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TECHNOLOGICALLY-ASSISTED INTERVENTIONS IN NEUROLOGICAL AND PSYCHOLOGICAL APPLIED DISCIPLINES IN SOUTH AFRICA: A SCOPING REVIEW.

by

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Title of mini-dissertation: Technologically-Assisted Interventions in Neurological and Psychological Applied Disciplines in South Africa: A Scoping Review.

I declare that this mini-dissertation is my own original work. Where secondary material is used, this has been carefully acknowledged and referenced in accordance with the University's requirements.

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ABSTRACT

Technologically-assisted interventions are evolving modern tools in the field of healthcare that have had international success in the treatment of pervasive psychological disorders. They have also been used successfully as an adjunct to traditional medical procedures and as an aid to facilitating patient rehabilitation. Technologically-assisted interventions provide unique opportunities in the treatment of various conditions associated with numerous psychological and neurological disorders, which have resulted in improved learning experiences and social interactions. The purpose of this distinctive study was to explore the nature of primary research on technologically-assisted interventions in South Africa published between and including the years 1996 and 2021. These interventions were chosen due to their specific applications in neurology and psychology. Applications in neurorehabilitation were also investigated in the study, which are currently clinically under-utilised in South Africa. Using specific exclusion and inclusion criteria, and the PRISMA-ScR search strategy, 14 databases were used for the search. After the appropriate screening, 13 studies were included in the scoping review and five prominent trends were found to exist in the research. First, the geographic locations of the reviewed studies, which indicated that studies appeared to have been largely located in provinces with large populations and/or economic input. Second, the year of publication of the studies, which highlighted their growing accessibility. Third, the sample size and study population of the selected studies, which contextualised the range of participants observed in each study. Fourth, the modality of the technologically-assisted interventions utilised in the scoped studies, which highlighted a gap in South African literature in the neurological and psychological sciences as the bulk of readily accessible literature focused on telemedicine. Finally, the use of telemedicine as a popular modality played a significant role in the types of mHealth intervention and treatment support, where mHealth was defined within the broad terminology used to refer to improving the delivery of healthcare and services to individuals in rural and remote communities. This paper provides a novel overview of the current landscape of technologically-assisted interventions in psychological and neurological therapeutic treatments in South Africa. These findings have also been seen as crucial in understanding the limitations exsisting in the South African healthcare system context as well as avenues for further research into the ubiquitous potential of technologically-assisted interventions in this field.

Keywords: mHealth, Telemedicine, Telemonitoring, Technology-assisted interventions, Psychology, Neurology, Neurorehabilitation, Scoping review

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Chapter One: Introduction

1.1. Introduction

This research study provides a scoping review and taxonomy of technologically-assisted interventions utilised for treatment and neurorehabilitation in the neurological and psychological applied disciplines in the South African context. Chapter One provides an overview of background information relevant to this research topic, the research problem, and the research aim and objectives. This chapter will also outline the subsequent chapters making up the structure of the mini-dissertation.

1.2. Overview and Problem Statement

Technologically-assisted interventions are evolving technological tools in the field of healthcare that have had international success in treating both neurological and psychological patient cohorts (Wiederhold & Bouchard, 2014). These interventions have been utilised as an adjunct to traditional pharmacological and therapeutic procedures (Thurner et al., 2020) and employed as an aid in facilitating patient rehabilitation (Howard, 2017). Studies have indicated that these interventions provide unique opportunities to treat various conditions associated with numerous psychological and neurological disorders, resulting in improved outcomes (Botella et al., 2017; North & North, 2017; Parsons & Cobb, 2011). The popularity of the use of technology in applied neurosciences has also been noted in recent years, with progress in neurorehabilitation being seen as a significant area of interest (D'Cunha et al., 2019; Salisbury et al., 2016).

While research into the use of technologically-assisted interventions, in particular, has shown much promise internationally, and certain medical fields have begun to utilise it intensively, the extensive utilisation of this technology is limited in the South African context (Bohil et al., 2011). Owing to the dearth of awareness regarding published research into these interventions, the disconnect between internationally accepted evidence of success, and utilisation in the South African context, has resulted in this intervention being seldom applied in the South African mental healthcare sector (Liebenberg, 2021). Consequently, this study intends to contribute to the field by undertaking a bibliometric review on the uses of technologically-assisted interventions in the South African context, specifically neurological and psychological applied disciplines. The ultimate purpose is to develop a taxonomy of these findings and a useful heuristic tool for technologically-assisted interventions research and its applications in the neurological and psychological sciences.

1.3. Justification and Significance of Research

The only South African nationally representative study on the prevalence of common mental disorders in South Africa found that 30.3% (over 17 million individuals) of the nation's population presented with a lifetime mental condition (Tromp et al., 2014). This study demonstrated that over 75% of these individuals have limited access to treatment, and those who do receive treatment often face an overburdened and understaffed healthcare system. Furthermore, the limited neurorehabilitation programs currently offered through the South African healthcare system have made it axiomatic that a more comprehensive consensus is needed regarding efficacious treatments for neurological disorders (Durojaye & Agaba, 2018). The challenges in the traditional delivery of healthcare in resource-constrained contexts substantiate the investigation into the uses of technologically-assisted interventions in the neurological and psychological disciplines for treatment and neurorehabilitation (Franz et al., 2017; Pillay, 2019; Tromp et al., 2014).

Technologically-assisted interventions offer enhanced accessibility, flexibility, and efficacy, having had international success in the treatment/neurorehabilitation of various neurological and psychological disorders (Opriş et al., 2012; Zhang et al., 2017). Moreover, studies have shown a mutualistic relationship between what technologically-assisted interventions offer, to both administrator and user, with both parties experiencing increased treatment longevity (De Ribaupierre et al., 2014; North & North, 2017; Pillai & Mathew, 2019).

In South Africa, not only are novel treatment methods to address the limitations mentioned above necessary, the current coronavirus (COVID-19) pandemic climate has further prompted the use of interventions which require minimal physical contact (Bokolo, 2021; Madigan et al., 2021).

1.4. Research Question

A meta-analysis by Franz et al. (2017) indicated that while there are many proposed strategies for interventions in individuals diagnosed with neurological and psychological disorders, a paucity of accessible literature with empirical evidence on efficacious treatment methods has resulted in dysfunctions and core deficits being treated in various ways with differing rates of success. Technologically-assisted interventions have been proposed as a viable biopsychosocial, evidence-based practise in healthcare to provide efficacious treatment solutions in resource-limited environments. This study therefore aimed to explore, collect, synthesise and discuss what research can be found in South African literature regarding technologically-assisted interventions. As such, the research question posed in this work is: what published literature is readily accessible concerning technologically-assisted interventions in South African neurological and psychological sciences?

1.5. Research Aims and Objectives

This study aims to provide a scoping literature review and taxonomy of technologically-assisted interventions utilised for treatment and neurorehabilitation in the neurological and psychological disciplines. The first objective is to briefly summarise the publication patterns and studies into technologically-assisted interventions in the South African context. The second objective is to record the studies of technologically-assisted interventions analytically, employing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: Extension for Scoping Reviews (PRISMA-ScR) statement's protocol for comprehensive research collection, appraisal and synthesis (Tricco et al., 2018). The final objective is to identify and discuss the applications of technologically-assisted interventions in the South African context.

1.6. Methodology of Current Research

Scoping reviews have demonstrated their nascent value in synthesizing topics that have not yet been extensively reviewed by providing a mapping of bodies of literature and identifying gaps in the literature to inform further research plans or policies, especially in healthcare (Arksey & O'Malley, 2005; Davis et al., 2009; Levac et al., 2010). As such, this researcher harnessed the scoping review methodology in accordance with the Joanna Briggs Institute's guidelines for scoping reviews to complete this body of work. The five-step scoping review framework includes: (i) identifying the research question, (ii) identifying relevant studies, (iii) selecting eligible studies, (iv) charting the data, and (v) collating, summarising and reporting the results (Arksey & O'Malley, 2005). The study focused on published research between 1996 and 2021 (25 years), specifically focusing on studies utilising technologically-assisted interventions in the neurological and psychological sciences within the South African context. Studies were therefore excluded if they were not conducted in South Africa, not published in the English language and did not have a focus on technologically-assisted interventions. A peer rater was included in the appraisal and inclusion process to enhance methodological rigour.

1.7. Definitions of Key Terminology

1.7.1. Telemedicine

Telemedicine is a term often interchanged with eHealth, mHealth, digital health or digital medicine and can be defined as a technological mode of healthcare delivery to individuals in remote locations (Rooij & Marsh, 2016; Sjöström et al., 2014). Additionally, telemedicine software, a term commonly interchanged with virtual software, is defined as the leveraging of computer programs whilst harnessing telemedicine interventions to contribute to the health field (Kaminski, 2020; Nitsch et al., 2016; Vidal-Alaball et al., 2020).

1.7.2. Telemonitoring

Telemonitoring in this research is defined as using technological devices to monitor health-related issues as part of the healthcare treatment plan regimen (Andreão et al., 2018; Lam & Fresco, 2015; Lang et al., 2021). This mode of intervention delivery was seen as an improved form of person-centred telemedicine, extended to treating chronic physiological and psychological illnesses (Granja et al., 2018; Jones et al., 2014).

1.7.3. The neurological sciences

According to Parsons (2015), the neurological sciences can be defined as the scientific study of the central nervous system (CNS) as far as it is associated with the neural connections in the human body. This was specifically reviewed in its application within the South African context.

1.7.4. The psychological sciences

This research has defined the psychological sciences as a field of brain studies which investigates the aetiology, treatment and developments in human perception, cognition, behaviour and emotion (Sue et al., 2015). This was also specifically reviewed in its application within the South African context.

1.7.5. Neurorehabilitation

Neurorehabilitation specifically represents programs designed to assist individuals in regaining optimal cognitive, emotional and physical functioning levels following brain extrinsic or intrinsic injuries, infections, diseases, disorders or structural brain impairments (Oña et al., 2018). Types of immersive brain-body interfaces derived from advanced technology to enhance the efficacy of treatment for mental health and neurorehabilitation will also be explored in the following chapter.

1.8. Structure of the Dissertation

This mini-dissertation will be divided into the following chapters:

- **Chapter Two: Literature Review**. This chapter examines the extensive literature on technologically-assisted interventions in the neurological and psychological applied sciences in the South African context. This chapter also defines and conceptualises the relevant neuropsychological and neurorehabilitation domains.
- **Chapter Three: Methodology**. This chapter provides an in-depth description of the research design and methodology used during this study and presents the process and steps taken during the scoping review.
- **Chapter Four: Results**. This chapter presents a summary of the findings obtained after the scoping review. This chapter also includes a discussion on the five prominent trends found in the research and the key outcomes of this research.
- **Chapter Five: Discussion and Conclusion**. This chapter integrates and discusses the findings from this research study concerning both the literature and the contextual background of the participants. The findings were discussed with the overall aim of the research in mind. The limitations of the study, and recommendations for future research, are also outlined.

Chapter 2: Literature Review

2.1. Introduction

This review chapter begins with defining key terms followed by an overview of technologically-assisted interventions, specifically in mental healthcare. The history of the development of technologically-assisted interventions in the neurological and psychological applied disciplines is then highlighted, together with literature on the current utilisation of various technology-assisted interventions in neurorehabilitation. The chapter concludes with an overview of the current state of knowledge regarding these interventions in the South African context.

2.2. Key Terms for Technologically-assisted Interventions in Healthcare

Technologically-assisted interventions dynamically employ technological devices or processes to provide treatment based on evidence-based practices (Holmes et al., 2019). The origins of technologically-assisted interventions in healthcare can be seen dating to the 1920s when the term eHealth was invented to group all healthcare-related activities that utilised technology to reduce costs and increase efficiency in medical diagnosis and treatment (Rooij & Marsh, 2016). Technologically-assisted interventions utilise telemedicine and telemedicine software, which serve as delivery systems for remote/virtual neurological and mental health treatment.

Telemedicine is a term often interchanged with eHealth, mHealth, digital health or digital medicine; and specifically refers to improving the delivery of healthcare and services to individuals in rural and remote communities (Rooij & Marsh, 2016). Telemedicine, therefore, enhances accessibility to technologically-assisted interventions, particularly for individuals who cannot access these services through conventional methods. Early examples of telemedicine's utility were documented in 1929 and 1942 when distance-based consultations in Australia were delivered using morse-code and pharmaceutical-focused interventions in remote Canadian locations (Kuzel et al., 2012; Terry et al., 2014). Since 1991, the healthcare field has collaborated with computer science researchers to move patient files into automated systems in the form of electronic medical or health records (Sjöström et al., 2014).

Telemedicine software, a term commonly interchanged with virtual software, has coalesced the successes of information and communication technology (ICT), as well as video software such as Google Duo, Zoom and Microsoft Teams, to leverage its contribution to the health field (Kaminski, 2020). Historical advances in telemedicine software for clinical patient care have potentially decreased clinical assessment time, reduced the movement of unwell individuals, informed the public of health concerns and precautionary measures as well as saved costs in the sanitisation of health equipment and facilities (Vidal-Alaball et al., 2020). Additionally, in an iterative engagement and usability study for telemedicine software for individuals with eating disorders, Nitsch et al. (2016) showed that when interactive and usability features for telemedicine interventions were piloted prior to program launch, motivation and adherence to these interventions also increased. The primary focus of telemedicine software in this review will discuss its applications in telemonitoring. This refers to the patient's ability to monitor and potentially influence their health from home or remote locations.

It is important to note that, over the past two decades, the internet has rapidly increased its contribution to online/virtual psychological and neuro-rehabilitative interventions. This has seen telemedicine software expand into areas such as online learning environments and telemonitoring in healthcare. This method of technologically-based education delivery has most recently been given high priority in education programs (Carrillo & Flores, 2020; Tadesse & Muluye, 2020). The unexpected emergence of the requirement to provide all levels of the curriculum with maximum social distance has subsequently led to great strides in the employment of technology in everyday use (Bokolo, 2021). As such, whilst educational studies directed at alleviating psychological disorders or neurocognitive impairments will be included in this review, the use of technology in the educational system will not be the focus of this research. This is to streamline this study, which focuses on using these interventions in the psychological and neurological applied sciences rather than in the broader societal scope.

2.2.1. Overview of Telemedicine

Efficacious use of telemedicine is commensurate with its ability to address the needs of the intended patient, assess its role in the experiential reality of the health user's treatment plan, train individuals in telemonitoring and improve the overall cost and resource management in emergency care (Davis et al., 2016; Shokri & Lighthall, 2020). For example, Davis et al. (2016) found that in their paediatric obese patient groups, telemedicine effectively delivered family-based behavioural interventions in rural communities. This form of healthcare delivery resulted in positive health behaviours, high satisfaction ratings and low treatment attrition.

In Shokri and Lighthall's (2020) study on the implications of telemedicine in facial plastic surgery in the era of the COVID-19 pandemic, they found that, whilst telemedicine software and its various functions are not intended to replace human interaction, the use of this software has resulted in a minimisation of adverse implications of physical contact such as unnecessary risk of exposure. These valuable contributions have been promogulated by the coronavirus (COVID-19) pandemic climate, in which modern advances in telemedicine software have contributed to the decrease in the spread of the disease, increased public knowledge of current statistical information and evidence-based preventative measures (Bokolo, 2021; Hofman & Madhi, 2020). Furthermore, Shokri and Lighthall (2020) found that in light of high quarantine circumstances such as the recent COVID-19 restrictions, telemedicine is a tool with wide-ranging benefits. Specifically for post-operative healthcare users, telemedicine decreases the risk of infection exposure. It allows for redistributing urgently needed resources where in-person consultations can be reserved for emergency appointments and operations.

According to Granja et al. (2018), telephonically-delivered telemedicine is predominantly used to increase the access and equity of healthcare services to individuals who may otherwise be unable to afford these health services. Web-based interfaces allow access and updating of one's medical information. This easy mode of communication has brought many benefits and drawbacks for providers and patients alike. On the one hand, healthcare services are easily promoted and reviewed online, increasing patient knowledge of reliable services in their area and allowing even small or specialised healthcare users to advertise their services. On the other hand, however, much misinformation has been posted online, and patients prone to researching symptoms before arranging doctor consultations have become susceptible to overwhelmingly inaccurate information (Shirzadfar & Lotfi, 2017).

Currently, telemedicine is used in the field of mental healthcare in two primary forms: telephonically and through the use of the internet such as consultations on virtual platforms (Karamachoski & Gavrilovska, 2019; Shirzadfar & Lotfi, 2017). Davis et al. (2013) and Davis et al. (2016) demonstrated the value of these interventions in rural communities through outcomes of randomised controlled trial studies treating paediatric obesity. These studies highlighted increased patient satisfaction when treatment for children in rural areas was delivered through telemedicine and/or a telephone to deliver multidisciplinary weekly group interventions. Benefits of this research also included treatment applicability in these areas. Traditionally, mental healthcare treatment in remote areas has proven difficult to scale and apply to a large number of families who may not have access to adequate financial resources. Value of this research was therefore found in these interventions increasing the recipients overall experience of otherwise unencountered strategies (Duncan et al., 2014).

2.2.2. Overview of Telemonitoring

The evolution of smartphones and smartwatches is amongst the most recognisable in terms of fast and efficient technological devices. Most have also developed and enabled health monitoring capabilities (Andreão et al., 2018). Leveraging this mode of healthcare delivery has added appeal, particularly in the self-management of treatment, due to its time efficiency and accuracy in detecting health-related issues. Telemonitoring health devices have increased in diversity, applicability and specificity, with various platforms offering differing healthcare evaluations. In their study of health-related quality of life in elderly, multimorbid individuals using a telemonitoring application, Lang et al. (2021) found that telemonitoring improved the mental health component of treatment. This study highlighted how the efficacious utilisation of telemedicine to treat psychological disorders was linked to higher perceived mental health-related quality of life.

Moreover, the telemonitoring of vital signs such as pulse and respiration rates, body temperature and blood pressure has become a useful method of tracking the improvement or deterioration of the health of individuals with chronic diseases such as diabetes (Pal et al., 2013). This has been key in improving self-agency and, therefore, patient treatment adherence. In a study by Boaz et al. (2009) of insulin-treated patients with diabetes, the highlighted findings included the lack of demonstrable increases in treatment competency where medical devices were used to monitor biological outcomes. Despite this, they showed gains in overall patient well-being and agency regarding their health management, indicating an alternative form of treatment success. This finding is important, as commitment to treatment and intervention goals is a primary determinant of desired outcomes in healthcare management (Lam & Fresco, 2015).

The efficacy of telemonitoring in the commitment to treatment and intervention goals has recently been extended to chronic psychological disorders with physiological presenting symptoms (Jones et al., 2014). According to a systematic review by Granja et al. (2018) on factors determining the success and failure of eHealth interventions, patients with psychological disorders and physiological presentations were aided by telemonitoring. This mode of intervention delivery was seen as a form of improved person-centred care, resulting in positive outcomes of eHealth interventions.

2.3. The Neurological and Psychological Applied Sciences

Defining and refining the key terms related to the scope of health sciences investigated in this study is an important step in gaining a proficient understanding of the technologically-assisted interventions employed in the neurological and psychological applied sciences. Neurological sciences, or neuroscience, refers to the scientific study of the central nervous system (CNS) as far as it is associated with the neural connections in the human body (Parsons, 2015). This review includes a discussion on technology-assisted interventions used in neurorehabilitation following brain injury/disease. Psychological sciences is a field of brain studies which investigates the aetiology, treatment and developments in human perception, cognition, behaviour and emotion (Sue et al., 2015). For the purpose of this study, the literature review focuses on technologically-assisted interventions utilised in mental healthcare across a diverse nomenclature of psychological disorders within the psychological and neurological sciences as well as neurorehabilitation.

2.3.1. Overview of (neuro)-rehabilitation in the neurological sciences

Neurorehabilitation specifically represents programs designed to assist individuals in regaining optimal cognitive, emotional and physical functioning levels following brain injuries, infections, diseases, disorders or structural brain impairments (Oña et al., 2018). The function of neuropsychological assessments is to assess the extent of cognitive damage in injuries. According to Silverberg and Millis (2009), these neuropsychological tests determine, firstly, whether the patient's cognitive damage can immediately or in due course be returned to premorbid functioning capabilities, and secondly, the extent to which these injuries affect activities of daily living (ADLs). The aetiological circumstances of and risk factors for these neurological injuries may be extrinsic (environmentally acquired) or intrinsic (neurodegenerative or biomedically acquired) in nature (Ferguson & Son, 2011).

The most disabling type of extrinsic neurological trauma, with the highest injury-related productivity loss, is a traumatic brain injury (TBI), closely followed by complications due to a stroke (Hon et al., 2019). A TBI refers to a local or diffuse externally-exacted injury to the brain, which results in long-term emotional, cognitive and/or physical difficulties (Lippa et al., 2021). Neurological disorders, or intrinsic neurological trauma, constitute one of the most widespread clinical conditions, with cerebral-vascular disease and spinal cord injury accounting for up to 3.5% of the world population and over a billion people with adult-onset disabilities (World Health Organization [WHO], 2017). Aside from the severity of the injury, patient sociodemographic factors influence the outcome of all neuropsychological treatments, including the patient's age, health, gender, socioeconomic status, and educational and employment level (Lippa et al., 2021). As such, connecting neurological injuries and traumas to the emotional and behavioural sequelae of the patient is often a varied and complex undertaking, resulting in expansive treatment considerations.

As a health treatment strategy, rehabilitation seeks to maintain efficient functioning in individuals experiencing or likely to experience problems with their health and/or disability conditions. Neurological rehabilitation or neurorehabilitation, therefore, encompasses all holistic treatments and therapeutic approaches designed to improve an individual's overall well-being. This aims to enhance functioning in society, regardless of whether the patient makes a partial or complete neurological recovery (Reinkensmeyer & Dietz, 2016).

Stien and Kendall (2014) express that the developing brain is especially susceptible to long-term psychological trauma when faced with acquired brain injuries. These may range from mood-related disorders to factors which contribute to personality configuration. In a study on effective treatments of chronic mild traumatic brain injury, patients with neurologically-based injuries presented with acute or chronic clinical disorders which adversely influenced health-related quality of life (Azulay et al., 2013). Given the intricacy of the difficulties which arise from neurological complications, the consensus amongst medical professionals favours the use of an interdisciplinary approach to treating such patients as opposed to a homogenous model (Miller et al., 2010). The interdisciplinary team comprises various healthcare workers who focus on different aspects of the patient's social experiences to manage the rehabilitation cycle. According to Oña et al. (2018), the rehabilitation cycle consists of four distinct stages: assessment, assignment, interventions, and evaluation.

The assessment stage highlights the data-gathering phase of treatment, during which diagnosis and prognosis are considered by identifying the patient's problems and needs. Personal histories are explored in-depth and collateral sources are questioned to ascertain the aetiological foundations for the presenting problem(s) (Duncan, 2013). During this stage, it is the impairments in the physical and cognitive capacity of the patient, the quality of activity whilst performing various tasks, and the degree of the patient's participation in treatment planning that are determined using specific neuropsychological assessments and therapeutic evaluations (Oña et al., 2018). The assignment stage entails identifying and attributing the patient's problems to precipitating and perpetuating factors limiting the patient's overall experiential well-being. These modifiable factors contribute to developing a treatment plan and involve the interdisciplinary team and patient in the planning process (Oberholzer & Müri, 2019; Reinkensmeyer & Dietz, 2016). This specific solution-focused treatment plan uses well-defined objectives to assist the patient in addressing the diagnosis such that they become increasingly functional and socially independent.

The intervention stage then entails the planning, implementation and coordination of various techniques aimed at addressing the objectives of the treatment plan. The interdisciplinary team members play a crucial role in communicating with each other and communicating with the patient the indicators of progress and how this meets the identified problem areas (Pomeroy et al., 2011). Reasonably expected daily activities are also designed to practice tasks relevant to the patient's environment physically. Finally, in the evaluation stage, the patient's discharge conditions are continuously re-evaluated against the expected outcomes of the treatment plan. The following parameters are therefore taken into account when possible: the vicissitudes of the pathology in terms of the disorder's nature and chronicity, the expected advancing and degenerative course of some neurological disorders, as well as the patient's self-perceptions of the course of the treatment and their possible dependence on assistance for continued rehabilitation (Doig et al., 2009; Oña et al., 2018).

Neurorehabilitation studies have been advanced by research into the processes which guide recovery treatments following neurological injuries (Gorgey, 2018). The current study focuses on literature highlighting relevant technology-assisted interventions and rehabilitation strategies used in the neurological sciences. According to Iandolo et al. (2019), flexibility in treatment intervention gives technologically-assisted interventions in neurorehabilitation a marked advantage over other treatment delivery methods. As these novel approaches are combined with traditional rehabilitation techniques, recovery is reported to improve significantly because of this flexibility. For example, Calabrò et al. (2016) and Cheung et al. (2017) have shown how assistive technological devices have been utilised in spinal cord injury rehabilitation for patients with functional loss in movement, which resulted in diminished independence. In these cases, robotic-controlled gait training was seen to enhance the quality and functionality of walking. Robotics as a type of technologically-assisted intervention in neurorehabilitation is discussed in a later section in this chapter.

An important area of research to further the field of neurorehabilitation in the neurological sciences is the optimal conditions for developing neurorehabilitation technologies. When discussing the perspectives and challenges of robotic neurorehabilitation, Iandolo et al. (2019) described how the healthy functioning of the central nervous system (CNS) post-intervention is a critical treatment outcome. Furthermore, where brain-computer interfaces have been employed, results have suggested unexpected beneficial impacts on cortical processes and improved patient quality of life. As such, evaluating brain regions involved during robotic guidance training may also contribute significantly to a deeper understanding of the impact of different rehabilitative strategies on the central nervous system (Bested et al., 2019).

Furthermore, Gassert and Dietz (2018) described how changes in neural plasticity were gleaned through insights into sensorimotor functions and their effects on independent movements. As such, boosting patient recovery was achieved through detailed quantifications of neural activity and behavioural performance before, during and after neurorehabilitation interventions. This has further extended the customizability of technologically-assisted interventions in neurorehabilitation.

Various factors have thus contributed to the nascent value of utilising technologically-assisted interventions in neurorehabilitation. These include ease of modulation, a normed training environment and adjustable support while decreasing the strain on the therapist. In a study on technologically-assisted interventions in neurorehabilitation, Semprini et al. (2018) showed how these interventions, and associated advantageous factors, propose that the benefits of technologically-assisted approaches to neurorehabilitation may have superiority over traditional approaches regarding treatment recovery time. Through the investigation of various technological approaches for neurorehabilitation, the study further demonstrated that personalised treatment, where technologically-assisted devices complemented standard biomarkers, resulted in positive treatment outcomes.

2.3.2. Overview of mental health in the psychological sciences

Based on evidence-based practices, mental health interventions that dynamically employ technological devices or processes to provide treatment are also known as technologically-assisted eHealth or mHealth interventions or telemedicine (Holmes et al., 2019). In treating psychological disorders such as depression, substance abuse and mood-related disorders, interventions directly using or facilitated by technological devices such as mobile phones and virtual platforms have shown increased mood gains and patient agency (Comer et al., 2017; Donley et al., 2017). This suggests that technologically-assisted interventions in mental healthcare may improve patient experiences in treating psychological disorders.

In a case report by Paul et al. (2020) investigating the efficacy of using virtual reality as an intervention for Major Depressive Disorder, results showed a significant impact on mood ratings. Within a month, participants reported reduced depressive symptoms, so much so that they were re-classified from moderate to mild depression. They also reported that they experienced the intervention as feasible, acceptable, and tolerable. Furthermore, according to a study by Migoya-Borja et al. (2020) examining the feasibility of a virtual reality-based psychoeducation tool for depressive patients, this intervention resulted in significant gains in patient satisfaction, cooperative therapeutic alliance and treatment. These findings are key components of medication adherence influencing clinical goals and patient care.

Interventions which purport a direct positive impact on patient mental health can also take the form of psychoeducation and online/virtual therapeutic techniques, with web-based learning or e-learning taking the form of asynchronous or synchronous delivery methods. Psychoeducation has also been used to train health professionals and patient support structures. In a study by Donley et al. (2017) of a telepsychiatry trial in a public hospital emergency department, researchers found that telepsychiatry was experienced as increasing feasibility and satisfaction for the long-term patient and staff experience. It was reported that this method of psychoeducation was not only a significant timesaver but also improved communication of follow-up appointments resulting in a greater perceived alignment in the overall mental health treatment regimen and goals.

According to North and North (2017), healthcare providers such as hospital and emergency unit personnel benefit from e-learning. These benefits are reported to increase confidence, perseverance, critical thinking, and data collection and analysis when delivering interventions. Whilst the use of technologically-assisted interventions such as tele-mental health should not be considered a panacea for all psychological and/or neurological disorders, a scoping review will allow for a contextual exploration of the hybridisation and use of technologically-assisted interventions in the context of psychological treatment and neurorehabilitation. The utility of the taxonomical heuristic tool then provided by this review will enable readers to briefly gauge publication patterns and studies in the South African context, which can potentially be used to inform further evidence-based practices in this field.

As outlined in this study, technologically-assisted interventions are currently an umbrella term which includes various modes of intervention such as eHealth, telemedicine, virtual therapy, web-based interfaces, mHealth, robotics, and neurofeedback. Technologically-assisted interventions have been designed to improve the efficacy and application of biopsychosocial healthcare delivery. Additionally, tele-mental health interventions have shown promising treatment outcomes in externalised psychological disorders, such as attention deficit hyperactivity disorder (Comer et al., 2017; Olsen et al., 2016), anxiety (Wiederhold & Bouchard, 2014), trauma and stress-related disorders (Jones et al., 2014), as well as internalized psychological disorders such as depression and pathologised eating habits (Duncan et al., 2014).

2.4. Types of Technologically-assisted Interventions used in Mental Health Care and Neurorehabilitation.

This section explores the main types of technologically-assisted interventions used in mental health care and neurorehabilitation. The following technologically-assisted interventions utilise immersive brain-body interfaces and highlight modern interventions that derive from advanced technology to enhance the efficacy of treatment for mental health and neurorehabilitation. Exploring these interventions will briefly include their influences on patient treatment and recovery outcomes, which affect their psychological well-being.

2.4.1. Robotics

The efficacy of the use of robotics for neurorehabilitation is well-established. It is no longer a question of whether it can be used but rather with whom and for which range of neurological concerns (Masiero et al., 2014). Robotics for rehabilitation has been used in rehabilitative exercises to enhance the neuro-motor engagement of limbs in the upper and lower extremities, which have lost their function (Iosa et al., 2016). The various machine devices are typically grouped into endpoint robots, robotic devices with a single interaction location with the human user, or wearable robots, such as exoskeletons with multiple points of interaction with the human user (Maciejasz et al., 2014). These devices can seamlessly integrate important assessment data in the form of biokinetic sensorimotor information and reproducible results regarding treatment progress.

While there is a lack of conclusive evidence in the literature of the utility of robotics or prosthetics over traditional physical exercise as a treatment method, recent studies have defended the outcomes of robot-assisted therapy (Klamroth-Marganska et al., 2014; Mehrholz et al., 2020; Morone et al., 2017). In studies on the utilisation of robotics in training for walking for stroke patients, Mehrholz et al. (2020) and Morone et al. (2017) found that patients reported faster recovery rates and significant improvement in activities of daily living when combining robot-assisted therapy with training, as opposed to using physiotherapy alone. While older robot-assisted neurorehabilitation focused on lowering the physical efforts of repetitive movement, newer devices are more responsive and modulated to adapt in richer, more variable environments (Semprini et al., 2018). Numerous studies have also illustrated the feasibility of a shift towards evidence-based practices and real-time, precise measurements, which, when factoring in the nature of the injury and the recovery process, could become part of the basis for selecting a suitable prosthetic device for neurorehabilitation (Casadio & Sanguineti, 2012; Reinkensmeyer et al., 2016).

2.4.2. Brain stimulation

A more 'immersive' brain-body device interface used in the psychological and neurological applied sciences is exemplified in brain stimulation. The use of electrical neurostimulation to treat inveterate pain and drug-resistant post-injury complications dates back to the 1950s, with deep brain stimulation being the predominant procedure (Nardone et al., 2014). Brain stimulation refers to using electrical currents via a neuromodulation device implanted in the brain to stimulate brain areas compromised by disease or injury directly. This technology-assisted neurotherapy is used to treat medically intractable neurodegenerative motor disorders and psychiatric disorders (Chen et al., 2017). This operation is invasive and costly, with neurosurgeons being amongst the few skilled health professionals with the expertise to perform such a risky procedure.

With the advent of neuroimaging technology in the 1990s, minimally invasive treatments such as transcranial direct current stimulation (tDCS), based on laws of electromagnetism, as well as repetitive transcranial magnetic stimulation (rTMS) and transcranial electrical stimulation (tES), based on imperceptible electrical currents, have become preferred methods of exciting neuronal activity (Polanía et al., 2018). These minimally invasive brain stimulation techniques are applied to the scalp and harness neuromodulating devices to painlessly activate the currents in the cortex, which have been shown to correlate with specific human behaviour. Valuable applications of non-invasive brain stimulation techniques are seen in that they can be applied in short or long bursts in one or more interconnected areas in the brain whilst allowing tests of causal links between neuronal activity and contextual behaviour. However, factors such as an absence of a standardised design protocol for minimally and/or non-invasive brain stimulation studies and a lack of diverse patient populations have resulted in mixed efficacy results when testing these interventions with patients who have functional impairments due to chronic strokes (Elsner et al., 2016; Hao et al., 2013; Russo et al., 2017).

According to Nardone et al. (2014), deep brain stimulation, and other invasive procedures, such as epidural motor cortex stimulation (EMC), have been used decreasingly. While impressive for movement disorders, the results of these techniques were found to be lacking in sufficient empirically tested clinical studies investigating the treatment of psychological disorders, contributing to their diminished status as evidenced-based procedures. As such, whilst these procedures are still extensively used for motor disorders, there are still equivocal results for psychiatric/psychological disorders. Conversely, whilst some researchers consider deep brain stimulation to be highly variable, there is a body of literature which advocates for its specific use for carefully selected patients with chronic psychological and psychiatric disorders such as treatment-resistant depression and anxiety (Bewernick et al., 2010; Cassimjee et al., 2018), obsessive-compulsive disorder (Denys et al., 2010; Lozano et al., 2013) and dementia-related disorders (Aldehri et al., 2018; Hescham et al., 2013). These studies not only purport that this is an efficacious treatment approach for these identified individuals but also suggest that their nascent value may also lie in their ability to induce neuroplastic changes, which increase the regulatory functions of neuronal synaptic processes.

Previous studies have focused on their short-term benefits, specifically on adults with heightened cortical impairments. However, noteworthy regarding the rehabilitative value of minimally invasive brain stimulation is the ethical implications of long-term use of oscillating electrical currents on neural activity. According to Fitz and Reiner (2015), individuals seeking intervention for more complex, chronic neuropsychological difficulties must be advised about the patient-specific variability in outcomes and that all interference with neural activity is “minimally invasive” at best. Therefore, these researchers have cautioned that using this requires careful monitoring, especially with children whose neuro-development is still dynamic and burgeoning.

Consequently, robotics and invasive and minimally invasive brain stimulation can be examples of technologically-assisted telemedicine interventions. These interventions utilise aspects of telemedicine software and telemonitoring to improve patient satisfaction and promote the dynamism of continued neuronal healing following treatment. The sections below will include a more focused discussion of telemedicine software and telemonitoring in the neurological and psychological applied sciences.

2.4.3. Neural interfaces

Neural interfaces refer to graphic user interfaces of medical devices which mediate the communication between the brain and a machine (Semprini et al., 2018). Neural interfaces can therefore be seen as a form of telemedicine software specifically aimed towards neurorehabilitation. Modern neural interfaces are considered all brain communication interface (BCI) systems, which can detect a neuronal signal, selectively extract it, organise it within pre-determined parameters and apply an interface through which it can be interpreted (Naseer & Hong, 2015). Through the utilisation of sensitive modulation, BCI systems can transmit these brain signals to the desired device to command or control it to perform specific tasks and produce live displays of brain activity for self-regulation and neurofeedback. Other examples of neural interfaces include functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (fNIRS), electroencephalography (EEG), and magnetoencephalography (MEG) (Ferrari & Quaresima, 2012; Mellinger et al., 2007; Weiskopf et al., 2004).

Recent studies have indicated that compared to basic rehabilitation techniques alone, MEG and EEG BCI training in conjunction with standard rehabilitative treatment has achieved great motor functionality in the hands of chronic stroke patients who have lost muscle strength due to brain injury (Downey et al., 2017; Monge-Pereira et al., 2017). For example, the systematic review of 141 stroke patients by Monge-Pereira et al. (2017) emphasised that using BCI-EEG techniques promoted functional rehabilitation of upper limb movement. Cognitive recovery in the form of improved cortical synchronisation and increased activity in the motor cortex was also seen as a positive outcome of combined therapeutic approaches, validating the neuro-rehabilitative value of different BCI approaches for patients with motor and cortical impairments.

2.4.4. Neurofeedback

Neurofeedback, a specific form of electroencephalography (EEG) biofeedback, refers to the real-time measurements of the nervous system's activity in the brain. This is represented to the individual in such a way that they can monitor and adjust this biofeedback to self-regulate their neural and, ultimately, behavioural processes (Sitaram et al., 2017). Neurofeedback is therefore seen as an example of a BCI technique which has demonstrated success in treating psychological dysfunctions such as Attention-deficit/hyperactivity disorder (ADHD), cognitive disorders and stroke-related cognitive impairments (Sueyoshi & Sumiyoshi, 2018; Wang et al., 2018). The relevance of this approach to utilising neurofeedback-assisted technological devices can be seen in the MUSE application of mindfulness training. In this regard, neurofeedback is applied to address central nervous system dysregulation, which underlies chronic psychological disorders such as depression and anxiety-related disorders (Cheon et al., 2016; Larsen & Sherlin, 2013).

A prospective study by Cheon et al. (2016) on patients with major depressive disorder highlighted that regulating frontal lobe stimulation by targeting lower-frequency brain waves produced symptom improvements. Neurofeedback was seen as having additional benefits in alleviating comorbid anxiety symptoms. Neurofeedback as a form of technologically-assisted intervention can thus be used in conjunction with psychotherapies such as cognitive behavioural therapy and mindfulness therapies to train patients and alter behavioural patterns interfering with their well-being. It is, however, important to note that more studies are needed for patients suffering from more salient cognitive impairments, such as those often found resulting from TBIs (Gray, 2017). Larsen and Sherlin (2013) stated that using neurofeedback showed significant benefits in brain activity in treating psychological and neuropsychiatric disorders such as ADHD. This research outlined the positive indicators for neurofeedback, as an adjunct to medication and traditional therapies, in treating disorders with mood and other central nervous system dysregulation.

Individuals diagnosed with ADHD have difficulties regulating and maintaining appropriate brain wave activity, resulting in deteriorated attention, memory, movement control, and functioning. ADHD is, therefore, a complex disorder with various mood disorder-related comorbidities and insidious effects. Oliveira et al. (2022) demonstrated the role of neurofeedback in treating ADHD in the South African context. This research explored the experiences of six neurofeedback therapists in the province of Gauteng, treating individuals diagnosed with ADHD. Findings demonstrated how the modulation of biofeedback, as part of a multimodal approach, strengthened the therapeutic relationship resulting in improvements in symptom severity and perceptions of quality of life.

In Balt et al.'s (2020) study on the impact of infra-slow fluctuation neurofeedback training on the autonomic nervous system, peripheral biofeedback indicators were used to provide physiological markers of treatment progress. This is a key outcome of using neurofeedback as symptom reduction in anxiety and mood-related psychological disorders is not easily observed and subjectively experienced by individuals diagnosed with these disorders. According to Balt et al. (2020), this contributes towards poor treatment outcomes, such as patient compliance with medication. The lack of self-awareness regarding their recovery also has a compounding effect on patient symptoms. Consequently, the perception of lack of progress introduces additional feelings reinforcing the self-perpetuating cycle of their pre-existing condition.

Finally, Hunkin et al. (2021) investigated the application of neurofeedback in mobile applications (apps) designed to offer guidance in meditative therapies and practices. Utilising neurofeedback in the form of auditory feedback outputs, patterns of the impaired neural processes were measured and compared to expected cognitive functioning. Sounds are then simulated to elicit desired, reparative EEG neural waves whilst patients are guided through mindfulness strategies aligned with restoring cognitive optimal functioning and improving psychological outcomes such as stress. After a session, patients could view their performance and track their progress over time. Modelling the intervention's effects on the users has also expanded the reach of these applications into psychological well-being, such as increased treatment insight and self-mobility.

2.4.5. Virtual reality

Finally, a modern example of the coalescence of a technologically-assisted intervention which encapsulates telemedicine and telemonitoring in real-time can be seen in virtual reality-based healthcare interventions. A virtual reality intervention uses computer-based 3-dimensional imagery to create alternate realities that provide selected stimuli wherein an individual can receive treatment (Wiederhold & Bouchard, 2014). Virtual reality interventions utilise user-controlled VR-constructing apparatus to immerse individuals in artificially created virtual environments (VEs). This created reality gives the individual a greater opportunity to fully immerse themselves in the intervention scenarios with fewer negative health risk implications on the healthcare user compared to other invasive interventions (American Psychological Association [APA], 2019). The seminal work of Joseph Wolpe in cognitive and behavioural therapies, which focused on maladaptive cognitions and behaviour, has been extended to practical applications to virtual reality (VR) in the fields of mental and medical health (Wolpe, 1948). Behavioural approaches include traditional and interoceptive exposure therapy, which refers to introducing harmless bodily sensations to de-sensitize oneself to them, and re-imaging techniques, which have been proven unreliable and unrealistic.

Studies into communication and social skills training showed early on how behaviouristic approaches have higher levels of success than alternative treatments in individuals with psychological disorders (Guler et al., 2018; Rathod et al., 2013; Rosenstein & Seedat, 2011). In a qualitative South African study on the importance of context in early autism intervention, Guler et al. (2018) found that intensive individualised behavioural approaches focused on caregivers playing a greater role in the intervention addressing challenging contextual factors. Factors such as low income and distrust of community-based health interventions were mitigated with caregiver-mediated interventions at a low cost, yielding positive outcomes such as continued treatment utility.

VR interventions address communication impairments and social outcomes using behaviouristic approaches, while consistent environmental inputs improve interactional exchanges in real-time. Virtual environments are modified by detecting the user's senses and emotions, adjusting accordingly to provide interactive, real-time experiences of the synthetic situation (Fuchs, 2017). The probative value of VR interventions lies in their potential to provide efficacious environmental validity. Combining brain imaging techniques and collaborative therapy models offer information on spontaneous mentalization processes (Guler et al., 2018; Holyfield et al., 2017; Parsons, 2015; Wadge et al., 2019).

Furthermore, in behavioural therapies, this variation of the exposure therapy application has seen success in the treatment of individuals with phobic, social and/or anxiety disorders (Botella et al., 2017; Chesham et al., 2018; Compton et al., 2002; Fodor et al., 2018). For example, the systematic review by Botella et al. (2017) highlighted that VR technology better managed and repeated graduated exposure to anxiety-provoking events or environments. This review investigated the efficacy of virtual reality exposure therapy (VRET) for phobias in randomized controlled trials published from 2012 until the time of the study. This research found that VR applications enhanced approaches to phobias whilst reducing attrition to treatment. The use of VR technology in treating these psychological anxiety-related disorders was therefore seen to be an effective alternative, or a potential improvement, to traditional psychotherapies.

In a study on the feasibility of using VR as a technologically-assisted intervention in treating depressive patients, Migoya-Borja et al. (2020) showed how comprehension of the dynamics affecting treatment was better understood when utilising technology in treatment which allowed for increased self-efficacy and self-regulation. As technologically-assisted interventions require a basic understanding of the intervention effects and outcomes, these approaches have been seen to target user sensitivity to their own awareness of the treatment itself. In cases where technology was used to facilitate the intervention, insight was gained into how these approaches increased user enjoyment. This study, therefore, demonstrated how the application of these interventions in rehabilitation in the clinical setting has been seen to improve patient psychological outcomes, which affect treatment adherence and overall recovery.

Previously, concerns regarding the pragmatic viability of VR technology have hindered explorations of suggestions and solutions surrounding VR intervention use. One such concern is the effect of VR hardware on the VR user. According to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM–5; American Psychiatric Association [APA], 2013), consideration is required for the hyper- or hyposensitivity to sensory motor input and lack of reality awareness that individuals diagnosed with various neurological and psychological disorders may experience (APA, 2013). However, the ranges of such hardware are numerous and varied (Yang et al., 2017). Risk factors about contraindications such as cybersickness and the healthcare user believing that the VE is real should also be considered. Unfortunately, little is understood about both concerns (Parsons, 2015). However, certain techniques can be used to mitigate these risks, including questionnaires and gradual introductions to VEs.

Previously, the financial costs of technologically–assisted treatment approaches have also been a concern; however, software for specific technologically-assisted options, such as VR for social and spatial cognition, has been made free and available to clinical and novel users (Bohil et al., 2011). As a result of the increased shift towards technology in everyday use, such as tablets and iPads, as well as the user-friendliness and effective applications provided by VR technology, it is a treatment method that South African communities can benefit from greatly (Franz et al., 2017). A focus on the body of knowledge regarding available publications can be established in identifying the dissemination of literature surrounding technologically-assisted interventions. Ultimately it is a coalescence of research into these interventions which will guide this proposed study's enquiry into studies utilising technologically-assisted interventions for psychological treatment and neurorehabilitation in South Africa thus far.

2.5. Current state of knowledge in the South African context

International findings regarding the efficacious use of technologically-assisted interventions in neurorehabilitation have been illustrated in the use of various techniques to treat a wide range of neurological conditions. For example, Schneider and Biglan (2017) showed how technologically-assisted interventions may be used to treat chronic neurological disorders such as Parkinson's disease. In their study, these interventions were deemed effective when synchronous delivery methods were utilised for outpatients attending regular follow-up appointments. These interventions increased treatment access by reducing commuting time to local clinics and overall cost to patients receiving continued rehabilitation. Furthermore, in the international context, the use of technologically-assisted interventions in neurorehabilitation has been illustrated in techniques such as brain stimulation.

According to Pons et al. (2016), cortical and subcortical remapping can be achieved when utilising these techniques to harness principles of neural plasticity in neurorehabilitation. Following traumatic brain injuries (TBIs) may result in both restoring lost functioning and compliment other movement therapies. However, a study of robotic interventions in stroke injuries by Kwakkel et al. (2008) highlighted that technologically assisted versus human interventions were indistinguishable when using high-quality repetitive rehabilitation methods. International research has proliferated in the areas of technologically-assisted interventions, and study results have shown the efficacy of various technologically-assisted intervention techniques. This study aims to explore and review the South African literature on technologically-assisted interventions in the neurological and psychological sciences.

South Africa has many ecological, psychosocial and medical challenges wherein the repercussions of the state of mental healthcare on the human experience are still under study (Patel et al., 2018). In a country with 11 official languages, some inhabitants do not possess the language to describe many of the behaviours and sensations characterised by mental disorders (Pillay, 2019). Moreover, stigmas surrounding mental health and psychological disorders are often cultural challenges faced in treating and disseminating adequate support. As such, where services exist to meet such needs, they are grouped in urban areas that are onerous to access from rural communities (van der Hoeven et al., 2012). Insight into the background underpinning these environments requires further investigation into the significant contributors to the disconnect between knowledge and the application of technologically-assisted interventions and neurorehabilitation.

The first potential contributor to the under-utilisation of these interventions is the lack of trained South African healthcare professionals (Fernandes, 2020). Sectors with the resources to outsource technologically-assisted apparatus and expertise or train staff members to become efficient in its use may be perceived as clustered and producing research findings with limited scope into its full-scale applications. A study by the World Health Organization – Assessment Instrument for Mental Health Systems (WHO – AIMS) indicated that up to 20% of South African professionals immigrate to more lucrative countries within five years of having completed their training (World Health Organization [WHO], 2007). Published studies may therefore result from the capability to publish data rather than a true reflection of the efficacy of studies conducted.

According to a report by the South African Human Rights Commission and the Lancet Commission, major obstacles in the implementation of both the Mental Health Care Act of 2002 and the National Health Policy Framework and Strategic Plan, 2013 – 2020 were significantly compromised by insufficient funding (Makgoba, 2017; Patel et al., 2018). This finding directed the National Department of Health (NDOH) to mobilise various investigative teams dedicated to expanding financial avenues towards mental health services, especially in the public sector. However, these investigations have concentrated on already well-established treatment methods and issues addressing communication within various healthcare departments. As such, it is unsurprising that convincing policymakers to allocate funding towards research into technologically-assisted interventions is a significant challenge faced by healthcare professionals (Pillay, 2019). These interventions in the South African context are heavily dependent on easily accessible knowledge and its brief, solution-focused applications with less emphasis seen in much-needed research-driven practices (Govender, 2017).

Noteworthy is also South Africa's quadrupled burden of disease (Hofman & Madhi, 2020). According to Hofman and Madhi (2020), this is characterised by (1) increased chronic diseases, (2) maintenance of poverty-related and infectious diseases such as HIV and tuberculosis (TB) with obesity, (3) non-communicable diseases and (4) patterns of child and maternal mortality, which include injury and violence. Distinct effects of this burden are seen in many health-related outcomes, directly influenced by inequitable resource distribution and interactions with available services. Therefore, solutions in health science sectors must be geared towards ease of use, accessibility and evidence-based practice, not to marginalise impoverished groups further.

Finally, as highlighted by South African President Cyril Ramaphosa's State of the Nation address in 2019, the fourth industrial revolution (4IR) has brought with it pressures and shifts in operations within many sectors which are yet to be developed in the South African context (Ramaphosa, 2019). The fourth industrial revolution refers to the increased shared activity and amalgamation of various technological fields with the biological and physical ambits of whole societies (Schwab, 2017). The South African government has accentuated its keen interest in bettering its position in the global market to take advantage of these technologies. According to Cunningham (2018), virtual and augmented realities and neurotechnology are technologies promoted by 4IR, positioning studies into their efficacious utilisation as potential areas for research and development.

Noteworthy is South Africa's contributions to technologically-assisted interventions in healthcare. While the extent of the body of this knowledge is to be reviewed in the current scoping review, a critical review on the efficacy of VR in the clinical psychology context has been conducted by Liebenberg (2021), who demonstrated its international prominence whilst highlighting the gap in South African literature for its use in psychotherapy. The study emphasized the paucity of research in VRET in the South African context and the areas in which these studies may be beneficial, such as low-cost healthcare and improved promotion of patient treatment independence.

Conversely, there are published studies highlighting developments in the various types of technologically-assisted interventions used in mental health care, and neurorehabilitation has at times been pioneered in South Africa. For example, South Africa has successfully utilised robot-assisted systems to perform delicate surgical procedures in robotics. In 2014 the Urology Hospital in Pretoria was the first to offer robotic surgery for prostatectomy, whilst the first robotic-arm knee replacement surgery was performed in Linksfield Hospital in Johannesburg in 2019 (Mahomed, 2020; Sihlangu, 2019). Gaps in robotics have also been explored in assistive technologically-assisted systems to enhance early detection and diagnosis of common ailments such as diabetes in healthcare (Sehume & Markus, 2020).

In a South African guideline on Parkinson's disease, Anderson et al. (2017) demonstrated the psychological implications of deep brain stimulation. This study highlighted that this approach to therapy resulted in reduced symptoms and overall costs in medicinal aftercare. Furthermore, longitudinal studies have shown how brain stimulation has been successfully explored to treat mood-related disorders in South Africa (Cassimjee et al., 2018). According to Verkijika and De Wet (2015), neural interfaces and neurofeedback have also been successfully applicable in South African education, where BCIs were utilised to address and reduce anxiety.

In the SA context, seminal studies into communication and social skills training showed early on how behaviouristic approaches have higher levels of success than alternative treatments in children diagnosed with Autism Spectrum Disorder (Silver, 1970). According to Wiederhold and Bouchard (2014), the advantages of VRET, as opposed to other applications of exposure therapy, include the utilisation of more senses to experience the simulated situations. Furthermore, in behavioural therapies, this variation of the exposure therapy application has seen success in the treatment of individuals with phobic, social and/or anxiety disorders, where graduated exposure to anxiety-provoking events or environments is better managed and repeated by VR technology (Maples-Keller et al., 2017; Wiederhold & Bouchard, 2014).

Published studies in South Africa regarding the rehabilitative nature of technologically-assisted interventions have thus far predominantly focused on the technology readiness of elderly patients, with special interests being on the impacts of these interventions on those with various forms of cognitive decline or impairments in effective communication (Chipps & Jarvis, 2017; Hoffman et al., 2019). It is, therefore, imperative to not only consolidate this understanding but also to provide through a scoping review a structured, accessible catalogue of the evidence-based uses of these interventions and the populations which have benefitted from them. As such, the emphasis of this review is to discuss relevant literature and create a platform to scope South African research in this field, highlighting what it may possibly yield in terms of knowledge and application. The result of this scope and collation of all research available within the study parameters may thus benefit future research on varying demographics. In this way, many additional groups of patients may benefit from concerted advances in the knowledge of the applications and interventions available.

2.6. Conclusion

For this scoping review, technologically-assisted interventions focus on telemedicine/web-based virtual therapy and the more 'immersive' brain-body device interfaces used in the psychological and neurological applied sciences. The development of technologically-assisted interventions has established itself as a viable biopsychosocial healthcare method for evidence-based eHealth treatments for patients requiring neurorehabilitation following brain injury/disease and for patients diagnosed with psychological disorders (Contreras-Vidal et al., 2016; Rooij & Marsh, 2016). Historically, eHealth treatments have significantly impacted patients' perceptions of their treatment plans and the success of treatment outcomes compared to conventional interventions (Jones et al., 2014). The coalescence of advances in technologically-assisted interventions has resulted in increased solution-orientated, cost-effective treatment plans, which have been found to increase patients' overall well-being and satisfaction towards their healthcare management.

This chapter has highlighted how advances in technologically-assisted interventions used in the neurorehabilitative and psychological processes improved patient ADLs when using robotics, brain stimulation, neural interfaces, neurofeedback and virtual reality as a mode for therapeutic administration. It is important for future research that evidence-based research outcomes in the psychological and neurological sciences are reviewed to provide a context which South African researchers can utilise in the studies of the use of technologically assisted interventions in South Africa. This review, therefore, aims to provide researchers with a body of collated knowledge on which future research can be built to better serve patients of varying demographics and socioeconomic statuses who are likely to benefit from novel interventions. The following chapter outlines the methodology utilised in this study.

Chapter 3: Research Methodology

3.1. Introduction

This chapter outlines the research methodology utilised for this study. The chapter begins by exploring the definition and value of scoping reviews. The research aims, and objectives are briefly revisited, followed by the search design employed for this scoping review, after which the search strategy is delineated. In order to enhance the efficacy and repeatability of the research, the selection procedure, data extraction, quality assessment and synthesis are then highlighted. The chapter concludes with ethical considerations.

3.2. Research Design

3.2.1. Scoping reviews

The Joanna Briggs Institute (JBI) first published a frame for scoping reviews in 2005 in an attempt to clearly distinguish this method of research synthesis from other traditional forms, such as systematic reviews (Peters, Godfrey, Khalil, et al., 2015). Where traditional systematic reviews attempt to answer a particular research question based on a specific condition or intervention and assess the quality of studies utilised, scoping reviews of literature focus on the breadth and depth of a research area. Unique to scoping reviews is the utilisation of broad search methods to investigate developing areas of research and identify gaps in which further research can be embarked (Levac et al., 2010; Peters MDJ et al., 2020).

Scoping reviews explore various research studies, which may have used differing viewpoints, mapping existing gaps in knowledge (Piškur et al., 2012). Consequently, reviews often do not follow the strict traditional strategies of qualitative, quantitative or mixed methods frameworks that speak directly to research data's synthesis and analysis procedures. Rather, they prefer to use specific procedures to converge on the degree of method synthesis (Gough et al., 2017; Peters, Godfrey, Khalil, et al., 2015). Furthermore, the review itself may not meet the criteria of any framework for disseminating and discussing its findings and conclusions. As such, rather than state an epistemological point of departure, this research utilised a configurative approach in analysing and organising appropriate data to describe the extent of its synthesis mode (Gough et al., 2017). Therefore, the advantages of scoping reviews purport to provide a transparent lens through which the reader can readily evaluate clear insights into the degree, scope, and purpose of research pursuits in a particular research area (Garg et al., 2008).

The recommended methodology of scoping reviews follows the JBI guidelines for scoping reviews and the proposed five-step framework by Arksey and O'Malley (2005). The five steps are: (i) identifying the research question, (ii) identifying relevant studies, (iii) selecting eligible studies, (iv) charting the data, and (v) collating, summarising and reporting the results (Arksey & O'Malley, 2005). Review processes are reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) checklist, seen in Appendix A, and the four-phase flow diagram, seen in Figure 1. The PRISMA-ScR was developed as a checklist for authors to verify that their scoping review was according to the JBI standard. The four-phase flow diagram is also useful for illustrating the flow of information over the different phases of a scoping review (Levac et al., 2010; Tricco et al., 2018).

For the purposes of this review, the researcher gathered data ethically by refraining from using any illegal sites and pirated articles and declaring there are no conflicts of interest and funding for this study. According to Peters MDJ et al. (2020), it is not required for scoping review protocols to be registered; however, ethical clearance (HUM008/0721) was obtained from the Postgraduate Research Ethics Committee at the University of Pretoria. According to Mertz et al. (2016), deficiencies in ethical compliance pose a risk in these reviews as they include studies which may fall short of sound ethical judgements. Scoping review methodologies do not yet consist of protocols preventing the inclusion of unethical studies; as such, this review will include a quality assessment check in the study selection section phase (outlined below) dedicated to addressing these ethical considerations (Cherry & Dickson, 2017; Peters, Godfrey, Khalil, et al., 2015).

3.3. Research Aims and Objectives

This study aims to provide a comprehensive scope of the South African literature and taxonomy of technologically-assisted interventions utilised for treatment and neurorehabilitation in the neurological and psychological disciplines. The first objective is to briefly summarise the publication patterns and studies into technologically-assisted interventions in the South African context. The second objective is to analytically record the studies of technologically-assisted interventions, employing the PRISMA-ScR statement's protocol for comprehensive research collection, appraisal, and synthesis (Tricco et al., 2018). The final objective is to identify and discuss the applications and outcomes of technologically-assisted interventions in the South African context.

3.4. Data Collection

3.4.1. Eligibility Criteria

Inclusion and exclusion criteria were determined by literature on the use of technologically-assisted interventions in the South African context, which fell under the following six broad fields: Health care services, Health care sciences, Neurosciences, Clinical neurology, Psychology and Neurorehabilitation. The JBI Manual for Evidence Synthesis (JBIMES) provides the useful mnemonic "PCC", standing for Population, Concept, and Context, for entitling scoping reviews (Peters MDJ et al., 2020). This is therefore utilised in this section to outline the parameters of the eligibility criteria. The type of evidence sources was also an important component of the eligibility criteria for this review.

3.4.1.1. Population, Concept & Context. The population (P) investigated in this study included any data which reported the use of technologically-assisted interventions in the psychological and neurological applied sciences in the South African context, including but not limited to data originating from users, providers, caregivers, family members, healthcare professionals, academics, as well as any other persons speaking to the application of this intervention in these fields. Additionally, no exclusions were made based on age, gender, race, method of diagnosis, setting, or comorbidities of study participants. The concept (C) explored in this scoping review is technologically-assisted interventions in the psychological and neurological applied sciences. The definition of technologically-assisted interventions as an umbrella term in this study refers to interventions dynamically employing devices or interfaces to provide treatment for psychological or neurological disorders. Chapter 2 of this review further expanded on various common modes of technologically-based interventions. Finally, this evaluation is placed within the context (C) of the neurological and psychological sciences in a South African setting. As such, all studies conducted in South Africa and/or on a South African population were deemed eligible.

3.4.1.2. Types of evidence sources. This review considered various types of academic data sources without prejudice to publication status. These included various forms of study designs, including qualitative, quantitative and mixed methods studies. No limits were imposed to data which would bear significance to the research, such as editorials and case studies involving technologically-assisted interventions in mental healthcare, guidelines, research agendas and letters. The review also investigated grey literature, such as published and unpublished studies and abstract contributions from major conferences. According to Haddaway et al. (2020), including grey literature ensures methodological rigour as it minimizes the risk of selection bias. While similar research strategies recommend analysis of data produced over the last 15 years, this review included data from a timespan of 25 years to generate an exhaustive taxonomy of the limited available literature (Chan et al., 2018; Holyfield et al., 2017; Howard, 2017). Excluded from this study were non-English language publications and those that focus on non-technologically-based interventions outside of the South African context.

3.5. Data Extraction

This section comprises the steps taken towards the data extraction for this review. It begins with the search strategy, which describes the process undertaken from the conception of appropriate keywords utilised to search for studies relevant to the review to the compilation of the initial studies obtained for analysis. This is followed by the study selection process, highlighting how the initial studies were filtered to reveal the final studies selected for review.

3.5.1. Search strategy

The methodology used for this research comprises a comprehensive search strategy conducted within the constraints of available time and resources. The search strategy was completed by a primary and an additional reviewer to enhance the study's methodological rigour. According to Peters, Godfrey, McInerney, et al. (2015), the use of an additional review is not mandatory; however, it is recommended to decrease the risk of reporting bias. Consequently, whilst the primary researcher developed the keyword search string to be utilised for the search protocol, this was tested and amended independently with the reviewer to enhance the external validity of the final search.

The search strategy employed the three-step search strategy outlined by JBIMES. The first step was an initial limited search of the MEDLINE and Scopus databases using a search string based on the PCC mnemonic device. These two online databases were identified as appropriate for technologically-assisted interventions in the neurological and psychological sciences. According to McGowan et al. (2016), the Peer Review of Electronic Search Strategies (PRESS) is an evidence-based peer review strategy for electronic literature and health technology assessments. As such, the PRESS checklist (Appendix C) was utilised as a guideline when designing each search.

The second step was analysing the text words in the title and abstracts of retrieved papers to refine the keywords utilised in the subsequent searches. This was followed by a second search applying the keywords indicated across all databases identified for the review. These databases included Cochrane Library, EBSCOHost, ERIC, Google Scholar, JSTOR, MEDLINE, Ovid, ProQuest, PsycINFO, PubMed, Science Direct, Scopus, Web of Science, and Wiley Online Library to scope and identify literature aligned with the broad gamut of the research question (Cherry & Dickson, 2017). Grey literature was also investigated from the following databases: BASE, Core Mednar, Duck Duck Go, Google, Microsoft Academics, Open Access Theses and Dissertations, ProQuest Dissertations & Theses A&I, and World Wide Science. Identified keywords, Boolean operators and wildcards were used to combine, exclude and produce variations within the search criteria. Search terms were guided by the inclusion and exclusion criteria and all word variations of the keywords of this review, namely technologically-assisted interventions, technology-assisted interventions, virtual reality, telemedicine, eHealth, mHealth, psychological interventions, neurological interventions, and neurorehabilitation in the South African context.

The third step was identifying additional relevant resources by examining the reference lists of the sources selected for the review. In order to locate and potentially expand on emerging publications, the searches were conducted in May 2022, and the full search was repeated in August 2022. As recommended by McGowan et al. (2016) PRESS guideline, a focused outline of the keywords utilised in the searches, and the complete keyword search string used for all selected databases have also been included in Table 1 and Table 2, respectively below. Data was then retrieved following the search strategy utilising the PRISMA-ScR guideline.

Table 1

Keywords Utilised in Searches

	Concept 1	**Concept 2**	**Concept 3**
Theme	Technologically-assisted Interventions	Psychological and Neurological Applied Sciences	Population

Key words	technologically-assisted intervention OR technological intervention OR technologically-delivered OR telemedicine OR eHealth OR mHealth OR digital medicine	psychological intervention OR neurological intervention OR neurological rehabilitation OR neurorehabilitation	South Africa

3.5.2. Study selection

Data extraction was directed by the PRISMA-ScR statement's protocol for comprehensive research collection, appraisal and synthesis (Arksey & O'Malley, 2005; Levac et al., 2010). The PRISMA-ScR statement comprises a 22-item checklist (Appendix A) illustrating the requirements for critical appraisal of published articles for scoping reviews (Tricco et al., 2018). It also includes the PRISMA flow diagram (Appendix B), which delineates how appropriate articles will be screened for inclusion and exclusion in the review. Following PRISMA-ScR guidelines, thorough searches yielding initial bodies of text containing relevant data were vetted and selected according to their pertinence in answering the research question. This PRISMA-ScR protocol outlines three stages of screening employed to result in the final selection of studies to be discussed in the research, and these stages include identification, screening, and eligibility to arrive at the final studies.. The primary researcher and reviewer completed independent searches, followed by appraisal meetings between each stage until the final stage; however, the primary researcher formed the final decision to include and exclude articles (Tricco et al., 2018).

The identification stage comprises compiling all studies retrieved from the search strategy and excluding duplicates that may have been discovered. During the identification stage's appraisal meeting, it was determined that all 134 studies were identified as matching the keyword search string constructed for the search strategy. Of these studies, 79 were seen coming from academic database searches, which included Cochrane Library, EBSCOHost, ERIC, Google Scholar, JSTOR, MEDLINE, Ovid e-Books, PsycINFO, PubMed, Science Direct, Scopus, Web of Science, and Wiley Online Library. Table 2 below outlines the findings of the database searches. Furthermore, 40 studies were retrieved from other sources (e.g. grey literature) such as BASE, Core Mednar, Duck Duck Go, Google (screening all the hits of the first 10 pages), Microsoft Academics, Open Access Theses and Dissertations, ProQuest Dissertations & Theses A&I, and World Wide Science. Additionally, 15 studies were from reference list searches. Of the total 134 studies obtained, four were duplicates and therefore excluded; therefore, the remaining 130 studies were considered preliminary studies suitable for the second stage of the study selection protocol.

Table 2

Database search results based on the designed keywords

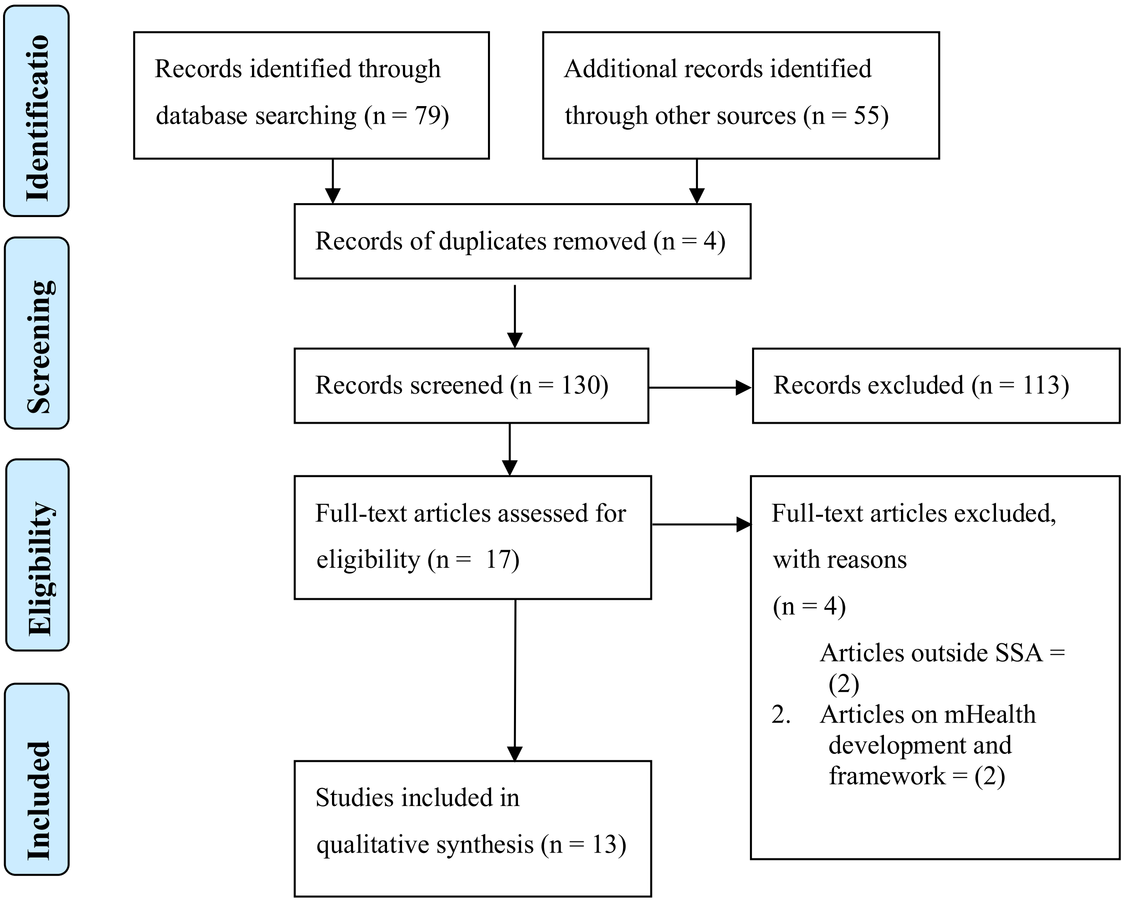
Database	Number of search results	Keyword search string used for all selected databases
Cochrane Library	17	technologically-assist* intervention OR technological intervention OR technologically-delivered OR telemedicine OR eHealth OR mHealth OR digital medicine OR psychological intervention OR neurological intervention OR neurological rehabilitation AND South Africa*
EBSCOHost	20	
ERIC		
Google Scholar	5	
JSTOR		
MEDLINE		
ProQuest	13	
PsycINFO	16	
PubMed	4	
Scopus		
Web of Science	4	
Wiley Online Library		
Science Direct		

The second stage of the PRISMA-ScR protocol introduces the screening process of these preliminary studies (Tricco et al., 2018). These studies were screened according to each study's appropriateness to meet the research aims according to the study's title and abstract. As such, the 130 preliminary studies were selected for independent title and abstract screening by the primary researcher and the reviewer, and 113 sources were ultimately excluded as they did not meet the eligibility criteria outlined for this scoping review in the Data Collection section of Chapter 3. This criterion included the inclusion of studies with technologically-assisted interventions and the exclusion of studies not in the health care services (e.g. neurosciences, clinical neurology or psychology and neurorehabilitation) or a related field outside of the South African context. It is also worth noting that during the screening stage appraisal meeting, both the primary researcher and the reviewer agreed that four articles were unclear regarding their suitability for the research. As such, they were included in the next stage of the study selection process. Therefore, the 17 remaining articles were seen to be eligible for full-text assessment.

The final stage of the PRISMA-ScR protocol assesses the eligibility of the studies remaining for their inclusion in the final selection of studies to be discussed in the research (Tricco et al., 2018). This eligibility screening entails an evaluation of the full text for each study. Of the 17 articles given full-text assessment, four were excluded for the following reasons: two sources were contextualised outside of the South African context, and two focused on the development and framework of mHealth applications and did not feature specific interventions. Consequently, at the end of the screening process, 13 studies met the inclusion criteria and were selected for data extraction. Figure 1 below outlines the process followed.

Figure 1

PRSIMA-ScR Flow Diagram of Reviewed Studies



3.6. Data Synthesis

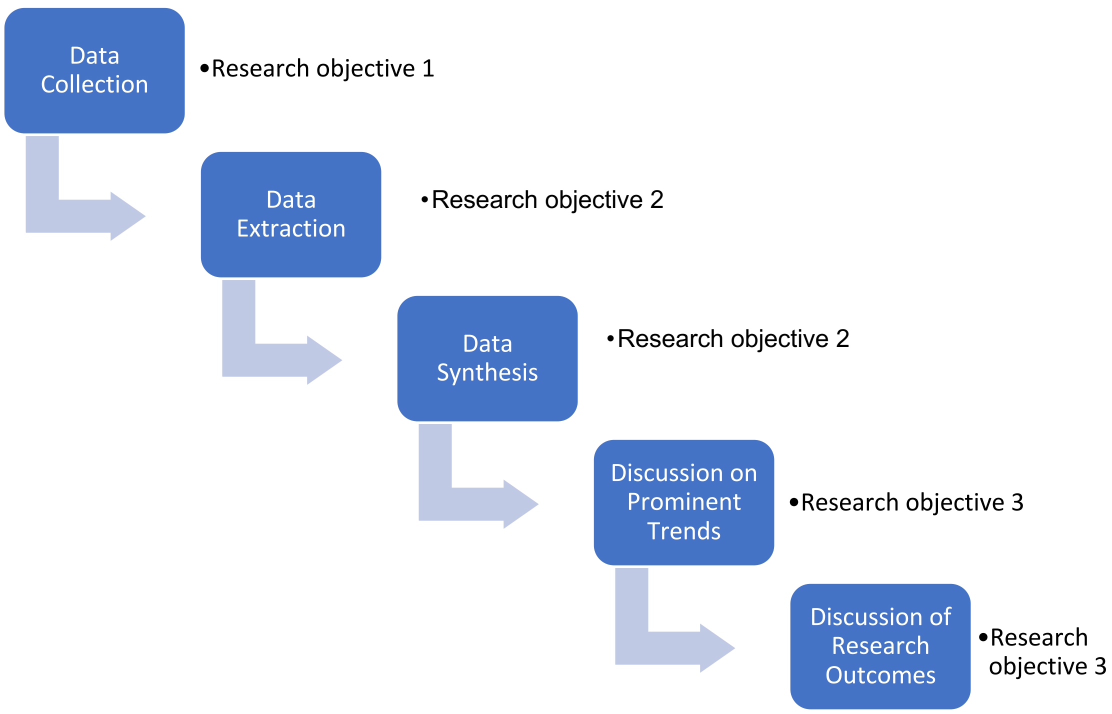
According to Peters MDJ et al. (2020), a data extraction table may then be used to isolate and synthesize the study characteristics of each data source. As such, a master table was developed using Microsoft Excel to analyse studies, as seen in Table 3. The master table was therefore utilised to create a comprehensive taxonomy. This was generated to synthesize and represent the results in a tabulated form. This table organises the key schema of each study. It answered questions such as categorisations (first author and publication year), type of data source, study design methodology, sample size and study population, context/setting, aims/purpose of study psychological/neurological disorder being addressed, focus (type of technologically-assisted intervention utilised), as well as data collection and synthesis.

3.7. Reporting on important information in final studies

Once the final 13 studies were extracted, selected and synthesized, discussions on the prominent trends found in the research and the outcomes from the review were utilised to highlight important information gleaned from the final studies. According to Kerr (2022), whilst there are various options in presenting important trends and/or themes found in qualitative research, qualitative analysis often does not follow a set design or approach. As such, a broad discussion was chosen as an appropriate approach to representing the data in the 13 studies to meet the research objectives. The first objective is to briefly summarise the publication patterns and studies into technologically-assisted interventions in the South African context. The second objective is to record the studies of technologically-assisted interventions analytically. The final objective is to identify and discuss the applications of technologically-assisted interventions in the South African context. Figure 2 below, therefore, illustrates the methodology utilised to meet the objectives of this research in relaying the important discoveries in the scoped studies.

Figure 2

Process Illustrating Methodological Links for Each Research Objective



3.8. Methodological Rigour

Assessing the Methodological Quality of Systematic Reviews (AMSTAR 2) tool, which has been found applicable for scoping reviews and examining healthcare interventions, was developed to assess the quality of reviews by producing a rating score, wherein a score of 8 and above indicates high quality and scores of 0-3 indicates low-quality studies (Zarin et al., 2017). This 16-item checklist assesses reviews based on criteria such as compliance with protocol registration, exhaustive literature search, justification for exclusion of studies and appropriateness of review (Appendix E). Bias is also a critical domain as it investigates the acknowledgement of biases in included studies, risk biases when interpreting results and consideration of the presence and impact of the publication bias. As such, this tool was employed to assess the quality, applicability, and rigour of this review in line with the broad fields (Aromataris & Pearson, 2014; Fleeman & Dundar, 2017; Shea et al., 2017). Furthermore, according to Arksey and O'Malley (2005), it is not necessary to assess the quality of identified studies or use any such assignment as inclusion or exclusion criteria. This is due to the fact that scoping studies do not aim to assess quality and can therefore not provide information on the robustness or generalisability of study findings. Consequently, while the AMSTAR 2 tool was utilised to appraise this review in its completion, identifying and correcting potential flaws, it was not used to eliminate studies selected for investigation during this process.

Finally, the use of an additional reviewer of the available data for a higher degree of consistency in selecting the final article sample and rating was utilised. The reviewer was an academic peer. This reviewer independently screened the abstracts of identified articles applicable to the review. Following a virtual meeting to confirm articles to be excluded from the review based on this screening, the reviewer also independently determined articles eligible for the review based on their full texts. A final virtual meeting was completed with the reviewer to confirm the studies to be included in the review. As such, following the suggestions by Haddaway et al. (2020) to improve the literature reviews, this detailed search strategy and screening process is clearly and comprehensively outlined to ensure replicability. Tools such as PRISMA-ScR and AMSTAR 2 reporting standards ensure that reliability and transparency are maintained throughout the scoping review.

3.9. Conclusion

For this research, the methodology utilised a scoping review to provide a comprehensive scope of the literature and taxonomy of technologically-assisted interventions applied in the South African context for treatment and neurorehabilitation in the psychological and neurological disciplines. A scoping review was therefore selected due to its strengths in broad search methods to investigate developing areas of research and identify gaps in which further research can be conducted. Utilising tools such as the PRISMA-ScR protocol, PRESS and AMSTAR 2 as well as an independent reviewer for the screening and eligibility processes, the quality, applicability, and rigour of this review was in line with the broad guidelines ensuring that a comprehensive research collection, appraisal, and synthesis process was upheld (Tricco et al., 2018).

Chapter 4: Findings and Discussion

4.1. Introduction

This chapter outlines the results obtained in this study. The chapter begins by describing the study selection process for the articles scoped for this research. It then outlines all studies identified and details all studies represented in the findings. In order to enhance the efficacy of analytically recording the studies of technologically-assisted interventions, a framework on the characteristics of the studies was identified to categorise the final selection of studies. This is followed by a discussion on the five prominent trends found in the research as well as the key outcomes of this research. The chapter concludes with the quality appraisal for this scoping review.

4.2. Descriptive results

This section introduces the steps taken during and findings of the study selection process and provides a structured outline for the main characteristics of each study. As discussed in Chapter 3, the literature determined inclusion and exclusion criteria for using technologically-assisted interventions in the South African context in the last 25 years (1996 - 2021). These fell under the following six broad fields: Health care services, Health care sciences, Neurosciences, Clinical neurology, Psychology, and Neurorehabilitation. This study excluded non-English language publications and those focusing on non-technologically-based interventions outside of the South African context.

4.2.2. Characteristics of studies

This section highlights the characteristics of the 13 studies scoped and tabulated in this research. Characteristics of the 13 studies reviewed have been presented in Table 3 as a master data extraction table. The 13 included articles comprised five qualitative studies (Atujuna et al., 2021; Ettinger et al., 2016; Leon et al., 2021; Moriarty et al., 2019; Robbins et al., 2015), one cluster randomized controlled trial (Evans et al., 2022), four quantitative studies (Cassimjee et al., 2018; Davies et al., 2021; Kisten et al., 2022; Robbins et al., 2018), one mixed-method study (Jarvis et al., 2019), one longitudinal (Hasselberg et al., 2017), and one case review (Crumley et al., 2018). The diversity of study design methodology in these studies suggests a balanced sample of studies with the principal understanding of technologically-assisted interventions presented in the findings.

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Table 3

Master Data Extraction Table Outlining the Characteristics of Studies Reviewed

First Author & Publication Year	Title	Study Design Methodology	Area of Technologically Assisted Intervention	Sample size & Study population	Nature of mHealth Intervention	Aims/ Purpose of study	Treatment support
Atujuna et al., 2021	Khuluma: Using Participatory, Peer-Led and Digital Methods to Deliver Psychosocial Support to Young People Living With HIV in South Africa	Qualitative	Telemedicine	52 Adolescents (15–20-year-olds) living with HIV	Text message	Utilising mobile phone technology within a group setting to broaden outreach and take advantage of peer support groups and peer-driven educational initiatives.	Reminders and follow-up focus groups
Cassimjee et al., 2018	Longitudinal neuropsychological outcomes in treatment-resistant depression following bed nucleus of the stria terminalis-area deep	Quantitative	Neurorehabilitation	36-year-old Caucasian female diagnosed with Treatment-resistant depression and generalized anxiety	Deep brain stimulation	To investigate the neuropsychological status of a patient diagnosed with treatment-resistant depression (TRD) one year after undergoing deep brain stimulation (DBS) in the BNST (bed	Follow-ups

	brain stimulation: a case review					nucleus of the stria terminalis) area.	
Crumley et al., 2018	What do emergency medicine and burns specialists from resource-constrained settings expect from mHealth-based diagnostic support? A qualitative study examining the case of acute burn care.	Case Review	Telemedicine	N/A	N/A	To understand expert users' perspectives on implementing an mHealth clinical diagnosis system for acute burns in a resource-constrained setting. It also examines the implications for diagnostic trauma and emergency telemedicine within this context.	N/A
Davies et al., 2021	Demonstrating the feasibility of digital health to support pediatric patients in South Africa	Quantitative	Telemonitoring	40 children with refractory epilepsy or epilepsy associated with intellectual disability and/or behaviour difficulties	Mobile application	To evaluate the practicality of precision medicine initiatives and mobile health (mHealth) applications for home-based use, aiming to enhance	Reminders and follow-ups

						the care of children with epilepsy in South Africa.	
Ettinger et al., 2016	Building quality mHealth for low-resource settings	Qualitative	Telemedicine	Six participants from the study site in Paarl and four from Worcester enrolled in the usability study. The participants were all female and between 24 and 50 years old.	Mobile application	To utilise technology to enable the delivery of a high standard of care that can be safely administered by community health care workers (CHCWs).	Reminders and follow-ups
Evans et al., 2022	I was like intoxicated with this positivity": the politics of hope amongst participants in a trial of a novel spinal cord injury rehabilitation technology in South Africa	Cluster Randomized Controlled Trials	Robotics	16 participants reported in a randomised controlled trial of a novel intervention for spinal cord injury (SCI) rehabilitation	Reports on activity-based training (ABT) and robotic locomotor training (RLT)	To explore the physiological impacts of activity-based training (ABT) and robotic locomotor training (RLT).	3-month post-trial care
Hasselberg et al., 2017	A smartphone-based consultation system for	Longitudinal study	Telemedicine	N/A	Mobile application	To provide an overview of the system under consideration and assess its	Formative evaluations (not described

	acute burns – methodological challenges related to follow-up of the system.					implementation, with a specific focus on addressing methodological challenges.	in this study)
Jarvis et al., 2019	An Evaluation of a Low-Intensity Cognitive Behavioral Therapy mHealth-Supported Intervention to Reduce Loneliness in Older People	Mixed methods	Telemedicine	828 residents living in four inner-city residential NGO care facilities	Mobile application (WhatsApp)	To evaluate an mHealth-supported intervention using low-intensity cognitive-behavioral therapy (LI-CBT) through WhatsApp. The focus was on addressing maladaptive cognitions and reducing loneliness in older individuals living in a residential setting.	Reminders and follow-ups
Kisten et al., 2022	Efficacy of deep brain stimulation of the anterior-medial globus pallidus internus in tic	Quantitative	Neurorehabilitation	5 patients with refractory Tourette syndrome	Deep brain stimulation	To assess the results of tics and non-tic-related symptoms in treatment-resistant Tourette syndrome (TS)	Reminders and follow-ups

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	and non-tic related symptomatology in refractory Tourette syndrome					through the use of deep brain stimulation (DBS) in the anteromedial globus pallidus interna (amGPi).	
Leon et al., 2021	Process evaluation of a brief messaging intervention to improve diabetes treatment adherence in sub-Saharan Africa	Qualitative	Telemedicine	54 individual interviews in total	Text message	To appraise the effectiveness of brief text messaging compared to usual care in improving health outcomes and medication adherence for patients with Type 2 Diabetes Mellitus (T2DM) in Malawi and South Africa, through a pre- and post-trial process assessment alongside a randomized controlled trial.	Reminders and follow-ups
Moriarty et al., 2019	Improving TB outcomes by modifying LIFE-style	Qualitative	Telemedicine	696 participants	Text message	To evaluate the effectiveness and cost-effectiveness of the ProLife	Reminders and follow-ups

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	behaviours through a brief motivational intervention followed by short text messages (ProLife): study protocol for a randomised controlled trial					program in enhancing treatment outcomes for pulmonary tuberculosis (PTB) when compared to standard care.	
Robbins et al., 2015	Enhancing Lay Counselor Capacity to Improve Patient Outcomes with Multimedia Technology	Qualitative	Telemedicine	55 non- adherent South African HIV+ patients	Multimedia technology	To assess how patients comprehend and respond to a diagnosis of non-epileptic attack disorder and to investigate whether these factors play a role in determining outcomes.	Follow-ups
Robbins et al., 2018	A Mobile App to Screen for Neurocogniti ve Impairment:	Quantitative	Telemedicine and Neurorehabilitat ion	A total of 102 HIV-positive black South African adults aged 18 to 56 years	Mobile application	To determine the effectiveness of a modified NeuroScreen, administered by a lay health worker,	N/A

Preliminary Validation of NeuroScreen Among HIV-Infected South African Adults			in identifying Neurocognitive Impairment (NCI) among HIV-infected individuals in South Africa. This was compared to a gold standard neuropsychological test battery administered by a trained research psychometrist.

4.3. Prominent trends

This section provides a discussion of the five prominent trends in the current research to meet this review's first objective, which is to briefly summarise the patterns of publication and studies into technologically-assisted interventions in the South African context. The prominent trends discussed in this section include the geographic locations in which the studies were conducted, the years in which the studies were published, the sample size and study populations of each study, the modality of the technologically-assisted interventions utilised as well as the type of mHealth interventions and treatment support employed. These findings provide a detailed look into the contextual underpinnings of the studies in this research.

4.3.1. Geographic location

This research aimed to explore and review the South African literature on technologically-assisted interventions in the neurological and psychological sciences. As such, the South African context was considered an important criterion for the investigated studies. Highlighting the geographic locations of the studies reviewed was an important indicator of the popular regional areas for research regarding topics included in this research. Therefore, one of the prominent trends in the current research is the geographic location in which the studies were completed.

South Africa is a country with nine provinces, which each vary in size proportionate to the total population: Gauteng: (25.3%); KwaZulu-Natal (19.6%); Western Cape (11.5%); Eastern Cape (11.5%); Limpopo (10.2%); Mpumalanga (7.9%); North West (6.8%); Free State (5.1%); and Northern Cape (2.1%) (Alexander, 2023). Furthermore, there is a strong correlation between provinces with high populaces and their contributions to the South African economy, with the three largest provinces having the strongest economic inputs. When reviewing the geographical distribution by province location in South Africa of the final 13 studies: nine were completed in the Western Cape (Crumley et al., 2018; Davies et al., 2021;

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Ettinger et al., 2016; Evans et al., 2022; Hasselberg et al., 2017; Jarvis et al., 2019; Leon et al., 2021; Robbins et al., 2018, 2015), two in Gauteng (Cassimjee et al., 2018; Kisten et al., 2022), one in Gauteng and Western Cape (Atujuna et al., 2021), and one study spanning across Gauteng, Free State as well as North West (Moriarty et al., 2019).

This is buttressed by the trend observed in the utilisation of clinics and/or hospitals in each of the final 13 studies, where six were completed in a state setting (Atujuna et al., 2021; Davies et al., 2021; Hasselberg et al., 2017; Moriarty et al., 2019; Robbins et al., 2018, 2015); two in private settings (Cassimjee et al., 2018; Jarvis et al., 2019); and five in mixed settings (Crumley et al., 2018; Ettinger et al., 2016; Evans et al., 2022; Kisten et al., 2022; Leon et al., 2021). This demonstrates how most studies were completed in government or mixed facilities instead of privately owned institutions. Additionally, in terms of geographical settings, four of the 13 included studies were conducted exclusively in urban settings (Atujuna et al., 2021; Cassimjee et al., 2018; Crumley et al., 2018; Kisten et al., 2022), two studies were conducted exclusively in rural settings (Davies et al., 2021; Ettinger et al., 2016), four studies were conducted in rural, semi-urban and urban settings (Evans et al., 2022; Hasselberg et al., 2017; Moriarty et al., 2019; Robbins et al., 2018) and three studies were conducted in rural and semi-urban settings (Jarvis et al., 2019; Leon et al., 2021; Robbins et al., 2015).

According to Barron and Padarath (2017), the challenges of local government clinics compared to private in South Africa have historically been rooted in maldistribution. First, the maldistribution of spending in public compared to the private healthcare sectors, as a consequence of economic input availability, has propagated the trend of more affluent areas having better access to private, and therefore superior, healthcare. Second, the geographic maldistribution of public versus private clinics and hospitals, with urban areas receiving a larger proportion of private healthcare than rural/more impoverished areas, has also resulted in

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an inequitable distribution of levels of care by area. Finally, the maldistribution of resources in these areas due to the first two factors has reproduced the effects of public healthcare sectors being underfunded and underserviced compared to private sectors. As such, whilst the studies may provide a glimpse into participants' experiences in the public sector, their positioning in predominantly urban and semi-urban settings may result from convenience at the expense of generalisability.

Figure 3 below illustrates the correlation between the number of readily accessible studies located for this research and the proportion of population (and economic input) for each province in South Africa. This prominent trend is significant as a larger population size may enhance the reliability of the study findings; however, variations in resource distribution and socioeconomic baselines may skew the results in favour of/against the appropriate utilisation of the intervention. It is, therefore, noteworthy that the distribution of resources in the country may impact the selection of province, and therefore demographic, in studies conducted in South Africa. This may not only introduce sampling bias and influence the representation of participants selected for each study but also the propagation of uneven resource allocation and utilisation. This is due to the reporting on some provinces and not others over-generalising the needs and capabilities of individuals in various socioeconomic and contextual backgrounds. Figure 3, therefore, highlights the trend evidenced in the studies in this research, which appear to have been largely located in provinces with large populations and/or economic input in South Africa.

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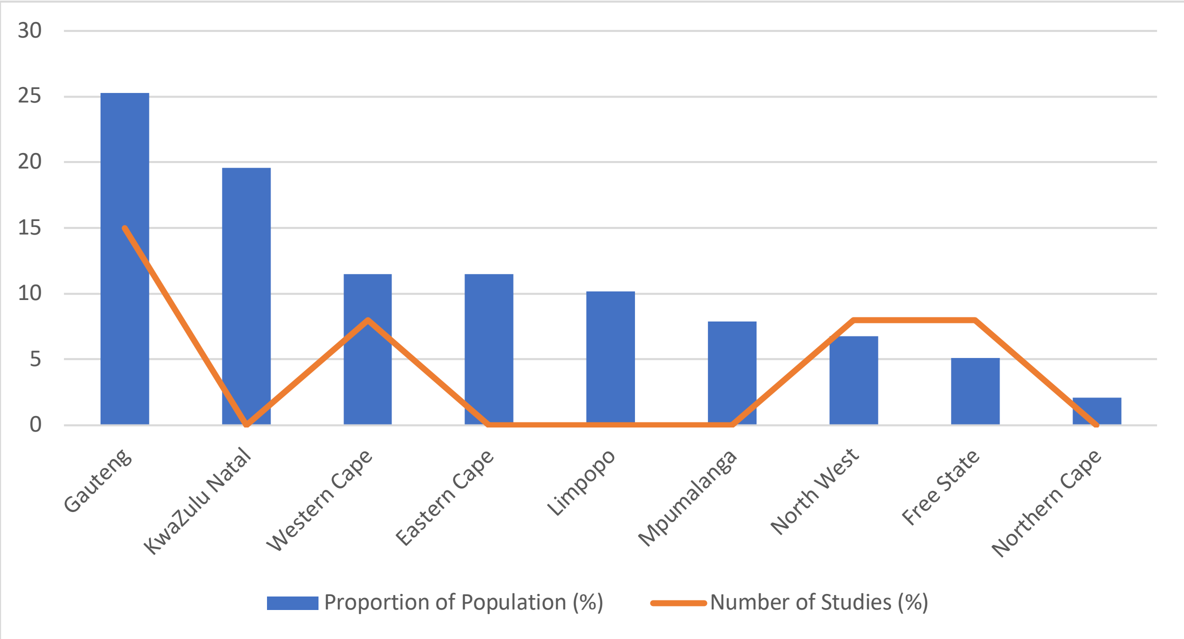
Figure 3

Geographic Distribution of Included Studies in South Africa



4.3.2. Year of publication

The findings of this study indicate that although this research searched articles relevant to the study's aims over the last 25 years, all of the studies reviewed were published in the last 10 years; this is seen below in the linear forecast illustrated by Figure 4. More specifically, a majority of these studies (>76%) were published in the last five years (Atujuna et al., 2021; Cassimjee et al., 2018; Crumley et al., 2018; Davies et al., 2021; Evans et al., 2022; Jarvis et al., 2019; Kisten et al., 2022; Leon et al., 2021; Moriarty et al., 2019; Robbins et al., 2018). This prominent trend suggests that studies highlighting the use of technologically assisted interventions in the psychological and neurological sciences have only been investigated, produced and published in the last eight years. This is buttressed by the studies explored in the academic literature review section of this study, where all 10 of the studies referenced in

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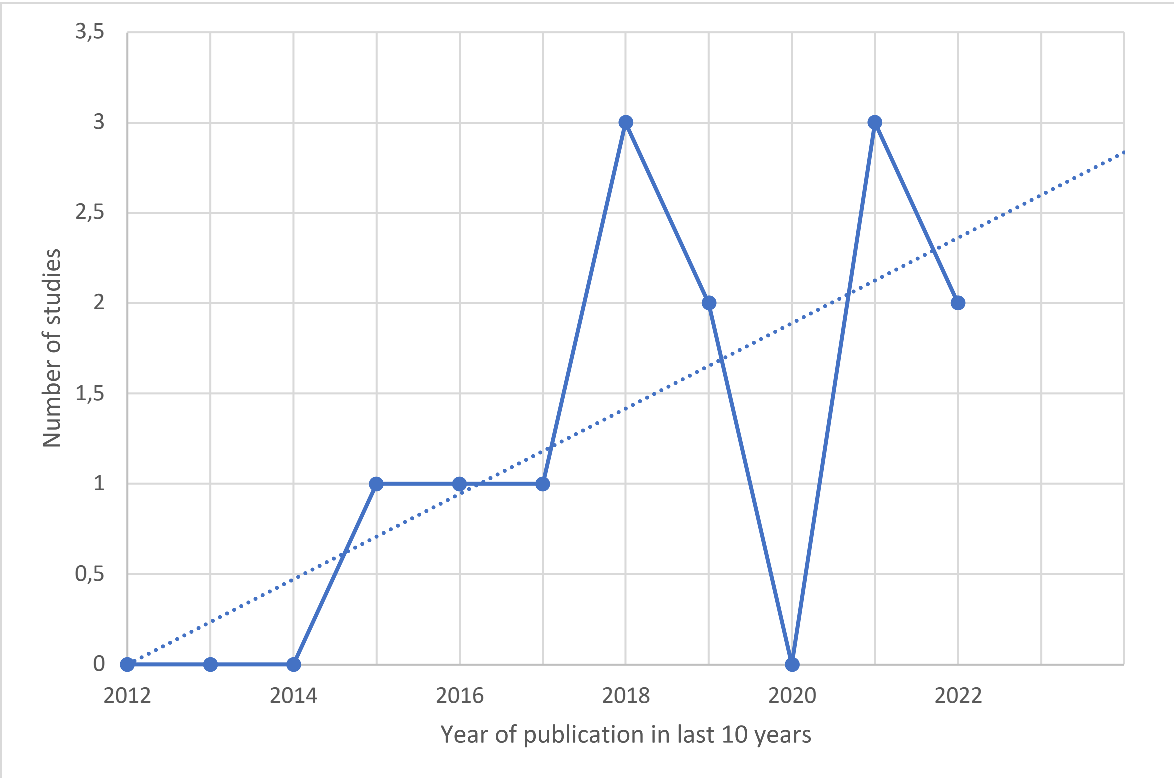
exploration of the current state of knowledge in the use of technologically assisted interventions in the South African context were also published within the last 10 years (Anderson et al., 2017; Cassimjee et al., 2018; Chipps & Jarvis, 2017; Ettinger et al., 2016; Hoffman et al., 2019; Mahomed, 2020; Maples-Keller et al., 2017; Sihlangu, 2019; Verkijika & De Wet, 2015; Wiederhold & Bouchard, 2014).

Figure 4

Number of Studies Found in Scoping Review by Year of Publication



The trend observed highlights two significant contributions to the findings of this research. First, the use of technologically assisted interventions in the psychological and neurological sciences appears to have gained international prominence dating back to the 1980s when technology was harnessed in healthcare assessments (Banta et al., 2009; Jonsson, 2009). In a critical review by Liebenberg (2021) on virtual reality in clinical psychology, the author highlights the gap in South African literature utilising these interventions. This study finding also suggests a lack of visibility for studies in this area in the South African context, citing a

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discovery of international studies that purport to harness virtual reality in mental healthcare. These findings, therefore, also challenge the accessibility with which these studies utilising technologically assisted interventions in healthcare assessment have been made available in South African literature over the years. Liebenberg (2021)'s review concludes with the advocacy for increased efficacious discussion and utilisation of these interventions in third-world countries such as South Africa as they may have a greater need for them than more advanced countries.

Second, there appears to have been a shift in favour of the reported use of technologically assisted interventions in the last 10 years. This may be, in part, the result of policies aimed towards improvements in evidenced-based practice in healthcare as highlighted in the Mental Health Care Act of 2002 and National Health Policy Framework and Strategic Plan 2013 – 2020 (Govender, 2017; Makgoba, 2017; Patel et al., 2018). Prior to 10 years ago, various interventions that harness technology may have been implemented in healthcare; however, funding and academic research into their efficacy and utilisation may have received limited attention. According to Norris et al. (2013)'s study on the potential and current uses of mobile phones in the mental health field in South Africa, this observable shift may also be in part the result of the exponential increase of the utilisation of mobile phones/technology in developing countries due to the relative cost-effectiveness of using mHealth to deliver health care. The increased utilisation of these approaches to treatment intervention directly impacts the research funding made available and the accessibility of viable participants for similar studies or areas of research.

4.3.3. Sample Size and study population

The study with the highest number of participants recruited 828 residents living in four inner-city residential NGO care facilities utilising a mixed methods study design to evaluate a mHealth-supported intervention delivered telemedicine to address maladaptive cognitions and

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reduce loneliness in older people living in a residential setting (Jarvis et al., 2019). Additionally, the qualitative study by Moriarty et al. (2019) assessing telemedicine's effectiveness recorded the second-highest number of participant engagement at 696 participants. Furthermore, the quantitative study by Robbins et al. (2018), which examined the sensitivity and specificity of an adapted version of a telemedicine application for neurorehabilitation among HIV-infected South Africans, reported the second-highest number of participants with a total of 102 HIV-positive adults aged 18 to 56 years. As such, studies that utilised mixed methods, combined technologically assisted intervention modalities, and/or comparing multiple treatment outcomes appeared to engage a larger number of participants than those which employed a single approach and intervention.

Conversely, the remaining 10 studies utilised a single study design methodology and type of technologically assisted intervention, and each recorded no greater than 60 participants. When comparing the two subsequent studies with the highest number of participants to the studies which recorded the two lowest participant engagements, qualitative studies which utilised telemedicine engaged a larger number of individuals compared to quantitative studies which employed neurorehabilitative methods. This is seen in the qualitative studies by Robbins et al. (2015) and Leon et al. (2021), with the following highest participant numbers of 55 and 54, respectively, utilising telemedicine. In comparison, the quantitative studies by Kisten et al. (2022) and Cassimjee et al. (2018), which both employed neurorehabilitative methods, reported the lowest number of participants, with five participants diagnosed with tics and non-tic-related symptomatology treated with DBS, and one 36-year-old female diagnosed with treatment-resistant depression and generalized anxiety respectively. A noteworthy caveat however is that the latter two studies were restricted in terms of the small number of individuals who receive DBS for psychiatric disorders and Tourette syndrome in the South Africa context.

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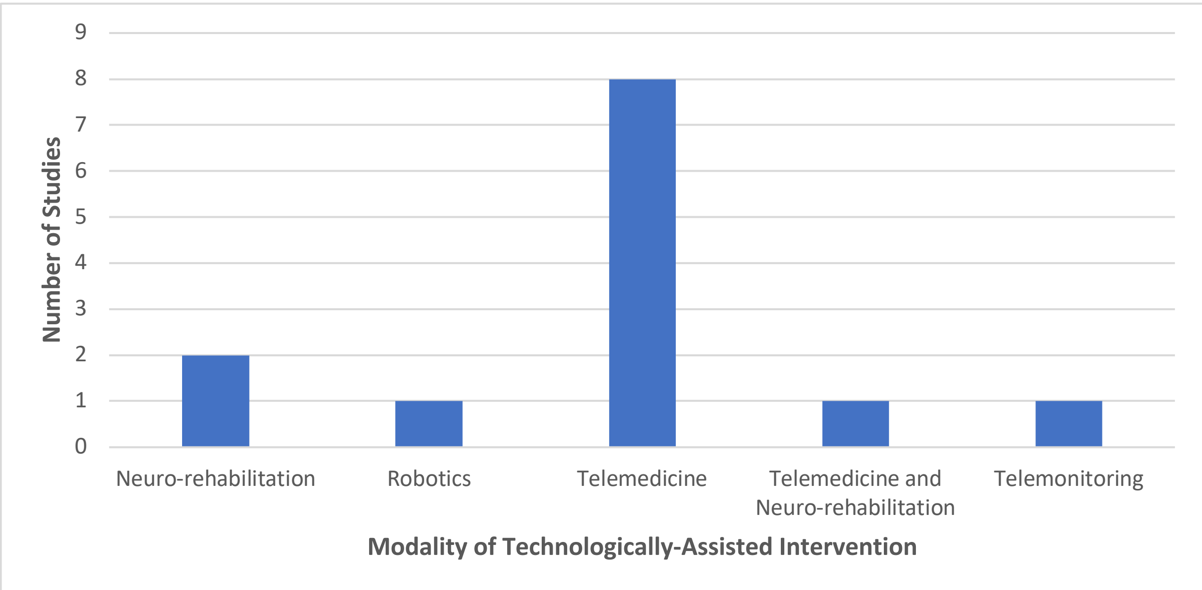
4.3.4. Modality of technologically-assisted intervention

The findings of this research indicate that a majority of the studies reviewed utilised telemedicine as the primary modality of technologically-assisted intervention (Atujuna et al., 2021; Crumley et al., 2018; Ettinger et al., 2016; Hasselberg et al., 2017; Jarvis et al., 2019; Leon et al., 2021; Moriarty et al., 2019; Robbins et al., 2015). Neurorehabilitation yielded the second-highest study results (Cassimjee et al., 2018; Kisten et al., 2022), with one additional study employing telemedicine and neurorehabilitation techniques (Robbins et al., 2018). Figure 5 below shows the distribution of included studies by modality of technologically assisted intervention.

Figure 5

Distribution of Included Studies by Modality of Technologically Assisted Intervention.



Compared to other modalities, such as robotics or neural interfaces, the predominant utilisation of telemedicine could result from ease of access in South Africa and potential deficits in the training of other modalities. Where telemedicine may include relatively simple healthcare assessment methods (e.g. text messaging), using more complex modalities such as virtual reality requires greater expertise and resources. Furthermore, the possibility of the prohibitive costs of utilising other modalities may deter researchers from exploring potentially

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better-suited telemedicine applications such as virtual reality as an intervention. The use of less demanding telemedicine techniques in areas with inadequate financial resources may therefore be used to address multiple difficulties in the South African context, such as limited access to resources in rural communities (Davis et al., 2016; Duncan et al., 2014). This highlights a gap in South African literature for emphasising other modalities in research of technologically-assisted interventions, specifically in the psychological and neurological sciences. The weight of readily accessible studies focused on telemedicine may also allude to publishing and reporting styles which do not avail themselves to commonly searched databases and/or effective utilisation of key terms. The popularity of the use of telemedicine is also reflected in the types of mHealth intervention and consequent treatment support provided.

4.3.5. Type of mHealth intervention and treatment support

The final prominent trend discovered in this research was the frequent utilisation of mobile applications and text messages employed in mHealth interventions and treatment support approaches among the final studies. It can be surmised that the predominant utilisation of telemedicine influences this trend as a modality of technologically assisted intervention, as discussed above. However, this may also be the result of additional influences such as a larger population size from which to select a sample, as well as ease of research resources such as access to infrastructure and tools. As exemplified in eight of the selected studies, the nature of the mHealth intervention required the use of mobile devices, which has implications on the financial history of each participant and their digital acumen acquired prior to the implementation of the study. This is noted in the study by Davies et al. (2021), where 87% of participants had to be provided with smartphones and taught how to use the application required for the study. Furthermore, seven of the selected studies distinctly utilised text messaging for treatment support in the form of reminders and follow-ups (Atujuna et al., 2021; Davies et al., 2021; Ettinger et al., 2016; Jarvis et al., 2019; Kisten et al., 2022; Leon et al.,

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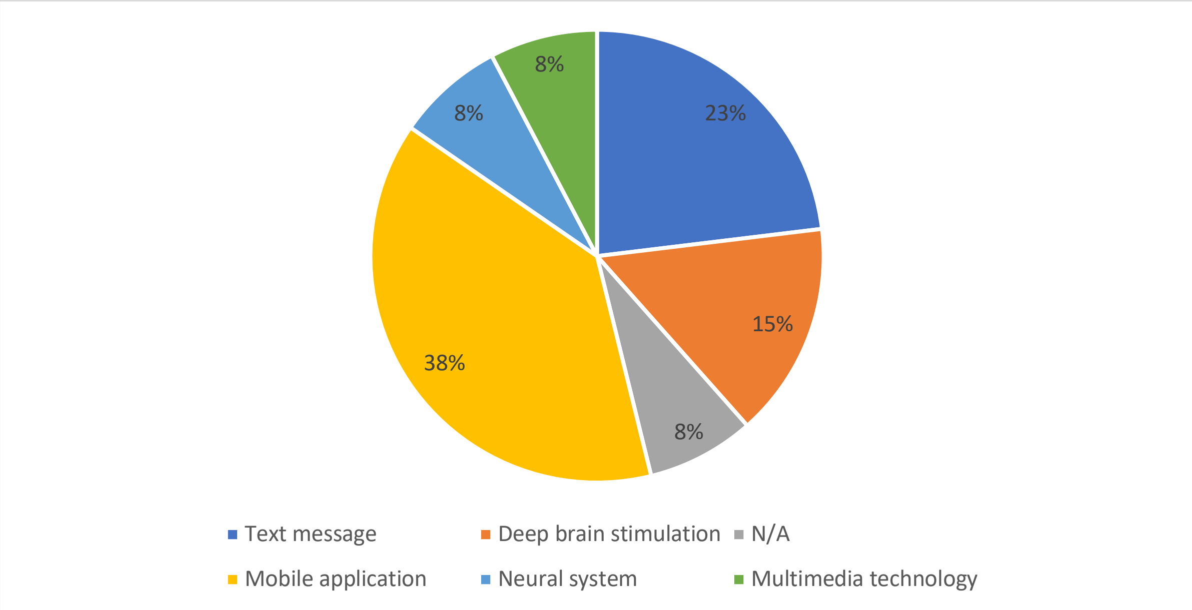
2021; Moriarty et al., 2019). Figure 6 below illustrates the various mHealth interventions employed in the studies selected for this review.

Figure 6

Type of mHealth Intervention



4.4. Discussion on outcomes

This section describes the key outcomes of this research by discussing influential findings pertinent to the scoping review, namely the scarcity of information obtained and each study's alignment with the research aims. This is reviewed to meet the final objective of this research, which is to identify and discuss the applications of technologically-assisted interventions in the South African context.

4.4.1. Alignment to research aims

In discussing the outcomes of this research, gleaning the extent to which the scoped studies align with the research aims and objectives is imperative in understanding this research in the appropriate context. As highlighted in greater detail in the literature review section of

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this research, whilst various interventions have been explored in the areas of the psychological and neurological sciences, a limited understanding of the effects of the functionality of technologically-assisted interventions remains (Franz et al., 2017). Studies focusing on practical interventions were seen as especially significant in the South African psychological context, where studies into the feasibility of technologically-assisted interventions in this area continue to require more academic attention (Patel et al., 2018).

Mental healthcare was noted in the Sustainable Development Goals (SDGs) proposed by the United Nations in 2015 as an area of urgent global importance (Hák et al., 2016). Shifts towards sustainable, evidence-based practices have become the priority of mental health practices, particularly in resource-constrained countries such as South Africa. Technologically-assisted interventions have been proffered to be strategies to meet these healthcare goals by strengthening the psychological aspects of treating clinical conditions. The importance of bolstered mental health in treating disease and disorders has resulted in positive health behaviours, lower treatment attrition, and the longevity of treatment outcomes (Davis et al., 2016). From the 13 included sources in this review, only three studies reported on the availability and use of technologically assisted interventions in areas of mental health or positive psychological outcomes. The scoped studies by Atujuna et al. (2021), Davies et al. (2021), and Jarvis et al. (2019) were seen best to embody the research aims of this scoping review.

In the study by Atujuna et al. (2021), text messages were utilised to provide psychosocial support to young people (15–20 years) living with HIV disease in South Africa. This study yielded positive psychological outcomes, with participants forming lasting relationships beyond the study parameters. Similarly, Davies et al. (2021) demonstrated in their study on the use of remote patient monitoring that patients with epilepsy may benefit from mHealth

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interventions as patient and caregiver moods reportedly improved; thus, improvements were seen in the management of the disease. Additionally, Jarvis et al. (2019) showed how mHealth intervention in conjunction with low-intensity Cognitive Behavioural Therapy with older people (≥60 years) showed significant improvements in maladaptive cognitions and subjective experiences of loneliness. Cognitive Behavioural Therapy is a long-standing psychological therapeutic modality seen successfully treating depressive or anxiety-related disorders. In the South African context, this intervention has also been extended to individuals who have experienced trauma and/or have a propensity for violence (Hinsberger et al., 2017; Kaminer et al., 2023). Experiences of social loneliness have been seen to influence levels of trust, especially in older South Africans, which may play a role in high levels of crime and social inequalities (Heylen, 2010; Mmotlane et al., 2010).

The studies by Atujuna et al. (2021), Davies et al. (2021), and Jarvis et al. (2019), therefore, demonstrated that technologically-assisted interventions had efficacious utility in supporting patients following traditional treatments of chronic medical diseases and pervasive psychological disorders. This finding is significant in understanding the adjunct value of technologically-assisted interventions in providing longevity in treatment outcomes. The implementation of these interventions provided a continuous qualitative assessment and follow-up basis, which aided in the contextualisation of the effectiveness of the treatments as a whole. Therefore, a strong indication is that supplementing these interventions into conventional treatment plans to reach remote and/or low-resourced communities may improve patient mental healthcare. While this study does not aim to investigate the plausibility of solely using technologically-assisted interventions in psychological healthcare, it is an area of suggested careful consideration for the sustainable development of mental healthcare initiatives.

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Neurological and psychiatric disorders constitute 25% of the global burden of disease; however, there remains a disparity between reported patients suffering from neurological health issues and established treatment approaches (Silberberg & Katabira, 2011). Consequently, neurological disorders and the efficacious management of neurorehabilitation programs are still areas of limited advancement in the South African healthcare system (Durojaye & Agaba, 2018). An area of consequence for this research was, therefore, to understand what literature was readily available regarding technologically-assisted interventions in the South African neurological context. These findings suggest that these interventions have been scarcely reported and distinctly under-studied in this particular context, with only two of the 13 studies in this research focusing on direct non-invasive brain stimulation neurorehabilitation interventions. These studies, by Cassimjee et al. (2018) and Kisten et al. (2022), were also seen directly responding to the current research aims as discussed and delineated in the literature review regarding approaches to neurorehabilitation. Where Cassimjee et al. (2018) utilised this approach to treat refractory depression, Kisten et al. (2022) focused on treating refractory Tourette Syndrome. Both studies demonstrated the clinical efficacy of deep brain stimulation in improving patients' physical and mental health outcomes by highlighting the cognitive safety and improved adaptive functioning of patients upon follow-up.

According to Naidoo and Bhigjee (2021)'s retrospective analysis of the spectrum of functional neurological disorders of 158 patients, the prevalence of neurological disease in South Africa has been poorly reported and inconsistently investigated. Moreover, recent studies include small sample sizes and have poor generalisability. Notably, both studies by Cassimjee et al. (2018) and Kisten et al. (2022) focused on brain stimulation and no studies reported on neural interfaces as interventions defined in this research. This suggests that while deep brain stimulation has become an area of evidence-based practice in South Africa, other

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technologically-assisted interventions with a neurological focus have received less academic focus. Thus, these scoped studies imply that there is some literature on deep brain stimulation, which has been reported to be successfully utilised in the South African context to positively impact the treatment management plans of patients with insidious psychiatric illnesses. Important to the efforts of sustainable development in neurorehabilitative healthcare, both studies recommended a larger number of neuropsychological studies to assess the long-term efficacy of these interventions in the South African population.

Additionally, the overlap and shared relationship between organic diseases such as HIV and neurocognitive impairment has been extensively documented (Anand et al., 2010; Rubin & Maki, 2019). The results have shown that individuals diagnosed with this disease face various social, mental and medical stigmas and higher risks of unhealthy long-term behaviours and nonadherence to medical treatment. Given that South Africa is a country with one of the high prevalence rates of HIV globally, it was noteworthy that one of the 13 studies selected for this review focused on screening measures in neurorehabilitation for patients diagnosed with HIV. Robbins et al. (2018)'s study on sensitivity and specificity among HIV-infected South Africans when administered by a lay health worker also highlighted a neurorehabilitation approach to mHealth in psychological and neurological sciences. However, rather than report on an intervention, it focused on the efficacy of the screening measure, the implementation and testing of which would be more directly in line with the aims of this research. Nonetheless, this study validated research findings advocating the use of this approach to technologically-assisted interventions in treating neurocognitive impairments.

Furthermore, five of the 13 studies in this review reported on treatment support for patients with medical diagnoses or bodily injuries. In Crumley et al. (2018)'s qualitative study on expert opinions on the feasibility of mHealth applications for remote diagnostic support,

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findings suggested that this approach to healthcare could enhance the provision of trauma and emergency care in resource-poor settings. In Ettinger et al. (2016)'s qualitative study on building a human-centred mHealth application, technology was leveraged to provide a superior level of care that community healthcare workers can safely deliver. These studies further indicated that positive psychological outcomes could be associated with the barriers in healthcare delivery purported to be addressed by technologically-assisted interventions.

A factor influencing the underutilisation of technologically-assisted interventions appears to be the lack of qualified, appropriately trained healthcare practitioners. Thus, the contributions of the studies by Crumley et al. (2018) and Ettinger et al. (2016) are especially significant in the South African context, where they partially respond to hypotheses of why technologically-assisted interventions are not more widely used and documented in the South African context. This study spoke to the voices of the healthcare practitioners who can provide a more personal, self-experienced insight into the feasibility of the real-world applications of these interventions. This finding confirmed that not only were these interventions considered a method of improving the treatment process, but that they had a unique contribution to engaging patients in remote locations more frequently and adaptively. It also highlighted the constructive relationship that these interventions provide between the diagnostic and treatment management of patients who may be resource constrained.

Moreover, Hasselberg et al. (2017)'s contribution described the potential of a smartphone-based intervention to strengthen the sensitivity and reliability of the assessment of burn injury victims. These findings were in line with Leon et al. (2021)'s study on the efficacy of text messaging. Improvements were seen in psychological outcomes, such as feelings of support, when contrasted to participants' previously negative perceptions of healthcare services, which impacted their receptivity to mental healthcare as a whole. Likewise, Moriarty

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et al. (2019) showed how combining counselling strategies and mHealth interventions enriched multiple lifestyle factors and tuberculosis-related treatment adherence. These studies communicate the reciprocal relationship between technologically-assisted interventions and the information which informs the treatment process, which improves patient symptomology and psychological well-being. These studies highlight how these interventions may play a critical role in the continuous moderations of assessment and remedies within the South African context. This work also provides evidence of the versatility of these interventions in various treatment outcomes such as support and user perceptions as well as directly influencing the status of medical diagnoses.

Finally, one of the 13 studies selected for this research reported on improving the treatment team's capacity for supporting the psychological well-being of patients with chronic medical conditions. In their study on the harnessing of multimedia technology to increase the capacity of health workers with the aim of delivering standardized, effective, and engaging antiretroviral medication adherence counselling, Robbins et al. (2015) demonstrated the efficacious use of mHealth interventions in healthcare. This study found that with the implementation of this intervention, enhancement in the quality of counselling provided was seen in heightened treatment adherence, whilst this approach was seen to be cost-effective, feasible, and acceptable in resource-constrained settings. This scoped study bolsters the discussion on the dire need for evidence-based, pragmatic, accessible and cost-efficient approaches to treatment in the South African healthcare system, without which the majority of the South African population continue to go under-serviced (Durojaye & Agaba, 2018; Naidoo & Bhigjee, 2021). The simplicity of the application of this intervention also augments the nascent value of technologically-assisted interventions, compared to other healthcare interventions, to provide adaptive functions in multiple contexts with diverse demographics.

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4.4.2. The South Africa context

The challenges faced within South Africa have historically posed risks and pitfalls in endeavours to provide premier, accessible, pragmatic healthcare solutions. These challenges include the quadruple burden of disease impacted by the resource constraints resulting from the economic disparities that influence resource distribution and the lack of widely trained healthcare professionals.

South Africa's quadrupled disease burden demands urgent and efficient action in the healthcare sector. Where traditional approaches may be adequate, especially in urban, well-resourced areas, these approaches may further alienate rural or remote communities from receiving proficient continued care. It is, therefore, of critical significance to the outcomes of this research that a majority (>60%) of the scoped studies focused on supporting and enhancing treatment for patients with poverty-related and infectious diseases such as HIV (Atujuna et al., 2021; Robbins et al., 2018, 2015) and TB (Moriarty et al., 2019), as well as chronic and non-communicable diseases (Cassimjee et al., 2018; Davies et al., 2021; Kisten et al., 2022; Leon et al., 2021). This highlights not only the scope of the need for intervention in these areas but also the adaptive functional ability of technologically-assisted interventions to meet the needs of struggling populations. In each study, these interventions were used uniquely and dynamically and were also found to be an improvement to previous approaches to the treatment plan.

Furthermore, the studies scoped in this research evidenced the efficacious utility of technologically-assisted interventions in bridging the gap between the cost-prohibitive factors influencing communities which are empowered to rise above these challenges and communities which cannot. This is seen in the studies highlighting cost-efficient approaches to equipping larger audiences with novel healthcare expertise (Crumley et al., 2018; Ettinger et al., 2016; Robbins et al., 2018). In the South African context, where resource distribution directly impacts

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the level of care available to particular communities, the financial implications of interventions are a very real factor when considering appropriate treatment measures. The utility of low-cost, practical and accessible interventions is therefore not only seen as an adjunct to traditional approaches but, at times, becomes the only comprehensive, evidence-based, viable remedy option.

Finally, this research finds that the exclusive utilisation of telemedicine, neurorehabilitative techniques and robotics in the South African context in rural and urban populations has therefore been demonstrated in the literature. The studies scoped in this research highlighted how technologically-assisted interventions could be garnered to meet the aims of the South African government to harness the progress within the fourth industrial revolution (4IR). According to Schwab (2017), the 4IR is uniquely positioned to propel the South African healthcare system as a whole through its coalescence of biological and physical technology to elevate current treatment approaches. Consequently, South Africa's healthcare system has the potential to benefit from the 4IR by conceptualising the capacities technology-assisted interventions have to reduce cost, workforce, resource requirements, and physical constraints which hinder effective, long-term treatment management for various types of communities. Additionally, by seizing the widespread applicability of these interventions within the aims of the 4IR, the standardisation of sustainable methods and approaches to treatment plans in the psychological and neurological sciences could be an invaluable focus for future research.

4.5. Quality of the evidence

According to Arksey and O'Malley (2005), the search process outlined by scoping reviews inherently offer a high degree of trustworthiness. Considering that no deviations were made from the steps outlined by the PRISMA-ScR protocol, this scoping review quality of the current research was presumed to be high. However, to enhance the transparency and

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transferability of this review, upon completion of the scope, the research was appraised utilising A Measurement Tool to Assess Systematic Reviews (AMSTAR 2) as well seen in Appendix C. According to Zarin et al. (2017), this 16-item checklist assesses reviews based on criteria such as compliance with protocol registration, exhaustive literature search, justification for exclusion of studies and appropriateness of review. As such, this tool was harnessed to bolster the methodical rigour of research and enhance the quality of the review as a whole. This quality assessment was conducted qualitatively by the primary researcher upon completion of the full-text assessment of the final selected studies. As this research is a scoping review without a meta-analysis component, categories evaluating the use of meta-analysis were not included in the appraisal. This research was therefore seen to have a high-rating of 86% as 12/14 of the applicable categories on the checklist were satisfied and seen as being met by this study. This tool was additionally used as a guideline throughout the review to uphold a high rating for the review upon its completion.

4.6. Conclusion

This chapter highlighted the results and findings of the current research. The research methodology utilised a scoping review, and the study selection process for this review followed the protocol outlined by the PRISMA-ScR (Tricco et al., 2018). The use of a primary and additional reviewer for the screening and eligibility processes was harnessed to enhance the quality, applicability, and rigour of this review (Peters, Godfrey, McInerney, et al., 2015). The characteristics of each of the final 13 studies selected for this research were then categorized in a master data extraction table to provide a heuristic of the literature of technologically-assisted interventions in the psychological and neurological sciences found in the South African context. This research also discussed the five prominent trends in the current research. First, geographic locations where the studies were conducted were explored, where findings highlighted how the studies in this research appeared to have been largely located in provinces

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with large populations and/or economic input in South Africa. Second, the years in which the studies were published were discussed as they reflected the shift towards more readily accessible publications on technologically-assisted interventions in the last 10 years. Third, the sample size and study populations of each study were briefly considered, which appeared to demonstrate a large and varied range of sampling selections dependent on the study design and modality of technologically-assisted intervention of each study. Fourth, the modality of the technologically-assisted interventions utilised made sense of the predominant utilisation of telemedicine compared to other modalities in South Africa. Finally, the type of mHealth interventions and treatment support employed was distinguished and linked to the modalities employed by the scoped studies. These findings provided a contextual lens through which the studies explored in this review were framed. A discussion on the key outcomes of the research was included in this section to explore the influential findings significant to this body of work, particularly regarding the extent to which they aligned with the research aims and their applicability in the South African context. Finally, the chapter concludes with a brief quality appraisal of each article utilising the AMSTAR 2 tool. The subsequent final chapter of this research will acknowledge the limitations of this review and provide conclusions and recommendations for future research.

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Chapter 5: Conclusion

5.1. Introduction

This chapter provides an overview of the published studies on technologically-assisted interventions in the neurological and psychological sciences scoped for this review. The chapter begins with a discussion of the conclusions of this research, followed by the study's limitations, and concludes with a brief outline of recommendations for future research.

5.2. Conclusions of research

This research has proferred a critical understanding of South Africa's current exisiting and easily accessible literature concerning technologically-assisted interventions within the context of the psychological and neurological healthcare system. The strategic harnessing of which may propel the mental and scienticific health landscape of a country searching for such innovative solutions in healthcare towards the advances de rigueur for many underpriviledged citizens. It is considered the responsilibity and role of papers such as these, particularily in fields at the cross-sections of science and humanity, to elucidate avenues of accessibility to better healing and treatment solutions for all individuals.

This study utilised a scoping review to provide an analysis of literature regarding technologically-assisted interventions utilised for treatment and neurorehabilitation in the neurological and psychological disciplines in South Africa, which was published in English, inclusive of grey literature, over the last 25 years to secure an exhaustive taxonomy. Excluded from this study were non-English language publications and those which focused on non-technologically-based interventions outside of the South African context. The first two objectives of this research were to provide a summary of the patterns of publication and studies into technologically-assisted interventions in the South African context and to analytically record the studies of technologically-assisted interventions employing the PRISMA-ScR statement's protocol, respectively. As such, the scoping review was completed following JBI

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guidelines which detail a five-step framework proposed by Arksey and O'Malley (2005). The PRISMA-ScR statement's protocol was employed as a useful tool in achieving a broad search in this research area to identify developing research and gaps in available literature (Tricco et al., 2018). Following Peters, Godfrey, McInerney, et al. (2015) recommendation, an additional reviewer was also used in the data collection and extraction stages of the research methodology to enhance methodological rigour. This search was ultimately conducted over 14 different search engines on the University of Pretoria's online library and included eight additional databases for grey literature. The searches were characterised by identified keywords, Boolean operators and wildcards used to combine, exclude, and produce search criteria specific to the desired outcomes of the research. The PRESS checklist was also utilised as a guideline when designing each search (McGowan et al., 2016).

Initially, 134 studies matched the inclusion and exclusion criteria of the research, however by the end of the identification and screening processes 17 studies remained. These were evaluated through a full-text assessment. Finally, four studies were excluded due to their contextualising outside of the South African context, focusing on the development and framework of mHealth applications and not featuring specific interventions. Consequently, at the end of the screening process, 13 studies met the inclusion criteria and were selected for data extraction. These final studies were then tabulated to provide a taxonomical heuristic tool to enable readers to briefly gauge publication patterns and studies in the South African context, which can be used to inform further evidence-based practices in this field. The final 13 studies selected for this review displayed a diversity of study design methodology with five qualitative studies (Atujuna et al., 2021; Ettinger et al., 2016; Leon et al., 2021; Moriarty et al., 2019; Robbins et al., 2015), one cluster randomized controlled trial (Evans et al., 2022), four quantitative studies (Cassimjee et al., 2018; Davies et al., 2021; Kisten et al., 2022; Robbins et

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al., 2018), one mixed-method study (Jarvis et al., 2019), one longitudinal (Hasselberg et al., 2017), and one case review (Crumley et al., 2018).

The final objective was to identify and discuss the applications of technologically-assisted interventions in the South African context. This was achieved by discussing this research's five prominent trends and the two key outcomes. Prominent trends in the research were seen first in the geographic locations of the studies reviewed, which indicated that studies appeared to have been largely located in provinces with large populations and/or economic input in South Africa. The current research showed that the study findings were predominantly conducted in high-populated areas and exclusively in urban settings. Furthermore, the geographic scopes of the studies analysed in this research indicated an uneven distribution of focus between provinces regarding the topics reviewed. This was attributed to the challenges of local government clinics to provide similar levels of service delivery with fewer resources and larger populations than their private clinic counterparts. As such, these challenges were rooted in the maldistribution of resources, affecting service delivery and demographic convenience for each study. Implicit in the findings of this trend was therefore the historical and sociocultural influences of service delivery in the South African healthcare system which are worthy of further focused research, reappraisals and remodeling in an effort to provide indiscriminate amelioration to all groups of individuals.

Second, the year of publication of the 13 scoped studies was a prominent trend indicating the growing accessibility of studies highlighting the use of technologically-assisted interventions in the psychological and neurological sciences in South Africa. The observed shift towards the visibility of these studies was credited to increased funding in these areas of research as well as the use of technologies such as mobile devices to deliver cost-effective healthcare solutions. Third, the sample size and study population of the selected studies were

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investigated to contextualise the range of participants observed in each study. It was highlighted that studies with single-study design methodologies and/or types of technologically-assisted interventions reported fewer participant engagements than studies with multiple features, such as more than one study design and/or type of technologically-assisted interventions. Additionally, studies that were characteristically qualitative and/or employed telemedicine approaches to the intervention demonstrated higher participant numbers than quantitative studies with neurorehabilitative approaches. However, it was ultimately determined that participant recruitment appeared predominantly dependent on the study design and modality of technologically-assisted intervention of each study. Furthermore, the nature of the disorder selected for treatment played a deciding factor in the number of eligible participants found in the South African context. These findings highlight the increased need for consistent research in technologically-assisted interventions with the primary goal of diversifying the study designs, metholodgies and participant demographics. This broadening of the lens through which these interventions are understood in South Africa, may then encourage unique and collaborative employment of resources used to further the reach of this type of research.

Fourth, the modality of the technologically-assisted interventions utilised in the scoped studies highlighted a gap in South African literature in the neurological and psychological sciences, as the bulk of readily accessible literature focused on telemedicine. This finding suggested that the predominant use of telemedicine could be the result of factors such as ease of access, various levels of training and expertise to be considered when utilising differing modalities, the widespread applicability of telemedicine in low-resource communities as well as the comparative cost efficacy of this modality in particular. Finally, it was also recognized as a predominant trend that the use of telemedicine as a popular modality played a significant role in the types of mHealth intervention and treatment support seen across the selected studies.

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Mobile applications and text messages dominated the types of intervention and treatment support provided in the scoped studies. The additional influences of larger populations for sample selection and ease of access to research tools contributed to this trend. These trends and their discussions therefore also highlighted the dire need for continued research in this area in an effort to increase the feasibility of sensitive, more intricate instruments to the enhance quality of the overall research endevours. Whilst it is important to value pragmatism in research these studies, it is equally vital to consider the growth of the field furthered by the evidence-based science which supports efficacious utilization of innovative tools.

This research further described the influential findings pertinent to this body of work, each study's alignment to the research aims and their relevance within the South African context. Furthermore, of the final 13 included studies, three reported on the availability and use of technologically assisted interventions in areas of mental health or positive psychological outcomes. The studies by Atujuna et al. (2021), Davies et al. (2021), and Jarvis et al. (2019) revealed the efficacious utility of technologically-assisted interventions when supplemented into conventional treatment plans as a means of reaching remote and/or low-resource communities. These studies showed how these interventions may improve the mental healthcare of patients with chronic medical diseases and pervasive psychological disorders.

Additionally, two of the 13 studies in this research focused on direct minimally -invasive brain stimulation neurorehabilitation interventions. The studies by Cassimjee et al. (2018) and Kisten et al. (2022) demonstrated the clinical efficacy of deep brain stimulation in improving patient neurological and psychological functioning. These studies highlighted the successful reporting on deep brain stimulation in South Africa; however, they proffered the publication of similar long-term studies with larger populations to understand the longevity of this treatment approach better. One of the 13 studies selected for this review specifically focused on screening

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measures in neurorehabilitation. Robbins et al. (2018) study on a sensitive and specific screening measure among HIV-infected South Africans also validated research findings advocating the use of this approach to technologically-assisted interventions in treating neurocognitive impairments.

Furthermore, 5 of the 13 studies in this review reported on psychological treatment support for patients with medical diagnoses or bodily injuries. Interestingly, the qualitative studies of Crumley et al. (2018) and Ettinger et al. (2016) indicated that positive psychological outcomes could be associated with removing barriers in healthcare delivery, a challenge purported to be addressed by technologically-assisted interventions. These studies demonstrated the nascent value of interventions to provide advances in the treatment management of patients who may be resource constrained. However, they also bolstered the hypotheses regarding the underutilisation of technologically-assisted interventions in South Africa which is attributed to the a lack of qualified, appropriately trained healthcare practitioners competent in providing these approaches to interventions.

Moreover, 3 of the 13 selected studies highlighted how technologically-assisted interventions may play a critical role in continuously moderating treatment plans within the South African context. Hasselberg et al. (2017), Leon et al. (2021), and Moriarty et al. (2019)'s contributions provided further evidence of the resourcefulness of these interventions in various treatment outcomes, directly enriching diagnostic proficiency. Likewise, 1 of the 13 studies selected for this research demonstrated the ubiquitous potential for technologically-assisted interventions to positively impact significant factors of the treatment regimen, such as treatment adherence in areas with limited resources and infrastructure. Robbins et al. (2015) exemplified the manner in which these approaches address the dire need for simplicity without sacrificing competency in the South African context. In this study, multimedia technology was

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utilised to assess patients' understanding of, and reaction to, a diagnosis of non-epileptic attack disorder and to explore whether these factors contribute to outcome. Results showed how this approach was seen to be cost-effective and appropriate in a low resource community whilst improving the quality of counselling provided, resulting in enhanced treatment adherence.

Lastly, when garnering the scope of this research's ability to meet the challenges faced within the South African psychological and neurological healthcare system, the quadruple burden of disease was brought to the fore in conjunction with the utility of technologically-assisted interventions. Supporting the importance of research in this area, over 60% of the studies selected focused on the burgeoning wherewithal of technologically-assisted interventions in meeting the demands posed by the quadruple burden of disease. This encumbrance, which is characterised by (1) increased chronic diseases, (2) maintenance of poverty-related and infectious diseases, (3) non-communicable diseases, and (4) patterns of child and maternal mortality, lies at the core of the appeal for pragmatic, evidence-based, accessible healthcare solutions in South Africa (Hoffman et al., 2019). As such, the cost efficacy of these intervention approaches was also discussed as a factor influencing the impact of resource distribution which may further marginalise penurious communities already struggling with inferior healthcare. Thus this research found evidence in South Africa that technologically-assisted interventions in the psychological and neurological sciences could not only harness the developments of the 4IR to improve treatment methods but also provide sustainable, long-term solutions to challenges unique to this context.

5.3. Limitations of research

The paucity of scoped studies in this research suggests a dearth of information regarding the applications of technologically-assisted interventions in the South African psychological and neurological context. Given the nature of scoping reviews, which determine the existing readily available literature in the chosen field of study, no minimum number of a priori studies

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is prescribed. However, in the process of discussing the current state of knowledge on technologically-assisted interventions in the South African context in Chapter 2, at least 15 studies were highlighted; however, only one of these studies was flagged by the scoping review process (Cassimjee et al., 2018). Consequently, based on studies cited in Chapter 2, at least 27 studies were expected to be revealed in the scoping process (the 14 studies from Chapter 2, the 12 studies scoped in Chapter 4 and the duplicate study found in both); however, only 13 studies were ultimately selected in total. As such, the lack of studies described in this section is determined by comparing the review's findings to what could reasonably have been expected given the initial research.

This research collected data using only the University of Pretoria's library database. This may have excluded other databases containing articles potentially pertinent to this body of work. The inclusion and exclusion eligibility criteria for the studies selected may have also limited the accessibility of particular studies. For example, this research excluded studies not published in English; however, the refinement of this study to the South African context may have invertedly resulted in several studies published in the home language of the author being simultaneously prioritised and excluded from this research. Given the South African context, which has 11 official languages, the cultural and community significance of studies published in indigenous languages cannot be undervalued.

The dearth of information regarding the outlined technologically-assisted interventions in the current research may also result from various confounding variables. For example, the final keyword string employed in the search strategy is ultimately a subjective decision based on the researcher's determination of the best combination of words in line with the research. Variations of these words and utilisations of Boolean operators may yield different results. It is noteworthy to mention that "telemedicine" and "neurorehabilitation" were keywords used in

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the search strategy. These two modalities formed 77% (10 out of 13) of the studies selected for this research, suggesting that this may have played a role in their accessibility as studies indicated for this research. As such, specificity in search terms may have influenced the nature of readily accessible studies for this research.

Furthermore, the search strategy employed in this research used broad terminology to include more studies for data extraction. However, while these broad terms are commonly used in international studies, they may not have been included in the wording of South African studies. For example, none of the final 13 studies selected for this research included the phrase "technologically-assisted"; rather, the studies described each intervention in terms of its use, applicability to the research aims and final outcomes. As such, whilst international studies may clearly delineate and utilise broad key terms to group research areas, South African studies concentrate on the contextual use of each intervention, technologically-assisted or otherwise. As such, it may be beneficial for future research to include specific approaches to interventions in the search strategy, such as "brain stimulation", "virtual reality", and "neurofeedback", to enhance the number and quality of studies obtained.

Finally, a scoping review aims to determine what literature is currently available related to the area of research interest. Therefore, the lack of readily available studies may indicate the paucity of information regarding technologically-assisted interventions in the South African context within the parameters of this research's inclusion and exclusion criteria. As discussed in the literature review chapter of this study, South Africa has numerous limitations regarding completing and reporting on studies that utilise technologically-assisted interventions. These limitations, which include insufficient knowledge of the use of technologically-assisted interventions and restricted resource distribution due to the quadruple burden of disease, may therefore contribute to the scarce study findings.

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5.4. Recommendations for future research

This research has specifically focused on the current state of knowledge in the South African context regarding technologically-assisted interventions in the psychological and neurological sciences. The context, therefore, necessitates that an evaluation of the impact of language differences and reporting styles be continuously modified and tailored to improve the accessibility of published research. Given the findings of this research, the possibility that the use of more specific keywords could have led to an increase in meaningful search results. This suggests that given the aims of this research, an additional scope with more specific key terms in line with what can be expected in South African literature may be beneficial as an area for future research.

Additionally, the apparent lack of readily available literature in South Africa contrasted with the profusion of international studies, which questions the extent to which this research area has been explored or published. This highlights the dire need for resource and funding allocation towards studies investigating the longevity of technologically-assisted interventions in the South African neurological and psychological sciences in particular. With aims for an increased standard of care to more remote communities, the approaches to SDGs in mental healthcare must gain a proficient understanding of the applications of these interventions. As frequently unpacked in this research, reliance on predominately traditional or exclusively mainstream approaches to treatment risk the proliferation of trends in healthcare which alienate resource-constrained demographics.

Finally, a thematic analysis may provide further exploration of the significance of the text discovered. It may also elucidate the extent to which relationships found within the text may assist researchers with understanding the nature of technologically-assisted interventions in South Africa's psychological and neurological healthcare system. As such, a thematic analysis of the studies in this body of work may yield valuable results in future research.

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APPENDIX A

Table 4

PRISMA 22-item checklist utilised for the methodology (Tricco et al., 2018)

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
		TITLE	
Title	**1**	Identify the report as a scoping review.	
		ABSTRACT	
Structured summary	**2**	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	
		INTRODUCTION	
Rationale	**3**	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	
Objectives	**4**	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	
		METHODS	
Protocol and registration	**5**	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	
Eligibility criteria	**6**	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	
Information sources*	**7**	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	
Search	**8**	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	
Selection of sources of evidence	**9**	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	
Data charting process	**10**	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before	

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		their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	**11**	List and define all variables for which data were sought and any assumptions and simplifications made.	
Critical appraisal of individual sources of evidence	**12**	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	**13**	Describe the methods of handling and summarizing the data that were charted.	
		RESULTS	
Selection of sources of evidence	**14**	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	
Characteristics of sources of evidence	**15**	For each source of evidence, present characteristics for which data were charted and provide the citations.	
Critical appraisal within sources of evidence	**16**	If done, present data on critical appraisal of included sources of evidence (see item 12).	
Results of individual sources of evidence	**17**	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	
Synthesis of results	**18**	Summarize and/or present the charting results as they relate to the review questions and objectives.	
		DISCUSSION	
Summary of evidence	**19**	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	
Limitations	**20**	Discuss the limitations of the scoping review process.	
Conclusions	**21**	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	
		FUNDING	
Funding	**22**	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	

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APPENDIX B

Table 5
PRESS Evidence-based Checklist (McGowan et al., 2016)

Translation of the research question	1. Does the search strategy match the research questions/PICO? 2. Are the search concepts clear? 3. Are there too many or too few PICO elements included? 4. Are the search concepts too narrow or too broad? 5. Does the search retrieve too many or too few records? (Please show number of hits per line.) 6. Are unconventional or complex strategies explained?
Boolean and proximity operators	1. Are Boolean or proximity operators used correctly? 2. Is the use of nesting with brackets appropriate and effective for the search? 3. If NOT is used, is this likely to result in any unintended exclusions? 4. Could precision be improved by using proximity operators (e.g., adjacent, near, within) or phrase searching instead of AND? 5. Is the width of proximity operators suitable (e.g., might adj5 pick up more variants than adj2)?
Subject headings	1. Are the subject headings relevant? 2. Are any relevant subject headings missing; e.g., previous index terms? 3. Are any subject headings too broad or too narrow? 4. Are subject headings exploded where necessary and vice versa? 5. Are major headings ("starring" or restrict to focus) used? If so, is there adequate justification? 6. Are subheadings missing? 7. Are subheadings attached to subject headings? (Floating subheadings may be preferred.) 8. Are floating subheadings relevant and used appropriately? 9. Are both subject headings and terms in free text (see below) used for each concept?
Text word searching	1. Does the search include all spelling variants in free text (e.g., UK versus US spelling)? 2. Does the search include all synonyms or antonyms (e.g., opposites)? 3. Does the search capture relevant truncation (i.e., is truncation at the correct place)? 4. Is the truncation too broad or too narrow? 5. Are acronyms or abbreviations used appropriately? Do they capture irrelevant material? Are the full terms also included?

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	6. Are the keywords specific enough or too broad? Are too many or too few keywords used? Are stop words used? 7. Have the appropriate fields been searched; e.g., is the choice of the text word fields (.tw.) or all fields (.af.) appropriate? Are there any other fields to be included or excluded (database-specific)? 8. Should any long strings be broken into several shorter search statements?
Spelling, syntax and line numbers	1. Are there any spelling errors? 2. Are there any errors in system syntax; e.g., the use of a truncation symbol from a different search interface? 3. Are there incorrect line combinations or orphan lines (i.e., lines that are not referred to in the final summation that could indicate an error in an AND or OR statement)?
Limits and filters	1. Are all limits and filters used appropriately and are they relevant given the research question? 2. Are all limits and filters used appropriately and are they relevant for the database? 3. Are any potentially helpful limits or filters missing? Are the limits or filters too broad or too narrow? Can any limits or filters be added or taken away? 4. Are sources cited for the filters used?

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APPENDIX C

Table 6

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Assessing the Methodological Quality of Systematic Reviews (AMSTAR 2) tool utilised for research appraisal (Zarin et al., 2017)

AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both

1. Did the research questions and inclusion criteria for the review include the components of PICO?

For Yes:	Optional (recommended)	
☐ Population ☐ Intervention ☐ Comparator group ☐ Outcome	☐ Timeframe for follow-up	☐ Yes ☐ No

2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?

For Partial Yes:	For Yes:	
The authors state that they had a written protocol or guide that included ALL the following: ☐ review question(s) ☐ a search strategy ☐ inclusion/exclusion criteria ☐ a risk of bias assessment	As for partial yes, plus the protocol should be registered and should also have specified: ☐ a meta-analysis/synthesis plan, if appropriate, *and* ☐ a plan for investigating causes of heterogeneity ☐ justification for any deviations from the protocol	☐ Yes ☐ Partial Yes ☐ No

3. Did the review authors explain their selection of the study designs for inclusion in the review?

For Yes, the review should satisfy ONE of the following:	
☐ *Explanation for* including only RCTs ☐ OR *Explanation for* including only NRSI ☐ OR *Explanation for* including both RCTs and NRSI	☐ Yes ☐ No

4. Did the review authors use a comprehensive literature search strategy?

For Partial Yes (all the following):	For Yes, should also have (all the following):	
☐ searched at least 2 databases (relevant to research question) ☐ provided key word and/or search strategy ☐ justified publication restrictions (e.g. language)	☐ searched the reference lists / bibliographies of included studies ☐ searched trial/study registries ☐ included/consulted content experts in the field ☐ where relevant, searched for grey literature ☐ conducted search within 24 months of completion of the review	☐ Yes ☐ Partial Yes ☐ No

5. Did the review authors perform study selection in duplicate?

For Yes, either ONE of the following:	
☐ at least two reviewers independently agreed on selection of eligible studies and achieved consensus on which studies to include ☐ OR two reviewers selected a sample of eligible studies and achieved good agreement (at least 80 percent), with the remainder selected by one reviewer.	☐ Yes ☐ No

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AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both

6. Did the review authors perform data extraction in duplicate?

For Yes, either ONE of the following: ☐ at least two reviewers achieved consensus on which data to extract from included studies ☐ OR two reviewers extracted data from a sample of eligible studies <u>and</u> achieved good agreement (at least 80 percent), with the remainder extracted by one reviewer.	☐ Yes ☐ No

7. Did the review authors provide a list of excluded studies and justify the exclusions?

For Partial Yes: ☐ provided a list of all potentially relevant studies that were read in full-text form but excluded from the review	For Yes, must also have: ☐ Justified the exclusion from the review of each potentially relevant study	☐ Yes ☐ Partial Yes ☐ No

8. Did the review authors describe the included studies in adequate detail?

For Partial Yes (ALL the following): ☐ described populations ☐ described interventions ☐ described comparators ☐ described outcomes ☐ described research designs	For Yes, should also have ALL the following: ☐ described population in detail ☐ described intervention in detail (including doses where relevant) ☐ described comparator in detail (including doses where relevant) ☐ described study's setting ☐ timeframe for follow-up	☐ Yes ☐ Partial Yes ☐ No

9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?

RCTs For Partial Yes, must have assessed RoB from ☐ unconcealed allocation, *and* ☐ lack of blinding of patients and assessors when assessing outcomes (unnecessary for objective outcomes such as all-cause mortality)	For Yes, must also have assessed RoB from: ☐ allocation sequence that was not truly random, *and* ☐ selection of the reported result from among multiple measurements or analyses of a specified outcome	☐ Yes ☐ Partial Yes ☐ No ☐ Includes only NRSI
NRSI For Partial Yes, must have assessed RoB: ☐ from confounding, *and* ☐ from selection bias	For Yes, must also have assessed RoB: ☐ methods used to ascertain exposures and outcomes, *and* ☐ selection of the reported result from among multiple measurements or analyses of a specified outcome	☐ Yes ☐ Partial Yes ☐ No ☐ Includes only RCTs

10. Did the review authors report on the sources of funding for the studies included in the review?

For Yes ☐ Must have reported on the sources of funding for individual studies included in the review. Note: Reporting that the reviewers looked for this information but it was not reported by study authors also qualifies	☐ Yes ☐ No

AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both

11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?

RCTs
For Yes:

- ☐ The authors justified combining the data in a meta-analysis
  - ☐ AND they used an appropriate weighted technique to combine study results and adjusted for heterogeneity if present.
  - ☐ AND investigated the causes of any heterogeneity

☐ Yes
☐ No
☐ No meta-analysis conducted

For NRSI
For Yes:

- ☐ The authors justified combining the data in a meta-analysis
  - ☐ AND they used an appropriate weighted technique to combine study results, adjusting for heterogeneity if present
  - ☐ AND they statistically combined effect estimates from NRSI that were adjusted for confounding, rather than combining raw data, or justified combining raw data when adjusted effect estimates were not available
  - ☐ AND they reported separate summary estimates for RCTs and NRSI separately when both were included in the review

☐ Yes
☐ No
☐ No meta-analysis conducted

12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?

For Yes:

- ☐ included only low risk of bias RCTs
- ☐ OR, if the pooled estimate was based on RCTs and/or NRSI at variable RoB, the authors performed analyses to investigate possible impact of RoB on summary estimates of effect.

☐ Yes
☐ No
☐ No meta-analysis conducted

13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?

For Yes:

- ☐ included only low risk of bias RCTs
- ☐ OR, if RCTs with moderate or high RoB, or NRSI were included the review provided a discussion of the likely impact of RoB on the results

☐ Yes
☐ No

14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?

For Yes:

- ☐ There was no significant heterogeneity in the results
- ☐ OR if heterogeneity was present the authors performed an investigation of sources of any heterogeneity in the results and discussed the impact of this on the results of the review

☐ Yes
☐ No

15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?

For Yes:

- ☐ performed graphical or statistical tests for publication bias and discussed the likelihood and magnitude of impact of publication bias

☐ Yes
☐ No
☐ No meta-analysis conducted

16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

For Yes:

- ☐ The authors reported no competing interests OR
- ☐ The authors described their funding sources and how they managed potential conflicts of interest

☐ Yes
☐ No

To cite this tool: Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, Moher D, Tugwell P, Welch V, Kristjansson E, Henry DA. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ. 2017 Sep 21;358:j4008.

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APPENDIX D

LETTER FOR ETHICS APPROVAL

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Humanities 100.
Since 1919

6 September 2021

Dear Mrs LK Eardley

Project Title:	Technologically-assisted interventions in neurological and psychological applied disciplines in South Africa: a scoping review
Researcher:	Mrs LK Eardley
Supervisor(s):	Prof N Cassimjee
Department:	Psychology
Reference number:	13331958 (HUM008/0721)
Degree:	Masters

Thank you for the application that was submitted for ethical consideration.

The Research Ethics Committee notes that this is a literature-based study and no human subjects are involved.

The application has been **approved** on 26 August 2021 with the assumption that the document(s) are in the public domain. Data collection may therefore commence, along these guidelines.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. However, should the actual research depart significantly from the proposed research, a new research proposal and application for ethical clearance will have to be submitted for approval.

We wish you success with the project.

Sincerely,

Prof Karen Harris
Chair: Research Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: tracey.andrew@up.ac.za

Room 7-27, Humanities Building, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa
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APPENDIX E

LETTER FROM THE EDITOR

REGCOR

ENTERPRISES PTY LTD

(2015/375453/07)

Date: 18/07/2023

Dear Sir/Madam

This letter is to certify that I, Sarah Louise Cornelius, of Regcor Enterprises Pty Ltd, have completed the initial editing of the dissertation titled TECHNOLOGICALLY-ASSISTED INTERVENTIONS IN NEUROLOGICAL AND PSYCHOLOGICAL APPLIED DISCIPLINES IN SOUTH AFRICA: A SCOPING REVIEW by Luyanda Kimberley Eardley.

I have ten years of experience in the field, having worked on multiple doctorates. Currently, I am a member of the Professional Editor's Guild (PEG).

All recommendations and errors have been noted in the comments. Any changes or lack of corrections done to the document after editing does not reflect the editing services provided. The onus is on the student to ensure the document is fully corrected before final submission, even if that requires multiple edits.

Kind Regards

Sarah Louise Cornelius

Professional Editor's Guild
Associate Member

Membership number: COR003

Regcor Enterprises Pty Ltd
Registration no: 2015/375453/07
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