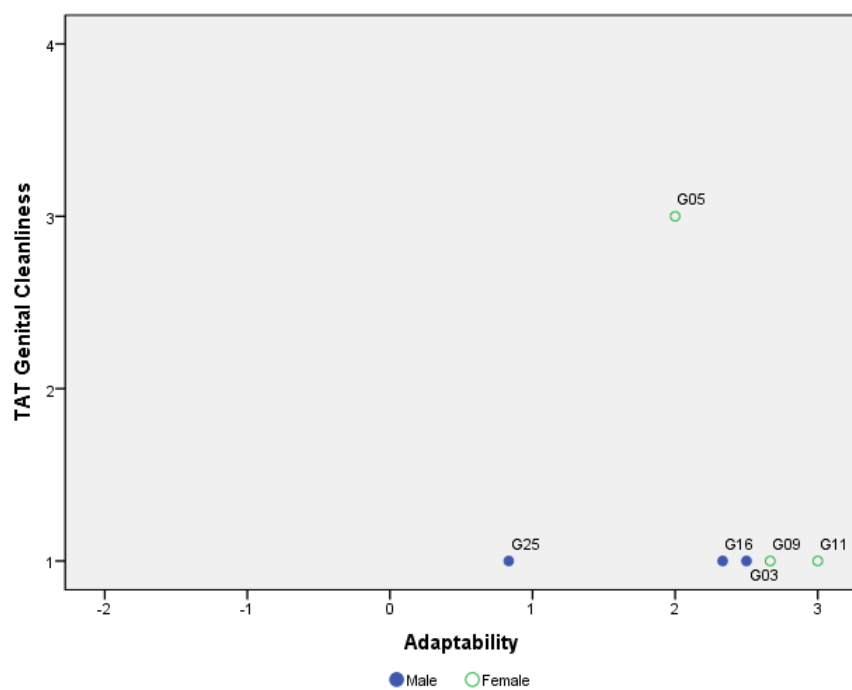


Figure 5. Distribution of TAT genital cleanliness and PIADS Self-Esteem scores. Includes participants who completed the full protocol. Labels identify participants

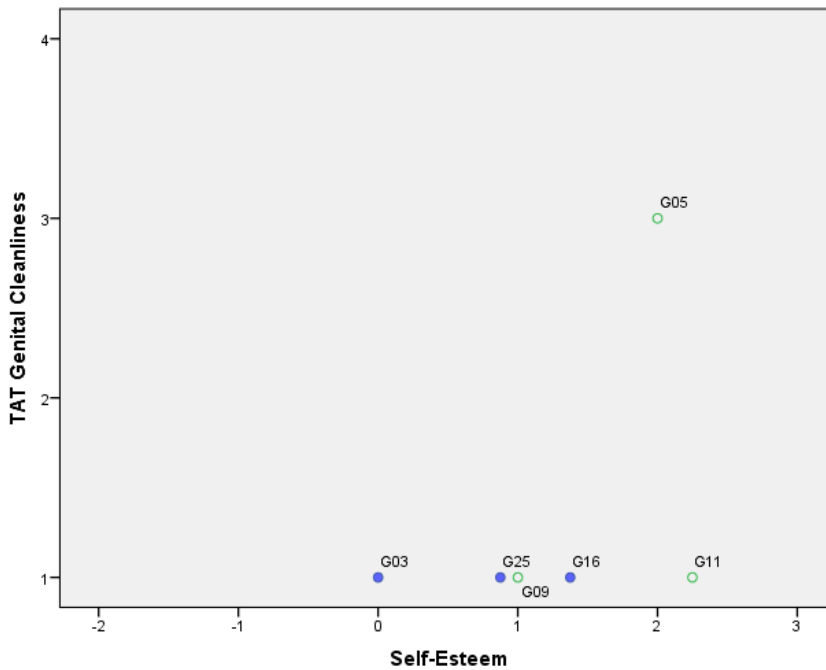


Figure 6. Distribution of TAT perineal cleanliness and PIADS Competence scores. Includes participants who completed the full protocol. Labels identify participants

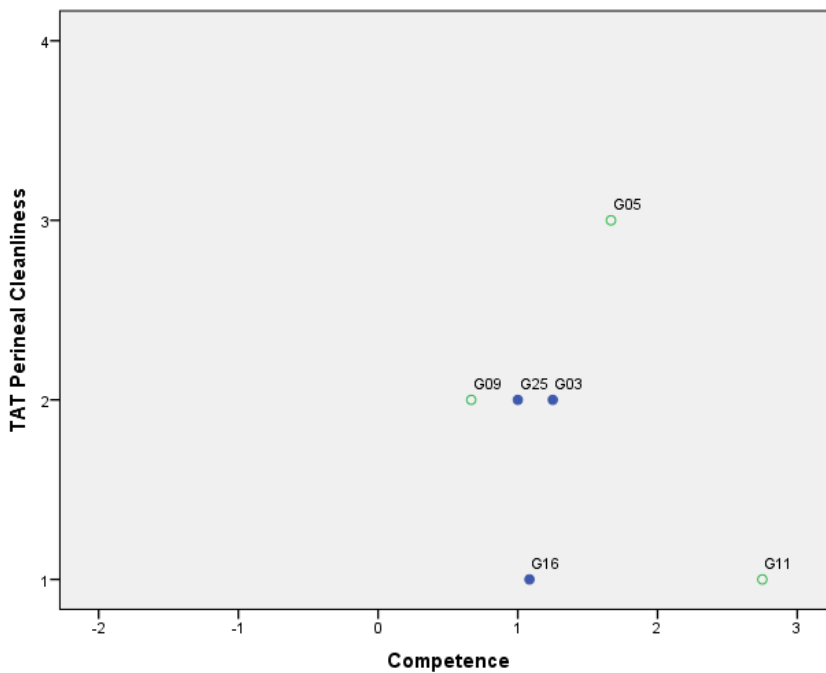


Figure 7. Distribution of TAT perineal cleanliness and PIADS Adaptability scores. Includes participants who completed the full protocol. Labels identify participants

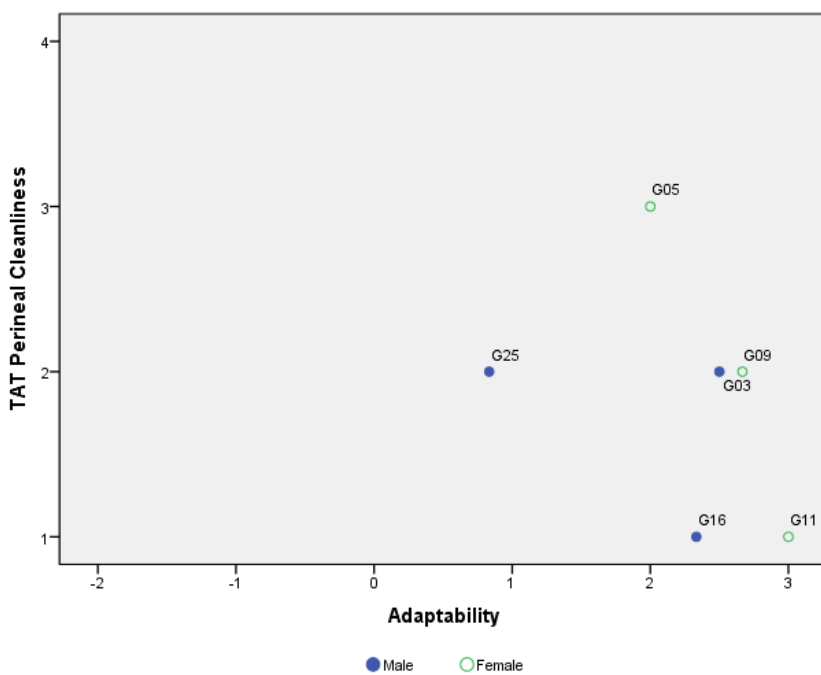


Figure 8. Distribution of TAT perineal cleanliness and PIADS Self-Esteem scores. Includes participants who completed the full protocol. Labels identify participants

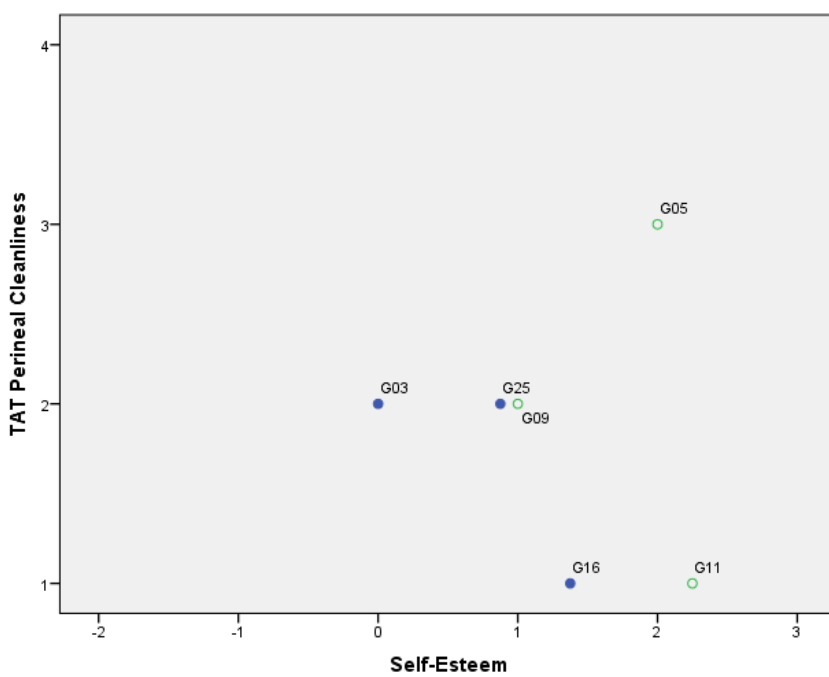


Figure 9. Distribution of wiping genital cleanliness and PIADS Competence scores. Includes participants who completed the full protocol. Labels identify participants

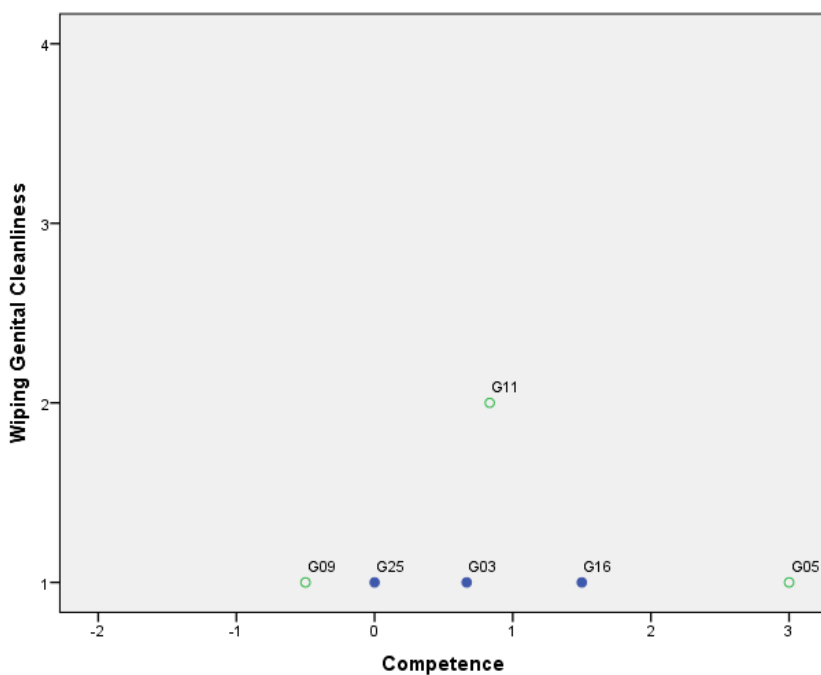


Figure 10. Distribution of wiping genital cleanliness and PIADS Adaptability scores. Includes participants who completed the full protocol. Labels identify participants

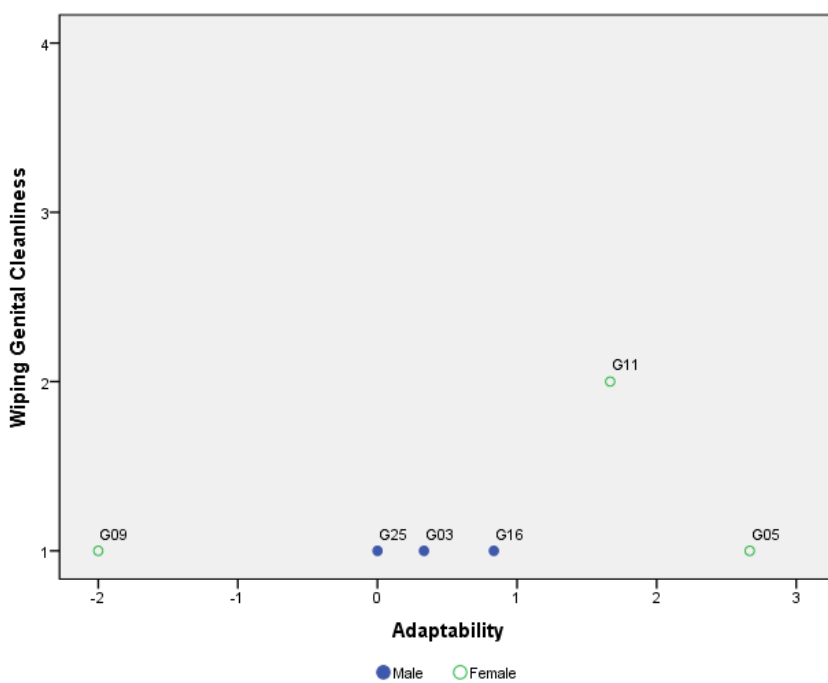


Figure 11. Distribution of wiping genital cleanliness and PIADS Self-Esteem scores. Includes participants who completed the full protocol. Labels identify participants

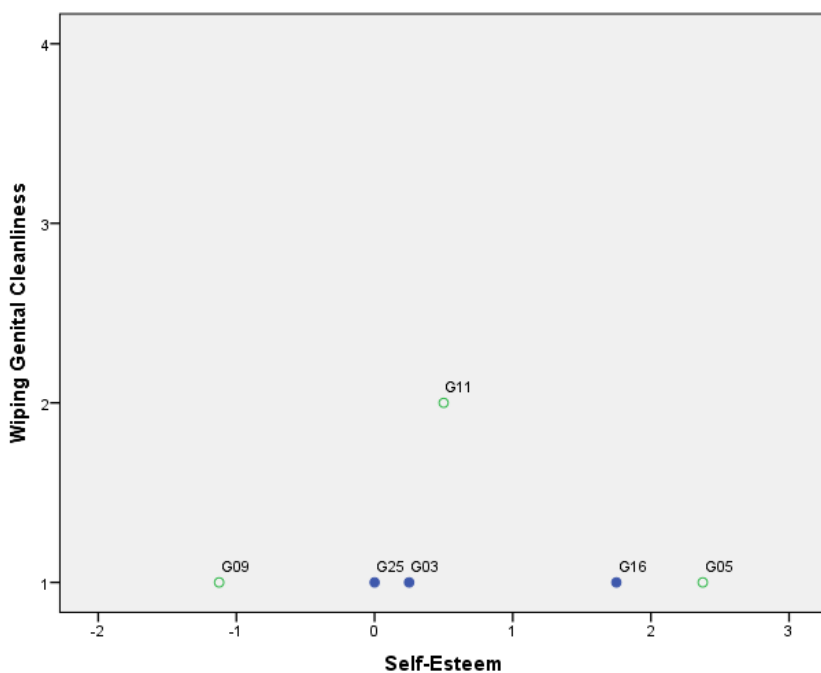


Figure 12. Distribution of wiping perineal cleanliness and PIADS Competence. Includes participants who completed the full protocol. Labels identify participants

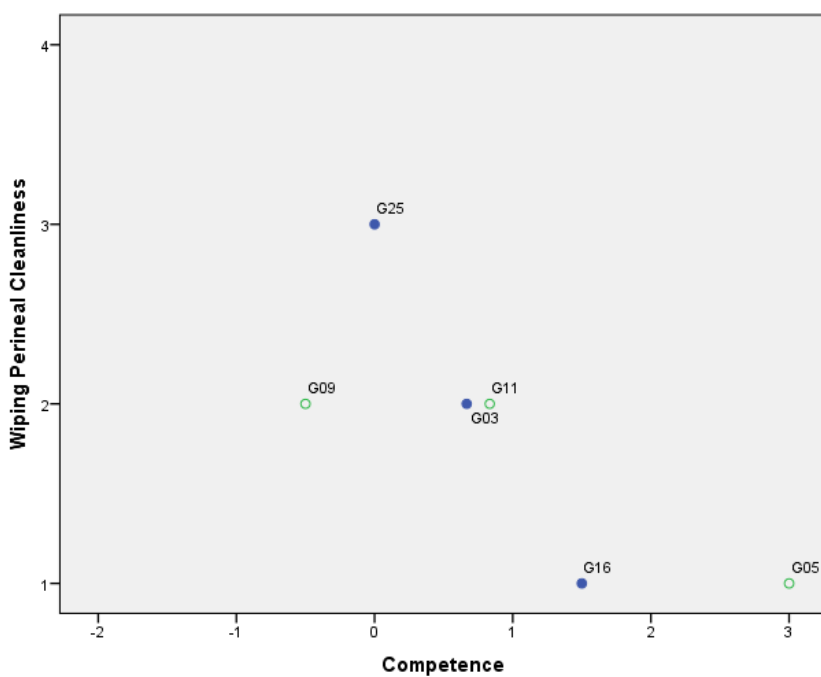


Figure 13. Distribution of wiping cleanliness and PIADS Adaptability scores. Includes participants who completed the full protocol. Labels identify participants

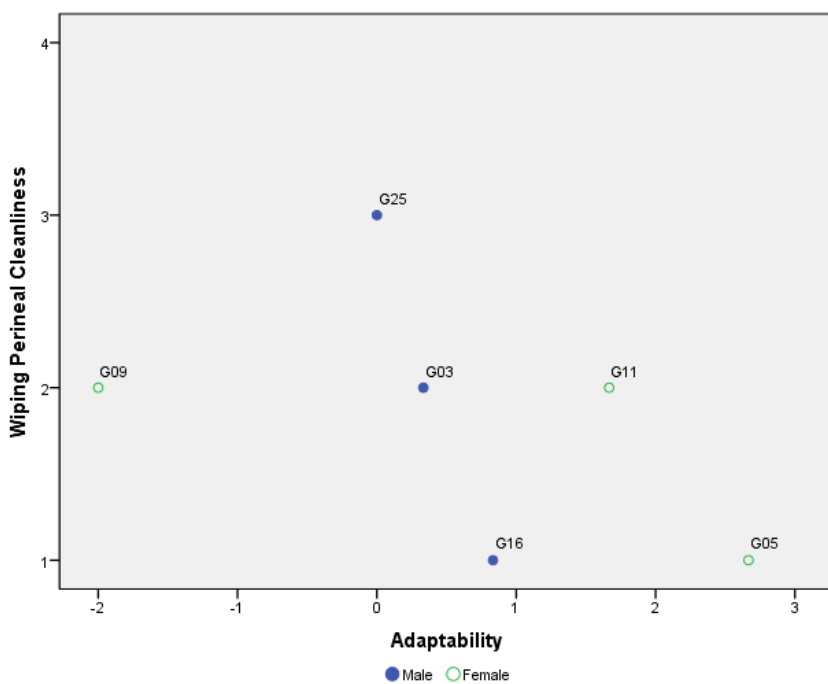
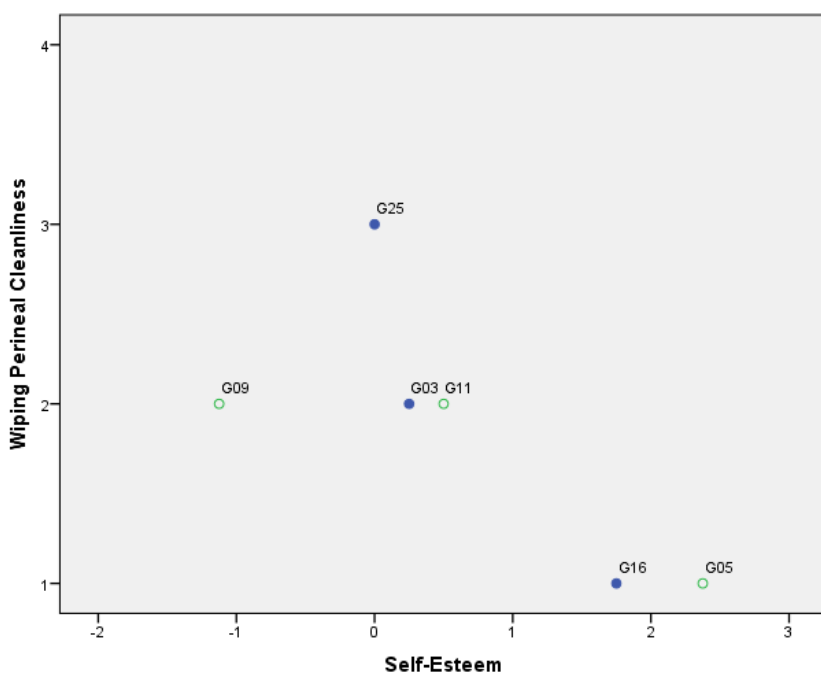


Figure 14. Distribution of wiping perineal cleanliness and PIADS Self-Esteem scores. Includes participants who completed the full protocol. Labels identify participants



## Appendix A: Cleanliness Scale

### Toileting Cleanliness Scale

Participant Identifier: \_\_\_\_\_ Gender: \_\_\_ Date of Assessment: \_\_\_\_\_

#### Front

1. Completely Clean
2. Mostly Clean, but some remaining smears or spots of urine/feces
3. Mostly soiled, but some clear evidence of cleaning
4. Completely soiled

#### Rear

1. Completely Clean
2. Mostly Clean, but some remaining smears or spots of urine/feces
3. Mostly soiled, but some clear evidence of cleaning
4. Completely soiled

If the person being assessed was not completely clean, describe below which areas of the front or rear were particularly unclean.

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If the person being assessed was not completely clean, identify what issues may have prevented them from cleaning effectively.

- |                                                     |                                                         |                                                |
|-----------------------------------------------------|---------------------------------------------------------|------------------------------------------------|
| <input type="checkbox"/> Upper Limb Mobility        | <input type="checkbox"/> Lower Limb Mobility            | <input type="checkbox"/> Size/Height of Toilet |
| <input type="checkbox"/> Cognitive Impairment       | <input type="checkbox"/> Obesity/Skin folds             | <input type="checkbox"/> Lack of Strength      |
| <input type="checkbox"/> Misuse of Assistive Device | <input type="checkbox"/> Assistive Device not Effective |                                                |
| <input type="checkbox"/> Other: _____               |                                                         |                                                |

## Cleanliness Scale Instructions

This scale is designed to be administered by a nurse or researcher after a patient or participant in a research project has urinated or had a bowel movement and has cleaned themselves. The person administering the scale should fill in the information above immediately after giving the person being assessed a visual inspection of the anal and genital regions and the skin surrounding these areas.

The following descriptions will clarify when to use each level of the scale:

### 1. **Completely Clean**

The person being assessed has no remaining feces or urine after they have cleaned themselves.

### 2. **Mostly Clean, but some remaining smears or spots of urine/feces**

The person being assessed is almost completely clean, but there are some remaining spots or smears of urine/feces remaining. Most of the skin has no soiling whatsoever. In this case, a nurse would require that a patient finish cleaning, with or without assistance, before finishing their toileting.

### 3. **Mostly soiled, but some clear evidence of cleaning**

The person being assessed has a moderate or large amount of feces/urine remaining after cleaning, but it is clear that they have been able to clean themselves to a small degree. Most of the anal or genital area has some feces or urine remaining.

### 4. **Completely Soiled**

The person being assessed has not been able to clean themselves at all. There is no evidence that the individual has attempted to clean themselves.

## **Chapter 6 - Conclusions**

### **6.1 Re-Statement of Objectives**

At the outset of these pilot studies, our primary goals were to investigate the potential impact that Technology-Assisted Toilets (TATs) could have on psychosocial outcomes and whether they could be used to increase the ability of geriatric rehabilitation patients to clean themselves independently. Our secondary objectives were to assess whether there were features of the TAT that would need to be improved or modified in order to be used in a rehabilitation setting, and whether healthcare staff felt that TATs could be implemented and used effectively in rehabilitation.

As pilot studies, these small-scale projects were designed in order to test whether it would be worthwhile to conduct larger trials on TATs and to identify potential challenges in TAT research. The “Limitations” and “Avenues for Future Research” sections of this chapter will elaborate on these goals.

### **6.2 Psychosocial Impact of TATs**

In our original pilot study on the use of TATs in stroke rehabilitation, participants reported that TATs improved their sense of competence, adaptability, and self-esteem. Despite a small sample size, the difference between participants’ ratings of TATs were significantly more positive than ratings for regular toileting. Participants reacted positively, saying that they would be happy to use the TAT regularly.

In the follow-up study with geriatric rehabilitation patients, the overall ratings of the TAT were higher than standard toileting, but the difference was not as striking as in our first study. While there was a trend towards higher scores on all PIADS subscales when using the TAT, there was no statistically significant difference between standard toileting and TAT toileting.

One possible explanation for the difference in scores between stroke and geriatric rehabilitation is the greater diversity in the geriatric population. In geriatric rehabilitation, there is a wider range of

disabilities and impairments, and it became evident during the course of the study that there were some participants whose disabilities made using the TAT considerably more challenging. For example, one participant was unable to turn her upper body and neck, making it difficult to look at and operate the remote control, which was mounted on the wall to the right of the toilet. In stroke rehabilitation, the set of impairments were well-suited to using the TAT, leading to higher PIADS scores.

The combined results concerning the psychosocial impact of TATs in these two studies show that TATs could improve a rehabilitation patient's general sense of well-being. In both studies, the participants indicated that there was a considerable increase in psychosocial outcomes when using a TAT. TATs should be considered as a device to improve the sense of competence, adaptability, and self-esteem of patients who are unable to clean themselves independently using standard toileting methods.

### **6.3 Effect of TATs on Toileting Hygiene**

The stroke rehabilitation pilot study indicated that TATs could effectively clean participants in the large majority of cases, showing statistically that TATs could be relied on to provide a high level of hygiene without assistance. This study, however, did not provide any comparison to standard toileting, meaning that no conclusions could be drawn on whether TATs could improve hygiene for stroke rehabilitation patients.

The geriatric rehabilitation study had participants tested for their ability to clean themselves using standard methods and using the TAT. The results show that the TAT provided at least as much cleanliness as standard toileting. When comparing the results of the geriatric and stroke rehabilitation studies, it is important to note that the difference in the two studies is not simply because one had a standard toileting condition and the other did not. In the geriatric rehabilitation study, the cleanliness scores revealed that hygiene levels were poorer when using the TAT than when TATs were used in the stroke rehabilitation study. Despite this difference, the overall levels of hygiene in the geriatric

rehabilitation study were fairly high in both the TAT and wiping conditions, which may have made differences between the two conditions difficult to detect.

Similarly to the PIADS scores, it is possible that the hygiene results were less convincing in geriatric rehabilitation than in stroke because of the greater diversity in geriatric rehabilitation. Some participants may have had greater difficulty using the TAT than others, which may have stopped them from being able to use the TAT effectively. This was illustrated through the specific, non-structured comments we received from participants after using the TAT. It is also possible that given repeated uses of the TAT, the geriatric rehabilitation participants would have shown an improvement in their ability to clean themselves. This was demonstrated by the section of the cleanliness scale in which the nurse making the assessment suggests a likely reason for the participant remaining unclean. In the TAT condition, the nurse frequently noted that the participants remained unclean because they had stopped the stream too quickly or did not operate the device properly, which suggests that given more time to learn to use the TAT, cleanliness scores may have improved.

The results concerning toileting hygiene indicate that TATs are a potential solution for rehabilitation patients who cannot clean themselves without assistance. It is important to note that in both studies, the participants were not given any assistance when cleaning themselves. With that taken into consideration, the strong positive results in stroke rehabilitation and the equal level of hygiene in geriatric rehabilitation show that it is possible for TATs to provide independent toileting hygiene.

## **6.4 Additional Conclusions**

By testing the use of TATs in rehabilitation programs, we hoped to identify features of the TAT that could be improved in order to make TATs more effective in rehabilitation. While we did not specifically collect data on individual features of the TAT, our observations of patients using the device have yielded a few recommendations on how to improve the TAT for use in geriatric rehabilitation. The first issue is

the effectiveness of the dryer, which requires that the user remain seated for a long time in order for it to completely dry them. A stronger dryer would make the device more comfortable and effective.

In order to make the TAT simpler to use and more effective, it could be worthwhile to include a function in which pressing a button to start cleaning commences a sequence that moves the stream automatically. This could allow the TAT to clean more thoroughly without making the device more complicated to control. The TAT includes manual controls that allow the user to move the stream and adjust the width, but each feature is operated by separate controls. An automated sequence would keep the device simple and reduce the possibility of user error, which could be beneficial for rehabilitation patients that have cognitive impairments, making it difficult to learn a complex set of controls, or those that would have difficulty manipulating multiple small buttons.

Through this research, we hoped to collect the opinions of healthcare professionals on the implementation of TATs in Canadian health institutions. The data collected in our stroke rehabilitation pilot study indicates that healthcare professionals believe that TATs could be an effective assistive device for improving toileting independence and hygiene. Healthcare professionals rated the TAT highly on the PIADS scale, but their scores were slightly lower than those of the patients who used the device. In general, we observed that the healthcare staff who were familiar with TATs felt that there was potential for implementation, and that the cost of the device was not unrealistic, but that there would need to be a considerable amount of data on the cost-effectiveness of TATs before health institutions would consider installing them for their patients.

In the second chapter of this thesis, a framework was presented that explored the elements that are required in order to consider a device an assistive technology (Jutai et al., 2005). This thesis demonstrates that TATs could easily be considered as legitimate assistive technologies according to the three vantages of the framework. To meet the requirements of the effectiveness vantage, it is critical

that a device improve the user's ability to care for themselves. The cleanliness data from both studies indicates that TATs can provide high levels of hygiene when toileting independently. The second vantage, societal significance, is concerned with whether a device impacts the amount of care that a patient requires, the cost-effectiveness of a device, and the extent to which a device impacts where the user is able to live. These studies do not shed light on the cost-effectiveness of TATs, but they do demonstrate that TATs could reduce burden of care by allowing users to toilet independently, which could in turn impact whether or not a patient is able to remain at home. Finally, the third vantage of subjective well-being indicates that the user of a device must feel that the device is improving their day-to-day life. The high PIADS scores in both stroke and geriatric rehabilitation show that participants felt that TATs could considerably improve their well-being along all three PIADS subscales of competence, adaptability, and self-esteem. For these reasons, it is clear that TATs can be classified as an assistive technology.

## **6.5 Limitations**

The first limitation of this thesis is the small sample size in both TAT studies. Due to the sensitive nature of toileting, recruiting participants proved to be exceptionally challenging, and many patients were reluctant to discuss toileting at all. The sample size was reduced further due to the low completion rate of both studies. For the most part, there was a low completion rate because the research staff needed to be present when a participant had a bowel movement to collect data. It is very difficult to predict when a patient will have a bowel movement, which resulted in many participants being discharged before a complete data set could be collected. In our geriatric rehabilitation study, we had hoped to have a large enough sample size that we would be able to analyze differences in the effectiveness of TATs based on the types of impairments of the participants. Our sample size was too small to do any statistical analysis of this type, but it became clear over the course of the study that the

TAT would not be a universal solution to improve toileting independence. Currently, we do not have enough information to conclude which groups would be benefited the most by TATs.

For these studies, we did not instruct the patients on how to use the more advanced controls of the TAT, such as stream position, temperature, and pressure. We did this in order to make the device simpler to use for our participants and to make sure that we were only testing features that are common in all models of TAT. It is possible that if the participants were using all of the functions available to them, they would have been able to clean themselves more effectively than standard toileting. The fact that TATs provide at least the same level of hygiene as standard toileting without using all of the TAT functions encourages the idea that TATs could be an effective assistive device to improve toileting independence.

## **6.6 Avenues for Future Research**

In order to fully accomplish the objectives of this research, a study with a much larger sample size would need to be conducted. From carrying out these pilot studies, we have learned that in order to efficiently gather enough data it would be necessary to have researchers embedded among the regular healthcare staff so that data could be collected at any time. A future study should be conducted with this methodology in order to have a higher completion rate, which would allow further conclusions to be drawn concerning which populations will benefit the most from TATs.

A critical aspect in the adoption of TATs as assistive devices is whether they will show beneficial clinical outcomes. When toileting hygiene is not adequate, it is possible that infections, skin breakdowns, and irritation can occur. If TATs can reduce the frequency of these issues, they are more likely to be adopted as assistive devices. A future study should investigate the long-term use of TATs to see whether rehabilitation patients using TATs show a lower incidence rate in health problems related to poor toileting hygiene.

Finally, there remains a lack of a standardized measurement tool to quantify toileting hygiene. A toileting cleanliness scale was created for this study, but we were unable to assess the validity of the scale through this research. A standardized tool could be beneficial to both clinicians and researchers, so a study should be carried out in order to assess the reliability and validity of our cleanliness scale, and to improve it as necessary.

## **6.7 Summary**

This thesis demonstrates that while TATs may still need some improvement before they can be fully effective, there is potential for them to be useful assistive devices for those that are unable to clean themselves independently in the bathroom. TATs have the potential to improve both the hygiene and the psychosocial well-being of rehabilitation patients. Considering the lack of assistive devices that are available to help rehabilitation patients with this personal activity of daily living, TAT research should not be abandoned. With the lessons learned from the pilot studies in this thesis, we can move forward with more robust and effective research on TATs that will firmly establish the utility of TATs as assistive devices in healthcare.

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