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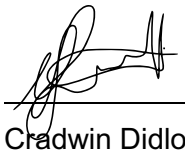
THE CLINICAL OUTCOMES AND PHYSIOTHERAPY MANAGEMENT OF PATIENTS WITH ORGANOPHOSPHATE POISONING: A PROSPECTIVE LONGITUDINAL DESCRIPTIVE STUDY

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A Research Report submitted to the Faculty of Health Sciences, University of the Witwatersrand Johannesburg, 2025, in partial fulfillment of the requirements for the degree of Master of Science in Physiotherapy

DECLARATION

I, Cradwin Didloff, declare that the work contained in this research report is my own, except where otherwise indicated in the acknowledgment section. This research report is being submitted to the University of the Witwatersrand, Johannesburg, South Africa, for a degree in Master of Science in Physiotherapy (in the field of Respirology, Cardiology, and Cardiothoracic Surgery). This work has not been submitted for any other degree or examination at this or any other university.



Cradwin Didloff

24/10/2025

Date

ABSTRACT

Background

Organophosphates (OP) are pesticides or insecticides used worldwide, which may cause an acute cholinergic crisis and subsequent permanent disability or death (if not managed medically) after accidental or deliberate ingestion. The most clinically evident signs and symptoms of OP poisoning are respiratory depression, muscle weakness or paralysis, tachycardia, urinary incontinence, sweating, and abdominal pain with associated diarrhea. The clinical outcomes of patients diagnosed with OP poisoning in South Africa are confined to mortality and morbidity, and patients' need for mechanical ventilation. Little is known about patients' discharge destination and clinical course in the hospital. The physiotherapy management of patients diagnosed with OP poisoning in South Africa is under-researched. Existing evidence supports physiotherapists' roles in the management of patients with critical illness as improving lung compliance and lung volume, clearing excessive retained secretions, optimizing oxygenation, recruiting collapsed alveoli, and assisting with early mobilisation (Stiller, 2013; Skinner et al., 2015).

This study aims to describe the incidence of OP poisoning at the participating study site, to describe patients' clinical course, as well as their physiotherapy management during hospitalisation at the study site in Gauteng province.

Method

A prospective, longitudinal, descriptive study was conducted over 18 months (October 2022 to March 2024) at the ICU of Thelle Mogoerane Regional Hospital (TMRH). Ethical clearance was obtained from the University of the Witwatersrand Human Research Ethics (Medical) (HREC) Committee (certificate nr. M211166). Permission to conduct the study was obtained from the TMRH physiotherapy department. Participants for the study had to be 18 years and older and not present with any preexisting respiratory pathology, physical disability, or cognitive impairment. Standard physiotherapy patient care provided was recorded by the clinician physiotherapists on the study-specific data collection form on days one to seven of the patient's stay in ICU, and again on days 10, 14, and on the day of discharge from ICU. Data was captured on Excel and imported to IBM Statistical Package for the Social Sciences (SPSS) version 29 software for analysis. Descriptive and inferential analyses were performed, and testing was done at the $p \leq 0.05$ level of significance.

Results

During the 18-month study period, 655 patients were admitted to the TMRH ICU, of which 118 were diagnosed with OP poisoning (18%). The study included 56 eligible participants. There were more males (n=36; 64%) admitted than females (n=20; 36%), and most had intentionally ingested OP poison (n=36, 64%). It is noted that 68% (n=38) of the participants required mechanical ventilation

with initial diagnosis. Patients received a median of 4 physiotherapy sessions delivered once daily during their ICU stay. The most common respiratory physiotherapy treatment techniques used on initial assessment were manual chest clearance techniques (n=33, 59%), suction (tracheal or oral) (n=37, 66%), positioning for ventilation-perfusion matching (n=19, 34%), and active cycle of breathing technique (n=10, 18%). Neuromusculoskeletal physiotherapy treatment techniques most used on day one of assessment and treatment were joint range of movement (n=33, 59%), sitting on the edge of the bed (n=9, 16%), sit to stand (n=10, 18%), marching on the spot (n=7, 13%) as well as assisted and independent mobility (n=4, 7% and n=7, 13% respectively). Upon participant discharge from the ICU, the median Peak Expiratory Flow (PEF) was 46% of predicted value, the median Medical Research Council Scale Sum Score (MRC-SS) of 42/60 (IQR: 36-48), and a median FSS-ICU score of 30.5/35 (IQR: 18-34). During physiotherapy sessions, no adverse events were noted. The only complication that developed was reintubation (n=5, 9%). This was necessary due to OP poisoning rebound (n=2; 4%), ventilator-associated pneumonia (n=1; 2%), and respiratory distress (n=1; 2%). For one participant, no reason for reintubation was recorded. Five participants demised (9%), and this was due to ventilator-associated pneumonia (n=1; 4%), cardiac arrest (n=1; 4%), and no reason recorded for 3 participants. A significant association (p=0.01) was found between the number of physiotherapy sessions received and the need for reintubation. No association was found between the final MRC-SS at discharge from hospital and the rate of reintubation (p=0.546). The study results found that participants had a median ICU length of stay of 7 (IQR: 4-11) days and a median hospital length of stay of 9 (IQR: 5-12) days. Sixty-eight percent of participants (n=38) were discharged home from, ICU, and none required outpatient physiotherapy follow-up services.

Conclusion

One-fifth of patients admitted to the TMRH ICU had OP poisoning, with a higher incidence in males. The hospital length of stay was longer than one week. All patients received physiotherapy while in the ICU. The need for reintubation was associated with the number of physiotherapy sessions received. A low mortality rate was observed, and patients were mostly discharged home.

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LIST OF ABBREVIATIONS

FDA	- Food and Drug Administration
FSS-ICU	- Functional Status Score for the Intensive Care Unit
HREC	- Human Research Ethics Committee
ICU	- Intensive Care Unit
MRC-SS	- Medical Research Council Scale Sum Score
OP	- Organophosphate
PEF	- Peak Expiratory Flow
SpO_2	- Saturation of Peripheral Oxygen
TMRH	- Thelle Mogoerane Regional Hospital

CHAPTER 1

1. INTRODUCTION

1.1 INTRODUCTION

Organophosphate (OP) compounds are toxins most used in herbicides and insecticides worldwide, which may cause poisoning and subsequent mortality and morbidity in humans after deliberate or accidental exposure (Robb et al., 2023). A South African-based cross-sectional study reported that at least 250 000 to 300 000 deaths occur globally due to OP poisoning (Razwiedani and Rautenbach, 2017). These compounds inhibit acetylcholinesterases, causing an acute cholinergic crisis due to the accumulation of acetylcholine (Abdollahi and Karami-Mohajeri, 2011). The signs and symptoms of OP poisoning can manifest in three phases: acute cholinergic syndrome, intermediate syndrome, and OP-induced delayed polyneuropathy, respectively (Sahoo et al., 2018).

The various syndromes, and their associated timeframe, can influence the clinical course of patients diagnosed with OP poisoning by increasing their hospitalisation and duration in the ICU, their days on mechanical ventilation, and their days requiring oxygen therapy (Omar et al., 2020). The literature references possible physical disability in the second and third phases of OP poisoning due to the aging of irreversible OP compounds (Sahoo et al., 2018, and Hulse et al., 2019). It is noted that the mortality rate of patients diagnosed with OP poisoning remains significantly low (Razwiedani and Rautenbach, 2017; Omar et al., 2020; Khonje et al., 2023).

The prevalence in a South African context only focused on the Western Cape (Patience, 2018), Tshwane District (Razwiedani and Rautenbach, 2017), TMRH (Khonje et al., 2023), Charlotte Maxeke Johannesburg Academic Hospital (Laher et al., 2022), and Chris Hani Baragwanath Academic Hospital (Omar et al., 2020) at the time of this research study. The reason for OP poisoning within a South African context has not been adequately investigated, and Omar et al. (2020) attribute the incidence in low-income countries to poor regulatory laws as well as the utilisation of low-cost farming products. Patience (2018) shared similar sentiments when exploring the effects of OP poisoning on patients in the Western Cape.

Generally, the medical management of patients with OP poisoning consists of a decontamination process where patients are cleaned and all items exposed to the OP compound are removed from the patient (Hulse et al., 2019). This is then followed by a high dose of atropine that will be titrated, followed by the administration of a combination of drugs (atropine, glycopyrrolate, and a benzodiazepine) (Omar et al. 2020; Reddy et al., 2020; Laher et al. 2022; Khonje et al. 2023). Patients who present with respiratory compromise may

require oxygen therapy or, in severe cases, mechanical ventilation (Laher et al. 2022 and Khonje et al. 2023). As the evidence for physiotherapy in managing patients with OP poisoning remains in its infancy and is confined to low-income countries, only case reports have explored the potential positive effects of physiotherapy on the clinical outcome of patients diagnosed with OP poisoning (Chordiya et al., 2017; Sahoo et al., 2018; Londhe et al., 2020; Salve et al., 2021; Vikhe et al., 2024).

Patients admitted to TMRH in Gauteng province, for the medical management of OP poisoning, often present with bronchorrhea, bronchospasm, hypersalivation, bradycardia, emesis, diarrhoea, proximal limb weakness, muscle fasciculations, and mechanical ventilator or oxygen dependency. These patients would receive physiotherapy as an adjunct to their medical treatment. Arumugam et al. (2019) aimed to design an ICU treatment protocol for physiotherapists working in the critical care setting, managing all types of patients admitted to the medical ICU. These authors state that physiotherapy patient management aims to assist with airway clearance, reduce symptoms of breathlessness, assist with early weaning from mechanical ventilation, decrease patients' anxiety and depression, manage pain, and encourage early mobility to facilitate functional independence. Marques et al. (2020) found that physiotherapy for a patient presenting with lower respiratory tract infections (of any etiological background) assisted with sputum clearance, improved saturation of peripheral oxygen (SpO_2) levels, and reduced dyspnoea, which ultimately improved the individual's functional exercise capacity. A study focusing on the imperatives of critical care physiotherapy for all patients admitted to the ICU, by Ogundunmade (2022), alluded to the importance of respiratory physiotherapy to optimize oxygenation, facilitate secretion clearance, recruit alveoli, and prevent pulmonary complications. The case report by Sahoo et al. (2018) found that long-term rehabilitation comprising strengthening exercises, balance retraining, mobility, and functional activities of daily living assisted in the management of OP-induced delayed polyneuropathy signs.

The physiotherapy intervention received by patients with OP poisoning, at TMRH, includes airway clearance, alveolar recruitment, assistance with successfully weaning patients from mechanical ventilation, strengthening exercises, and functional mobility exercises. No published evidence is available on the physiotherapy management of patients with OP poisoning in a South African context.

1.2 PROBLEM STATEMENT

Research conducted on OP poisoning in South Africa was done in Tshwane District, the Western Cape, and Soweto (Chris Hani Baragwanath Academic Hospital) (Razwiedani and Rautenbach, 2017; Patience, 2018; Omar et al., 2020). These studies focused on the medical

management of such patients and their cost implications, epidemiological findings, and public health implications, respectively. In 2023, Khonje et al. published a retrospective chart review conducted at TMRH hospital in the Ekurhuleni District. The aim was to determine the demographics and clinical course of patients diagnosed with OP poisoning. The authors reported that in 20 months, 205 patients were medically managed for OP poisoning at their facility. Patients with OP poisoning are often admitted to TMRH, but no evidence, at the time of this study, exists on the physiotherapy management of these patients. In addition, no evidence is available that describes the physiotherapy management of patients with OP poisoning within the larger South African context.

Further research is necessary to investigate the clinical course of patients with OP poisoning and the physiotherapy management that they receive.

1.3 RESEARCH QUESTION

What are the clinical outcomes of patients diagnosed with OP poisoning, and what is the current physiotherapy management received by these patients in the ICU during their hospitalisation at TMRH?

1.3.1 Aim of the Study

The study aims to describe the clinical outcomes (ICU length of stay and reintubation rate) of patients diagnosed with OP poisoning in the ICU at TMRH and to report on the current physiotherapy management that these patients receive.

1.3.2 Objectives of the Study

- To report the incidence of OP poisoning admissions to the ICU at TMRH during the study period.
- To describe the profile of patients admitted to the ICU at TMRH with OP poisoning.
- To describe the clinical course and outcomes of patients with OP poisoning during their ICU stay.
- To describe the physiotherapy management received by patients with OP poisoning during their stay in the ICU.
- To report on the complications and adverse events developed by patients with OP poisoning during their ICU stay.
- To identify factors that influence the clinical outcomes of ICU patients with OP poisoning.

1.4 SIGNIFICANCE OF THE STUDY

The study will describe the clinical outcomes and physiotherapy management of adults with OP poisoning who were admitted to the ICU at TMRH. The findings will assist physiotherapists to engage in discussion about the development of an evidence-based treatment protocol for patients with OP poisoning at TMRH and encourage passive surveillance as set out by the National Health Act of South Africa (National Health Act, 2003). The study's findings will add to the current existing knowledge in the physiotherapy management of patients diagnosed with OP poisoning, specifically within Ekurhuleni and the broader South African context. These findings will provide a platform from which future physiotherapy clinical trials may be conducted to determine the impact of various physiotherapy treatment interventions reportedly used at TMRH on relevant patient outcomes.

1.5 STUDY DESIGN

A prospective, longitudinal, descriptive study was conducted over 18 months after obtaining ethical clearance from the Human Research Ethics Committee (Medical) at the University of the Witwatersrand.

1.6 WORKING DEFINITIONS

The following working definitions were selected for this study:

1.6.1 Respiratory Pathology

Any long-standing and pre-existing disease affecting the lungs and other parts of the respiratory system (World Health Organisation, 2025) that has been evidently documented in the patient's file before their OP poisoning diagnosis.

1.6.2 Physical Disability

A long-term physical impairment that affects an individual's ability to participate in society (Baart et al., 2023) at an equal level before their OP poisoning diagnosis.

1.6.3 Cognitive Impairment

A medically documented intellectual disorder that impairs the individual's perception (Baart et al., 2023) and knowledge through thought, senses, and experience before hospital admission for OP ingestion.

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the research available on OP poisoning was reviewed. The incidence of OP poisoning cases in South Africa was reviewed and will be discussed. To understand the important role of physiotherapy when treating patients with OP poisoning, this chapter will provide a brief overview of the pathophysiology and relevant factors that influence the clinical outcomes of patients who were diagnosed with OP poisoning.

Evidence for this literature review was obtained from the University of the Witwatersrand Health Sciences Library. Databases searched included PubMed, Google Scholar, PEDro, ClinicalKey, and Cochrane Library. The search included articles written in English from 2013 to 2025. The keywords and phrases used to obtain articles from these databases were OP poisoning, organophosphorus toxicity, OP poisoning in South Africa, profile of patients with OP poisoning, clinical course in OP poisoning, complications in organophosphorus toxicity, neuromusculoskeletal physiotherapy, ICU physiotherapy adverse events, early mobilisation in ICU, critical care physiotherapy, respiratory physiotherapy, OP-induced delayed polyneuropathy, ventilator dependency, cholinergic toxidrome.

2.2 INCIDENCE AND PATHOPHYSIOLOGY OF ORGANOPHOSPHATE POISONING IN SOUTH AFRICA

The literature evidence on the incidence of OP poisoning in South Africa remains in its scarcity. Organophosphate poisoning, as described by Khonje et al. (2023), is a phenomenon that exists within low-income countries and very rarely within high-income countries. The World Health Organization estimates 250 000 – 300 000 deaths globally due to OP poisoning (Omar et al., 2020). Organophosphates are toxins that bind irreversibly to esterase enzymes, causing their inhibition (Robb et al., 2023). This pathophysiological process will result in various signs and symptoms that affect multiple organ systems (Hulse et al., 2019). The acute cholinergic syndrome is the initial phase of OP poisoning and is characterised by a cholinergic crisis. Within the initial 24 hours, patients often present with the following short-term signs and symptoms: bronchorrhea (increased mucus production in the bronchial tubes), bronchospasm, hypersalivation, bradycardia, emesis (vomiting), and diarrhoea (Hulse et al., 2019). Respiratory failure may occur in this phase due to localised pulmonary muscarinic effects or central nervous system depression (Robb et al., 2023). Many authors share that the organ system mostly affected by the cholinergic toxidrome, and often responsible for mortality, is the respiratory system (Carey et al., 2013; Peter et al., 2014;

Robb et al, 2023). Following the initial 24 hours, the individual may experience long-term signs and symptoms relating to the intermediate syndrome, which may last for two weeks. Hulse et al. (2019) report, in their clinical review, that the intermediate syndrome is characterised by paralysis of the proximal muscles, and this includes those necessary for respiration. A study conducted by Abdollahi and Karami-Mohajeri (2011) reviewed the clinical signs seen in the intermediate syndrome of OP poisoning as the most relevant for medical management. The intermediate syndrome is often followed by a delayed phase termed "organophosphate-induced delayed polyneuropathy" and is characterised by distal limb weakness as well as diaphragm paralysis (Hulse et al., 2019). Sahoo et al. (2018) commented on the clinical features of this stage and described an insidious increase in muscular tone and weakness of the distal part of the limbs. Neuromuscular pathology is often described according to three types of paralysis, which relate to a model of time to describe the signs and symptoms of OP poisoning: Type I, Type II, and Type III paralysis (Sahoo et al., 2018).

In South Africa (a country classified as developing), OP compounds can be found in illegal street drugs and non-food and drug administration (FDA) approved rat poisons (Khonje et al., 2023). The population of patients who present with OP poisoning at various hospitals within South Africa remains similar in number. Razwiedani and Rautenbach (2017) conducted a level II evidence epidemiological study on patients who presented with OP poisoning in the Tshwane District and reported on 207 cases from January 2012 until December 2014. In 2017, 168 patients presented to the emergency department at Chris Hani Baragwanath Academic Hospital, and this was reported on by Omar et al. (2020) in their level III retrospective comparative study on OP poisoning over two periods - 2012 and 2017. From November 2016 to October 2017, of the 288 patients diagnosed with a form of poisoning at Charlotte Maxeke Johannesburg Academic Hospital's emergency department, 25% had ingested OP (Laher et al., 2022). Recently, in 2023, Khonje et al. conducted a retrospective chart review that aimed to describe and review the clinical course, demographics, and mortality in patients diagnosed with OP poisoning and noted that 205 cases presented to the emergency department at TMRH from January 2020 to August 2021.

2.3 PROFILES, CLINICAL COURSE, AND OUTCOMES OF PATIENTS DIAGNOSED WITH ORGANOPHOSPHATE POISONING

In South Africa, Omar et al. (2020) reference suicidal ideation as one of the major causes of OP ingestion. Laher et al. (2022) confirm the latter and further note illegal substance abuse as a cause. The reports by Razwiedani and Rautenbach (2017) as well as by Khonje et al. (2023) note that OP poisoning is more prevalent in male adults and less likely in women, and

neither report on the reason therefore. The same study carried out by Khonje et al. (2023) at TMRH found that the median age of patients presenting with OP poisoning was 26 years, with a 13% mortality rate in all cases documented. An epidemiological study from the Tshwane District in South Africa (published in 2017) reports similar results to those of Khonje et al. (2023), with most of the OP poisoning cases observed in individuals younger than 40 years (Razwiedani and Rautenbach, 2017). Available evidence reveals that of the cases admitted to the emergency departments of various hospitals in South Africa, a smaller proportion of patients are often admitted to the ICU, and of the 168 cases in Soweto, 32 (19%) required ICU care (Omar et al., 2020). Laher et al. (2022) report that only 16 (5%) of 356 patients seen at the emergency department at Charlotte Maxeke Johannesburg Academic Hospital, diagnosed with a form of self-poisoning, required ICU admission, but it remains unclear as to how many of the 16 patients ingested OP. At TMRH, according to Khonje et al. (2023), 72 patients required intubation, but it cannot be assumed that all 72 patients met ICU-admission criteria and were admitted to the ICU. The same authors further report a survival rate of 81% for those with OP poisoning admitted to TMRH in Ekurhuleni District, where patients succumbed to complications due to sepsis, cardiac arrest, and the rebound effect of the pathology. Tshwane District, according to Razwiedani and Rautenbach (2017), experienced 7 deaths of the 207 reported cases, and Laher et al. (2022) report in their study that 5% of suicidal cases (13 participants) succumbed to death.

Khonje et al. (2023) and Bruins et al. (2019) were the only two articles reviewed for this study that highlight the medical management that patients with OP poisoning receive, which includes: atropine infusion, glycopyrrolate, as well as an oxime if available. Bruins et al. (2019) found the average ICU length of stay for patients with OP poisoning at Chris Hani Baragwanath Academic Hospital to be three days; they further report that patients diagnosed with OP poisoning had an average of three days on mechanical ventilation.

2.4 FACTORS THAT INFLUENCE CLINICAL OUTCOMES OF PATIENTS WITH ORGANOPHOSPHATE POISONING IN A SOUTH AFRICAN CONTEXT

Literature in South Africa highlights and introduces OP poisoning in terms of its epidemiology, brief medical management, as well as the patient profile, but there is minimal to no exploration on factors that influence the outcomes of these patients (Razwiedani and Rautenbach, 2017; Bruins et al., 2019; Omar et al., 2020; Laher et al., 2022; Khonje et al., 2023). Many of the international studies conducted in recent years, pertaining to the influential factors on the clinical outcomes of patients with OP poisoning, record and review the medical aspect of management (Vanova et al., 2018; Hulse et al., 2019; Reddy et al., 2020). Influential factors that are reported to impact on mortality, morbidity and hospital length of stay include the type

of OP ingested, use of home remedies to treat OP ingestion, time lag between OP ingestion and hospital admission, urban versus rural residence, type and dosage of medication used to manage patients with OP poisoning after admission, patient age, oxygen saturation, total leukocyte count, Glasgow Coma Scale scores, severity of patient's condition and availability of ICU beds (Amin et al., 2018; Shaik et al., 2018; Reddy et al., 2020; Tadesse et al. 2023). No studies were identified that investigated the influence of physiotherapy management provided to patients with OP poisoning in the ICU on their overall outcomes.

2.5 PHYSIOTHERAPY MANAGEMENT OF PATIENTS WITH ORGANOPHOSPHATE POISONING

Physiotherapists are healthcare professionals who are specialised in providing services to their patients or clients to help them maximize their functional mobility through assessment and examination, diagnosis, and intervention (World Physiotherapy, 2025). The aims of physiotherapy when managing patients with critical illness in an ICU environment include improving lung compliance and lung volume, aiding with the clearance of excessive retained secretions, optimizing oxygenation, recruitment of collapsed alveoli, and early mobilisation (Stiller, 2013).

No evidence exists on the physiotherapy management of patients with OP poisoning in South Africa, and much of the research reviewed was of international origin at a level III level of evidence. In 2018, Sahoo et al. reported on the rehabilitation that three patients diagnosed with OP poisoning received. The Specialist Unit for Review Evidence Appraisal Tool evaluates the validity and reliability of research studies by analysing the study design, methodology, results, and conclusion (SURE, 2018). For this study and due to the lack of available research, a SURE score above 50 percent was accepted, and this meant that the study design, source of participants, and results of the study by Sahoo et al. (2018) were acceptable (SURE, 2018). The case series by Sahoo et al. (2018) scored 55% on the Specialist Unit for Review Evidence appraisal outcome measure. Patients eligible for their case series presented with OP-induced delayed polyneuropathy and required physiotherapy management for spasticity, muscle weakness, and activities of daily living (Sahoo et al., 2018). A retrospective descriptive study commented on the effect that physiotherapy had on 20 patients, who were mechanically ventilated following an OP poisoning diagnosis, and statistically found improvement in static lung compliance and ventilation-perfusion 30- and 60-minutes post-intervention (Sikka and Mehra, 2016). A case report that scored 55% on the Specialist Unit for Review Evidence appraisal outcome measure discusses the physiotherapy management that a 48-year-old male received post OP poisoning diagnosis as: patient education, secretion mobilization, manual chest clearance, and incentive spirometry (Vikhe

et al., 2024). Salve et al. (2021) conducted an experimental study on 24 participants that aimed to review the effect that vertebral pressure and intercostal stretch techniques may have on patients diagnosed with OP poisoning. The aforementioned study reviewed the participants' respiratory rate, tidal volume, SpO2, and heart rate, and they found that respiratory facilitation techniques improved tidal volume and decreased respiratory rate and heart rate (Salve et al., 2021). The effects of respiratory neuromuscular facilitation techniques were evaluated in a comparative experimental study by Chordiya et al. (2017) for a group of 30 participants who were randomly sampled into group A (routine physiotherapy) and group B (physiotherapy with proprioceptive neuromuscular facilitation). Chordiya et al. (2017) noted that the addition of proprioceptive neuromuscular facilitation techniques improved static lung compliance, dynamic lung compliance, and minute ventilation.

2.5.1 Physiotherapy Interventions used for Managing Respiratory System Impairments

Various respiratory physiotherapy techniques can be used for the management of a patient admitted to the ICU (Stiller, 2013). In 2013, Stiller conducted a systematic review to assess the effectiveness of physiotherapy techniques used in the management of patients in the ICU, and evidence gave rise to the following techniques mostly used: manual hyperinflation, ventilator hyperinflation, suctioning, chest wall vibrations, and active mobility of patients at various functional levels. Early mobilization, which facilitates strength training, in the ICU is an important choice of treatment for patients presenting with respiratory pathology (Stiller, 2013). During the cholinergic phase that manifests within the first 24 hours after ingestion, patients present with bronchorrhea, bronchospasm, and in severe cases, respiratory failure (Hulse et al., 2019). Physiotherapy techniques are highly relevant in this phase, as many of the complications that patients with OP poisoning present with include excessive secretions, impaired airway clearance, and reduced gas exchange. Suctioning, postural drainage, airway clearance techniques, and manual and ventilator hyperinflation (Stiller, 2013) are directly applicable to manage these symptoms and to prevent airway obstruction and atelectasis.

Lottering and van Aswegen (2016) conducted a survey to review the physiotherapy practice in South African ICUs, and found that the most common physiotherapy techniques, in practice at the time, were active cycle of breathing techniques, nebulisation, manual chest clearance techniques, postural drainage, patient positioning, suctioning, and incentive spirometry. In 2015, Skinner et al. published an observational cohort study that aimed to report on the usual physiotherapy care and modalities for patients in a single Australian ICU. The authors noted that the techniques most frequently used (as seen later with the South African-based study in 2016 by Lottering and van Aswegen) are: ventilator hyperinflation, head-down tilt, suctioning, early mobility, deep breathing, active cycle of breathing, positive expiratory pressure, and nebulisation with normal saline (Skinner et al., 2015). These findings

suggest that physiotherapists already provide core respiratory support to patients in ICUs, and when applied to OP poisoning patients—who suffer predominantly from respiratory compromise—these techniques are highly appropriate and clinically justified.

Despite the gap in the existing evidence on the physiotherapy management of patients with OP poisoning, physiotherapists who work in South African ICU settings tend to use respiratory physiotherapy techniques for patient management that correlate with those reported by Stiller et al. (2013) and Skinner et al. (2015).

2.5.2 Physiotherapy Interventions used in the Management of Neuromusculoskeletal System Impairments

International literature supports the importance of physiotherapy for patients diagnosed with OP poisoning by introducing its various phases and its impact on the functional abilities of the patient (Sahoo et al., 2018). The existing studies in South Africa, of patients presenting with OP poisoning, do not delve into the specific neuromusculoskeletal effects (Razwiedani and Rautenbach, 2017; Omar et al., 2020; Laher et al., 2022; Khonje et al., 2023). When reviewing the evidence on the physiological effects of OP poisoning, on the neuromusculoskeletal system, it is known that the down-regulation of nicotinic receptors (N1 receptor at the neuromuscular junction) leads to muscle fasciculations, muscle weakness and in severe cases muscle paralysis as described in the Type I (weakness, fasciculations and muscle cramps), Type II (proximal muscle weakness, respiratory muscle weakness and cranial nerve palsy) and Type III (distal limb weakness, cranial nerve palsies, laryngeal paralysis and diaphragmatic paralysis) paralysis phases (Peter et al., 2014).

The general clinical practice for patients admitted to the ICU will be considered, as no evidence exists on the neuromusculoskeletal physiotherapy management of patients diagnosed with OP poisoning in South Africa. The latter affects the ability to compare national and international studies on their physiotherapy management. For all patients who are admitted to the ICU, the aims of neuromusculoskeletal physiotherapy are discussed in literature to assist with functional independence upon discharge from the unit (Hodgson and Tipping, 2016), improve muscle strength (De Paula et al., 2023), early activity and mobility to alter the outcome of critical illness (Skinner et al., 2015), reduce the risk of ICU acquired weakness and to reduce injury to skeletal muscle, due to minimal joint loading (Doiron et al., 2018).

Physiotherapy evidence for the management of patients diagnosed with OP poisoning exists in its scarcity and only in the form of case reports. In 2024, Vikhe et al. conducted a case

report that scored 55% on the Specialist Unit for Review Evidence appraisal outcome measure, as mentioned earlier. The aims for musculoskeletal physiotherapy were to prevent complications due to immobility by prescribing upper and lower limb mobility exercises and positioning every two hours. The case report noted the importance of movement and mobility for the 48-year-old patient by initiating sit-to-stand exercises, mobility with assistance that then progressed to independent mobility (Vikhe et al., 2024).

Sahoo et al.'s (2018) case series on three patients presenting with OP-induced delayed polyneuropathy highlights the physiotherapy management received by the patients to be: stretching of spastic contracted muscles, strengthening exercises, and proprioceptive neuromuscular facilitation. Sahoo et al. (2018) document that all patients presented with clinically significant improvement in upper and lower limb function as well as mobility and activities of daily living at the end of their eight-week rehabilitation program.

Recently, in 2024, a case study was published by Khan et al. (in India) that scored 75% on the Specialist Unit for Review Evidence appraisal outcome measure. The case report documents the physiotherapy management received by a 40-year-old male who had ingested OP poisoning and then presented with motor axonal polyneuropathy (Khan et al., 2024). The patient received active-assisted range of movement exercises and passive range of movement exercises to maintain and improve his joint range of movement (Khan et al., 2024). The author notes that the patient received proprioceptive neuromuscular facilitation to normalise tone (Khan et al., 2024). As liken to the previous case reports, the patient received bed mobility exercises, manual positioning to avoid pressure sores, balance retraining to improve standing balance, as well as ambulatory exercises, and his functional ability improved at the end of his six-week rehabilitation program (Khan et al., 2024).

Doiron et al. (2018) conducted a systematic review on the effects of early mobilization (for the general population of patients admitted to the ICU) on functional mobility, muscle strength, and health-related quality of life. The study found that bed rest predisposed the patient to decreased functional capacity, difficulty weaning from mechanical ventilation, and muscle weakness (Doiron et al., 2018). The systematic review does not comment on the exact physiological implications that immobility may have on the patients' organ systems but notes the interventions used by the physiotherapists, to address the negative effects of bed rest, to be: cycle ergometry, active assisted exercises, active range of movement exercises, bed mobility exercises, retraining of activities of daily living, transfer training, pre-gait exercises and ambulation (Doiron et al., 2018). In South Africa, Lottering and van Aswegen (2016) conducted a cross-sectional, quantitative, descriptive survey where most of their

respondents noted frequency of in and out of bed patient mobilisation as well as peripheral joint strengthening exercises.

Although the above can not correctly be compared to the management of patients with OP poisoning, these patients present with neuromusculoskeletal impairments (Khan et al., 2014; Sahoo et al., 2018; Vikhe et al., 2024) that would benefit from the general practice guidelines used nationally and internationally.

2.6 COMPLICATIONS AND ADVERSE EVENTS ASSOCIATED WITH ORGANOPHOSPHATE POISONING

2.6.1 Complications Associated with Organophosphate Poisoning

In addition to the signs and symptoms of OP poisoning (muscarinic and nicotinic side effects), patients may present with further complications noted in the existing evidence (Sikka and Mehra, 2016; Chordiya et al., 2017; Hulse et al., 2019; Bhakaney et al., 2024; Vikhe et al., 2024). In the clinical review by Hulse et al. (2019), the complications noted are respiratory failure, reduced consciousness, aspiration pneumonia, and recurrent cholinergic toxicity.

The case review by Bhakaney et al. (2024) commented on a physiotherapy protocol to prevent pulmonary complications as well as hospital-acquired diseases, but provides no further information on the exact protocol followed. The complications observed, amongst patients with OP poisoning, in the retrospective descriptive study by Sikka and Mehra (2016) were respiratory failure, ventilator-associated pneumonia, aspiration pneumonia, barotrauma, and septicemia. As with Chordiya et al. (2017), Bhakaney et al. (2024) mention the importance of preventing pulmonary complications, but no further information is provided on the specifics of those pulmonary complications.

2.6.2 Adverse Events Associated with Organophosphate Poisoning

Of the South African studies on OP poisoning discussed in this review, the physiotherapy-specific adverse events are rarely documented (Razwiedani and Rautenbach, 2017; Omar et al., 2020; Laher et al., 2022). Khonje et al. (2023) briefly highlight changes in the patient's Glasgow Coma Scale, hallucinations, tachycardia, absent bowel sounds, and urinary retention as an adverse reaction to atropinisation, not relating to physiotherapy. The literature on physiotherapy and OP poisoning is scarce and in the form of case reports, and of those reviewed, there is no mention of adverse events to the management received (Sikka and Mehra, 2016; Chordiya et al., 2017; Sahoo et al., 2018; Salve et al., 2021; Bhakaney et al., 2023; Khan et al., 2024; Vikhe et al., 2024).

Although not common, when Skinner et al. (2015) reported on the usual care of physiotherapy practice received by patients in ICU, it was documented that at least three point five percent of treatment entries reported on a drop in blood pressure as an adverse event. A Cochrane review on early mobilisation and exercises for critically ill patients noted a low incidence of adverse events (mortality, dislodging of devices, reintubation, falls, and desaturation) during physiotherapy, therefore supporting the clinical competence of physiotherapists for safe mobility in critical care units (Doiron et al., 2018).

2.7 INSTRUMENTATION AND OUTCOME MEASURES

A data capture form **[Appendix B]** was developed, based on clinical practice at TMRH. There was no content validation done, and the data capture form was reviewed by the university supervisor. The form included information about the patient profile, patient's clinical course and outcome, adverse events and associated complications, physiotherapy-specific outcome measure results, and physiotherapy treatment provided. A hard copy of the form was made available to the participating physiotherapist, where the patient participant's information was recorded.

The profile of each participant was assessed, and information on gender, age, residence, employment status, and cause for OP poisoning was included. The clinical course of the participant served as an outcome measure by reviewing the participant's length of stay in the ICU, where the participant was discharged to from the ICU (e.g., rehabilitation center, medical ward, or home), and whether they required a physiotherapy follow-up appointment or not. The mortality rate of the participants was documented. The clinical outcome was assessed by documenting any complications during the participant's length of stay in the ICU as well as any adverse events during physiotherapy sessions (e.g., falls, desaturation, and accidental removal of attachments). Physiotherapy-specific outcome measure results were documented daily: the patient's PEF rate, the Medical Research Council Sum-Score (MRC-SS), and the Functional Status Score for the Intensive Care Unit (FSS-ICU).

2.7.1 Peak Expiratory Flow

A peak flow meter is an inexpensive tool that is used to measure the PEF rate as well as the cough PEF (Reshmarani and Veena, 2020). The PEF rate, sensitive and accurate, can provide information about the lung recoil capabilities for the biomechanical response to a respiratory irritant, as well as respiratory muscle strength (Reshmarani and Veena, 2020). Mistry and Pathak (2024) aimed to evaluate the PEF rate in males and females according to anthropometric measures (weight and height) and noted that the normal ranges of PEF rate in healthy males are 360-900 L/min and 169-600 L/min in females.

The cough peak flow has been assessed in clinical practice to evaluate the respiratory function, and it has been documented that an individual presenting with critical illness requires at least 50% of vital lung capacity for effective respiratory function (Brennan et al. 2022). Inspiratory and expiratory muscle strength, airway obstruction, restrictive lung disease, and neuromuscular disease often cause a reduction in the PEF rate and ultimately the cough flow rate (Brennan et al. 2022). Limited research exists on the reliability and validity of the PEF meter for patients admitted to the ICU, but a retrospective cohort study done to assess the reliability and validity of the PEF meter to assess cough peak flow in patients with neuromuscular disorders found high intra-rater reliability and criterion-related validity (Kuroiwa et al., 2024). Therefore, the researcher found PEF a useful outcome measure to monitor amongst patients with OP poisoning.

The PEF of each participant was measured upon extubation, and when the patient had a level of consciousness that allowed them to follow instructions well on how to conduct the test. An image of the PEF rate meter can be seen below.



Figure 3.1: Peak Expiratory Flow Rate Meter

2.7.2 Medical Research Council Scale Sum Score

The Medical Research Council-sumscore (MRC-SS) is a readily available and inexpensive tool used to evaluate the muscle strength of patients receiving critical care management. Literature has supported the usage of the MRC-SS to determine the presence of ICU-acquired weakness in critically ill patients (Hermans and Van den Berghe, 2015). The summative score, which can range from 0 – 60, informs the healthcare practitioner of whether the patient has significant weakness (a score less than 48) or severe weakness (a score less than 36) (Hermans and Van den Berghe, 2015). The scale evaluates the global muscle strength responsible for shoulder abduction, elbow flexion, wrist extension, hip flexion, knee extension, and ankle dorsiflexion (Hermans and Van den Berghe, 2015). The results of the

MRC-SS can be used in conjunction with the FSS-ICU as a predictor for functional mobility (Hermans and Van den Berghe, 2015).

Fontela et al. (2021) report that patients with critical illness present with weakness of the respiratory and peripheral muscles and therefore found the MRC-SS to be a good predictor of spontaneous breathing test failure and difficulty weaning from mechanical ventilation. In 2024, a meta-analysis by Jochem et al. found strong correlations between a decrease in muscle strength and a one point eight fold increase in the risk of death in critically ill patients.

Hermans and Van den Berghe (2015) report on the importance of physiotherapy to reduce immobility in critically ill patients to improve the outcome of their MRC-SS. In 2023, Dos Santos et al. conducted a pilot cross-sectional study on the common contents between the MRC-SS, Physical function in ICU Test-scored, and the FSS-ICU and found that the MRC-SS had high inter-rater reliability in the ICU. Due to the physiological effects that OP poisoning has on the neuromusculoskeletal system (Sahoo et al., 2018; Hulse et al., 2019; Robb et al., 2023), the researcher found it imperative to assess the muscle strength of participants and review the effects that physiotherapy may have on the final MRC-SS outcome.

2.7.3 Functional Status Score for The Intensive Care Unit

It is not uncommon for critically ill patients to present with functional abnormalities whilst in the ICU setting and long after discharge from the unit (Jayachandran et al., 2024). Critically ill patients in the ICU often require various treatments that restrict their movement out of bed, and coupled with a potential inflammatory response, this will cause muscle atrophy (Tipping et al., 2017). Parry et al. (2015) describe the FSS-ICU as a tool that assesses five functional tasks of an individual (rolling, sitting, laying to sitting, sitting on the edge of the bed, sit to stand, and walking). Each of the five functional items (physical tasks) is scored on a seven-point system, and a higher score indicates a higher functional mobility (Parry et al., 2015). The inability to perform basic mobility tasks (such as rolling, moving from supine to sitting, sit to stand transfer, sitting on the edge of the bed and walking) can negatively impact the individual's health-related quality of life and mental well-being, and an improvement in a patient's FSS-ICU score can translate to the premorbid functional status at hospital discharge (Parry et al., 2015 and Jayachandran et al., 2024). The meta-analysis by Tipping et al. (2017) found that active mobilisation in the ICU improved body function at ICU discharge, ensured minimal activity limitations at hospital discharge, and limited participation restriction at six months after hospital discharge. The assessment findings from the tool will help the treating physiotherapist plan an appropriate rehabilitative program for the patient, as it is assessed before every physiotherapy treatment session (Parry et al., 2015). It shows minimal limitations for cross-cultural adaptation and translation, and for this reason, the inter-rater

reliability remains high (Parry et al. 2015). Dos Santos et al. (2023) note “excellent” validity in the ICU setting.

2.8 CONCLUSION OF THE LITERATURE REVIEW

In South Africa and other low-income countries, OPs are compounds found in illegal street drugs and non-FDA-approved poisons and are toxins often screened for in suicidal ideation cases (Laher et al., 2022, and Khonje et al., 2023). The OP’s mechanism of action causes a cholinergic toxidrome that affects multiorgan systems, which can cause mortality, although at a low incidence (Razwiedani and Rautenbach 2017; Bruins et al. 2019; Omar et al. 2020; Laher et al. 2022; Khonje et al. 2023). The OP poisoning cases seen in South African ICUs range from 16 to 72 patients (according to the study's specific data collection period), and these patients often required mechanical ventilation, with a higher incidence of males than females (Razwiedani and Rautenbach, 2017; Bruins et al., 2019; Omar et al., 2020; Laher et al., 2022; Khonje et al., 2023). Various factors can influence the clinical outcome of patients diagnosed with OP poisoning and they are, the time lapse between OP ingestion and medical intervention, the type of pharmacological therapy, Glasgow Coma Scale, laboratory findings of pseudocholinesterase and leukocyte levels, rural or urban residence, type of OP ingested, home remedies taken and SpO2 (Amin et al., 2018; Shaik et al., 2018; Reddy et al., 2020; Tadesse et al., 2023). The evidence on the physiotherapy management of patients diagnosed with OP poisoning exists in case reports and includes physiotherapy techniques such as: patient education, secretion mobilisation, incentive spirometry, manual chest clearance techniques, respiratory neuromuscular facilitation, strength retraining, range of movement exercises, transfer training, pre-gait exercises and mobility retraining (Sikka and Mehra, 2016; Chordiya et al., 2017; Doiron et al., 2018; Sahoo et al., 2018; Hulse et al., 2019; Bhakaney et al., 2024; Khan et al., 2024; Vikhe et al., 2024). Sikka and Mehra (2016) summarised the OP poisoning complications as respiratory failure, ventilator-associated pneumonia, aspiration pneumonia, barotrauma, and septicaemia. Little to no evidence exists on the physiotherapy-related adverse events for patients diagnosed with OP poisoning (Doiron et al., 2018).

The Peak Expiratory Flow (PEF) is a simple, inexpensive tool that evaluates lung recoil, cough strength, and respiratory muscle function, with reduced values seen in neuromuscular and respiratory diseases; it is reliable for ICU monitoring and relevant for OP poisoning patients (Reshmarani & Veena, 2020; Brennan et al., 2022; Kuroiwa et al., 2024). When reviewing the Medical Research Council Sum Score (MRC-SS), it is used to assess global muscle strength in ICU patients, help identify ICU-acquired weakness, predict ventilator weaning outcomes, and correlate muscle weakness with mortality risk (Hermans & Van den Berghe, 2015; Fontela et al., 2021; Jochem et al., 2024). Physiotherapy interventions play a

vital role in improving MRC-SS outcomes by reducing immobility and preserving muscle strength (Hermans & Van den Berghe, 2015; Dos Santos et al., 2023). The Functional Status Score for the ICU (FSS-ICU) measures five key mobility tasks—rolling, sitting, transfers, and walking—and provides insight into functional recovery, quality of life, and long-term participation (Parry et al., 2015; Tipping et al., 2017; Jayachandran et al., 2024). Both MRC-SS and FSS-ICU demonstrate high reliability and validity in ICU settings, making them essential outcome measures for guiding physiotherapy treatment and rehabilitation in OP poisoning patients (Parry et al., 2015; Dos Santos et al., 2023).

CHAPTER 3

3. METHODOLOGY

The STROBE guidelines and checklist were used to report on this study **[Appendix A]**.

3.1 TYPE OF THE STUDY

A prospective longitudinal descriptive study design was used.

3.2 STUDY SETTING

Thelle Mogoerane Regional Hospital is situated in the Ekurhuleni District of South Africa (one of the hospitals within this district) and provides essential services for the management of patients with OP poisoning. At least eight OP poisoning cases are seen per week in the emergency department, and of these cases, at least three are transferred to the ICU per week. All patients admitted to the ICU are screened daily for physiotherapy treatment by the physiotherapy clinicians. The physiotherapy clinicians describe the standard physiotherapy management that patients with OP poisoning receive as respiratory physiotherapy (manual chest clearance techniques, tracheal and oral suctioning, active cycle of breathing, deep breathing exercises, thoracic mobility, and respiratory muscle training) and neuromusculoskeletal physiotherapy (range of movement exercises, strengthening exercises, balance retraining, mobility out of bed, and gait re-education). The physiotherapy clinicians report that patients receive treatment once per day, and bi-daily treatments would be given to patients upon request from the intensivist in the unit.

3.3 RESEARCH PARTICIPANTS

3.3.1 Source of Participants

The source of the participants for this research study was from TMRH. Potential participants were identified as they were admitted into the hospital's ICU.

3.3.1.1 Inclusion criteria

- Patients with a confirmed medical diagnosis of OP poisoning
- Male and female patients 18 years and older.

3.3.1.2 Exclusion criteria

The patient's medical record was reviewed for the following documented clinical notes on the exclusion criteria:

- A formal diagnosis of respiratory pathology (e.g., chronic obstructive pulmonary disease, interstitial lung diseases, acute lung disease) before OP poisoning.
- A formal diagnosis of physical disability (e.g., paraplegia, quadriplegia, hemiplegia, cerebral palsy, limb amputation) before OP poisoning.

- A formal diagnosis of cognitive impairments (e.g., delirium, psychosis, amnesia) before OP poisoning.

3.3.2 Sample Size and Sampling Method

The sample size was estimated from the incidence of OP poisoning cases managed by the multidisciplinary team at TMRH ICU. Before the study, a total of 42 patients were admitted to the ICU with OP poisoning over five months (October 2019 – February 2020). Thus, the average number of patients with OP poisoning admitted per month was 8.4. A minimum sample of 96 patients with OP poisoning was therefore estimated to be admitted to the TMRH ICU over a 12-month data collection period. A purposive sampling strategy was used to identify all potential participants for this study, from those admitted consecutively to the TMRH ICU with OP poisoning. No formal sample size estimation was made, as the purpose was to include all consenting patients' data in the study, as the study was observational, not experimental, in nature.

3.4 INSTRUMENTATION AND OUTCOME MEASURES

Instrument	Description	Instruction
Peak Expiratory Flow	Measures the PEF rate as well as cough PEF	PEF measured upon extubation with the appropriate level of consciousness
Medical Research Council Scale Sun Score	Evaluate muscle strength	Global muscle strength is measured at each physiotherapy session
Functional Status Score for the Intensive Care Unit	Assesses functional abnormalities	Functional tasks are assessed at each physiotherapy session

3.5 ETHICAL CONSIDERATIONS

Ethical clearance was obtained from the University of the Witwatersrand Human Research Ethics (Medical) (HREC) Committee, and an ethical clearance certificate was issued (certificate nr: M211166) **[Appendix C]**. Permission to conduct research at the hospital was obtained from the CEO's office at TMRH **[Appendix D]**. A request for permission to conduct the study was made at the National Health Research Database, and it was noted that the aforementioned request would only be necessary for research conducted at clinics and that

hospital permission would be sufficient. For the participation of the physiotherapists, permission was obtained from the head of the physiotherapy department **[Appendix E]**. Before commencement of the study, the researcher completed Module One: Introduction to Research Ethics of the online TRREE course (https://elearning.trree.org/), and the certificate of completion was submitted to the supervisor and the Wits University HREC (Medical) committee **[Appendix F]**.

The process and reason for the study were thoroughly explained to the participant and the next of kin, and they were given the relevant information sheet **[Appendix G].** Temporary consent was obtained from the participant or family member whilst they were in the ICU. Written consent was obtained as soon as they presented with a full level of consciousness, and if the patient refused, they were no longer considered a participant in the study and their data was excluded from the analysis. The study upheld ethical conduct according to the Declaration of Helsinki by ensuring that the health of the patient was the study's main priority (World Medical Association Declaration of Helsinki, 2001). The participant's right to privacy and confidentiality of personal information was respected. The researcher obtained the completed data capture forms weekly from the treating physiotherapist, who stored the data capture forms in a locked drawer in the Physiotherapy department that had controlled access measures in place. The declaration alludes to a conduct that encourages the protection of the above personal information, and the clinician, physiotherapists, and the researcher adhered to this by ensuring each participant was given a unique identification, for anonymity, and data information was stored in a locked drawer in the physiotherapy department (World Medical Association Declaration of Helsinki, 2001). This also adhered to the Protection of Personal Information Act (No. 4 of 2013), which prohibits any infringement of the latter (South African Government, 2013). Participants remained anonymous to the researcher throughout the study, and all information obtained was only used for this research study.

3.6 PROCEDURE

3.6.1 Physiotherapist Recruitment

Permission was obtained from the head of the TMRH physiotherapy department **[Appendix E]** that allowed for the research study to be conducted. Three main clinician physiotherapists who volunteered to participate as research assistants received training from the researcher about the purpose of the study, its aims and objectives, and data collection procedures to be followed, in an orientation meeting. The research assistants were not remunerated but were allowed to collaborate in writing a paper for publication, and if they refused, they would be acknowledged in the paper. The research assistants remained consistent throughout the data collection period; therefore, no further training was required, although weekly feedback sessions were held between these research assistants and the researcher to clarify any

challenges that they may have experienced. These challenges pertained to documentation of treatment for patients who were not suitable for treatment (documentation was still to continue), difficulty following up patients in the wards, and recording epidemiological data (appropriate data to be recorded onto the data capture form **[Appendix B]**).

3.6.2 Physiotherapy Management Monitoring

The ICU at TMRH was screened by the physiotherapist in charge of the unit daily for potential research participants. The research assistants would explain the purpose of the study **[Appendix G]** to the patient or next of kin, and they would then obtain consent for participation in the study from the participant **[Appendix H].** If the patient was not able to provide consent immediately, the research assistants would obtain consent from the patient's next of kin to capture their data on the specifically designed data capture form **[Appendix B]**. The researcher provided the necessary support to the therapist treating the patient on how to complete the form. The data capture form was completed from day one to day seven of admission, then on day 10, day 14, and at discharge from the ICU. If the patient's level of consciousness influenced their ability to grant consent to participate, the research assistants would obtain consent from the participant's next of kin or the medical professional in charge of the ICU. During that process, the research assistants reviewed the hospital file and questioned the respective individual on any pre-existing cognitive, respiratory, or physical disability that the patient had before hospital admission, before agreeing to participate. If the participant regained consciousness and they exercised their right to refusal, their clinical findings were safely and ethically discarded and not included in data analysis.

Once consent was obtained, the participant's information was sourced from the ICU chart and the patient's hospital admission file and documented on the study-specific data capture form. The physiotherapy session was conducted in English, as per norm in the ICU, and if the patient did not understand English, the physiotherapist treating the patient would ask a family member or ICU staff member to translate. When the treatment provided to the participant came to an end, the physiotherapist recorded the date and the reason for treatment cessation and documented the last assessment and treatment findings.

Data was collected and captured over 18 months from October 2022 to March 2024. During the period of data collection, the researcher had a 10-minute meeting with the physiotherapy clinicians at the end of every week, where necessary, to assist them with any queries pertaining to the data collection process. When the data capturing period came to an end, the researcher informed the physiotherapists of this and that they were to only continue capturing the data of the last participant.

In the unforeseen event, during a physiotherapy treatment session, where any of the adverse events occurred (e.g., the participant fell, presented with a SpO_2 of less than 80% according to the ICU protocol, or a medical item in situ dislodged), the medical staff in the ICU were informed and the necessary protocol was adhered to.

The research assistants were responsible for data cleaning and capturing all participant information from the hard copy forms into Microsoft Excel.

3.7 BIAS

The process of data collection was strictly adhered to by the research assistants in order to eliminate bias in data sampling. The researcher developed a standardised data capture form **[Appendix B]** that was used for all participants. The researcher provided training to the physiotherapy clinicians on how to capture participant information. The researcher was available for weekly consults to address any concerns relating to data capturing that the physiotherapy clinicians may have had. The data was reviewed weekly by the researcher to identify and address any potential issues relating to missing data. The data-capturing forms were kept anonymous to prevent biased interpretation during data analysis.

3.8 DATA ANALYSIS

The data captured in Excel was imported into IBM Statistical Package for the Social Sciences (SPSS) version 29 software for analysis. In the case of missing data, the last observation carried forward principle was used except where a participant died or was discharged. Data was collected up to the point of the participant's discharge or demise and not carried forward into analytics. Descriptive statistics were used to summarise the data. Categorical data were summarized as frequency/number and percentages. Continuous data were summarized as mean and standard deviations (normal data distribution) or median and interquartile ranges (non-normally distributed data). The Shapiro-Wilk test was used to determine the distribution of data. Inferential statistics were used to assess changes in FSS-ICU and MRC-SS over time. Changes observed in outcomes over time (first assessment versus assessment at discharge) were determined using a paired t-test for within-participant analysis. To determine if an association exists between MRC-SS at ICU discharge and ICU length of stay, as well as between the number of days lapsed before the first physiotherapy session received and ICU length of stay, the Spearman correlation was calculated. Interpretation of r-values was done according to the guidelines published by Akoglu (2018). To determine if the number of physiotherapy sessions received during ICU stay (<median number of treatments and >median number of treatments) was associated with the need for reintubation (Yes/No), the Chi-squared test was used. In addition, Eta was calculated to assess the strength of association between the need for reintubation and the number of physiotherapy treatment

sessions provided. Similar Chi-squared calculations were made to determine if the need for reintubation (Yes/No) was associated with the MRC-SS (<median score and >median score). Throughout, testing was done at the $p<0.05$ level of significance.

3.9 DATA MANAGEMENT

Raw data were stored in a password-protected file on the researcher's computer and in a Microsoft password-protected online cloud space. The data will be kept for two years (if a manuscript is published from this study) and then destroyed. Alternatively, data will be stored for six years, according to the policies of the University of the Witwatersrand.

3.10 CONCLUSION OF THE METHODOLOGY

This chapter has provided an in-depth explanation of the study design and setting, study criteria, instruments used, and outcomes assessed, data collection procedure, and data analysis process followed. In addition, all relevant ethical considerations and permissions received were discussed.

CHAPTER 4

4. RESULTS

4.1 INTRODUCTION

All patients admitted to the ICU at TMRH during the study period with OP poisoning were invited to participate in the study. All patients eligible for the study presented with no preexisting neurological, respiratory, or ambulatory disabilities or disorders. Of the 655 patients admitted to TMRH ICU during the study period, 118 were diagnosed with OP poisoning and were possible participants for the study. Of the 118 participants, 62 were excluded due to age, lack of consent due to mortality, decline in participation, or incomplete and missing data. In total, 56 participants were included, which represents 58% of the anticipated 96 patients that were expected to be included in the study (Chapter 3, section 3.3.2). The recruitment of participants to the study can be seen in Figure 4.1

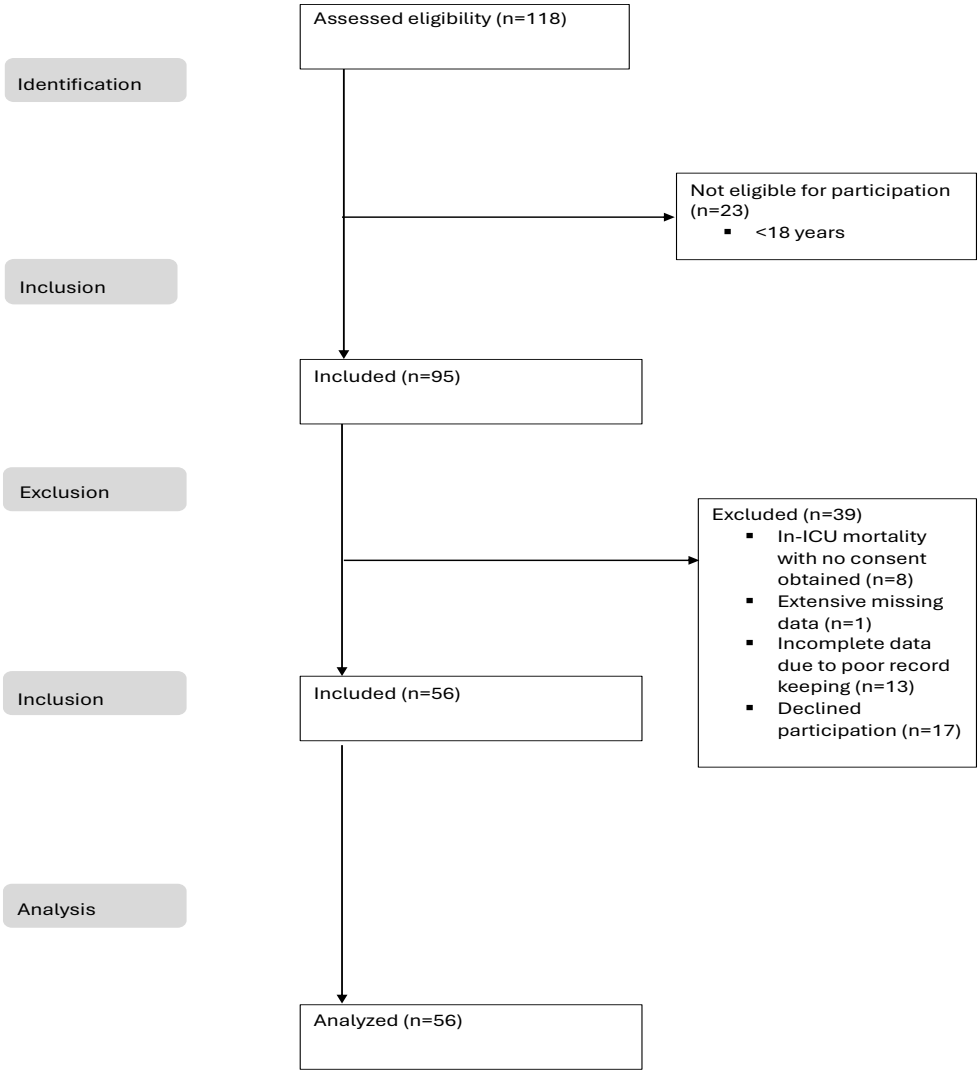


Figure 4.1: Flow Diagram of Participant Recruitment to the Study

4.2 PARTICIPANTS

4.2.1 Incidence of OP Poisoning

This study found that 118 patients were admitted to the ICU during the study period with OP poisoning. The incidence of OP poisoning cases admitted to the ICU at TMRH from October 2022 to March 2024 was 18% (n=118/655), with 23 patients under the age of 18.

4.2.2 Profile of Patients

Of the participants included in the study (n=56), the median age was 29 (IQR:24-40) years. The sex distribution shows that there was a higher male admission rate (n=36, 64%) than a female admission rate (n=20, 36%). The researcher found that 100% of the participants (n=56) resided in the Ekurhuleni District (Vosloorus and surrounding areas). The data revealed that 63% (n=34) of the participants were unemployed, with two (4%) participants on a pension grant. Most of the participants ingested OP poisoning intentionally (n=36, 64%), 34% (n=19) reported accidental exposure, and only one participant (2%) reported forced ingestion.

4.2.3 Clinical Course of Participants

The median ICU length of stay was seven (IQR: 4-11) days, and the median hospital length of stay was 9 (IQR: 5-12) days. Of the patients admitted (n=56) to the ICU, 68% required mechanical ventilation for a median of two (IQR: 0-5) days.

None of the participants required admission to a rehabilitation center after discharge from the hospital, where 68% (n=38) of the participants were discharged home from the ICU, 23% (n=13) were transferred to the hospital's psychiatric ward, and 9% (n=5) demised. All the participants discharged from the ICU (n=38) did not require outpatient physiotherapy.

4.3 PHYSIOTHERAPY MANAGEMENT

It took a median of two (IQR: 1-3) days till the participants (n=56) received their first physiotherapy session. Each participant received a median of four (IQR: 2-6) physiotherapy sessions, where no patient received bi-daily physiotherapy (Figure 4.2). It is noted that two percent (n=1) received no physiotherapy and that two percent (n=1) received 18 physiotherapy sessions.

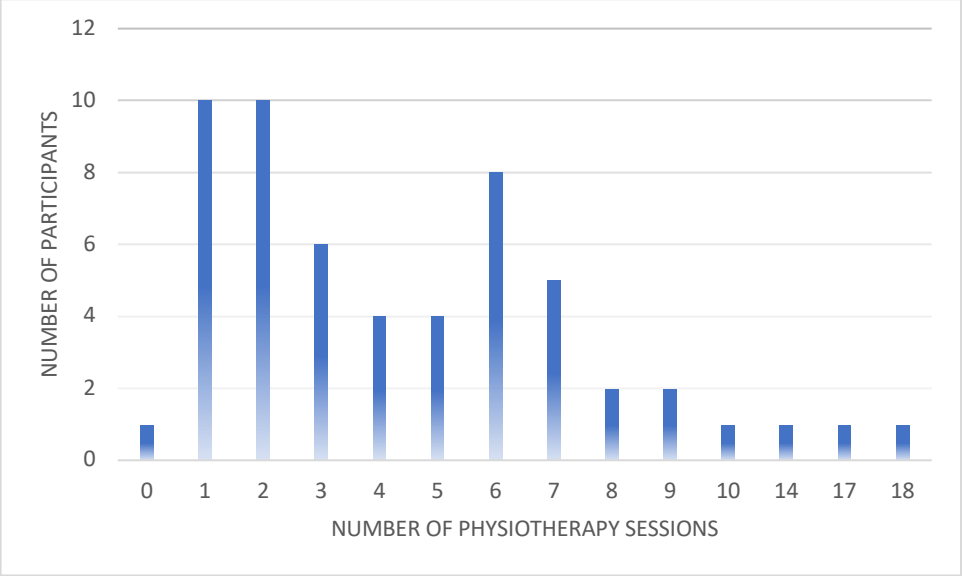


Figure 4.2: Number of Physiotherapy Sessions During ICU Stay

The respiratory physiotherapy treatment techniques are displayed in table 4.1 and it is noticeable that the most common respiratory physiotherapy techniques used were: manual chest clearance techniques (n= 33; 59%), suction (tracheal or oral) (n=37; 66%), positioning to improve ventilation-perfusion matching (n=19; 34%) and active cycle of breathing technique (n=10; 18%). These modalities were mostly used for patient care on days one to 14 of the participant's ICU stay. None of the clinician physiotherapists recorded using positive expiratory pressure therapy or incentive spirometry as part of their patient management in the ICU.

The neuromusculoskeletal physiotherapy treatment techniques are displayed in table 4.2 and it is noticeable that the most common treatment techniques used were: joint range of movement (n=33;59%), sitting on the edge of the bed (n=9; 16%), sit to stand (n=10; 18%), marching on the spot (n=7; 13%) as well as assisted (n=4; 7%) and independent mobility (n=7; 13%). These modalities were mostly used for ICU patient care on days one to 14 for joint range of movement, sitting on the edge of the bed as well as marching on the spot, and on days one to 10 for sit-to-stand and assisted and independent mobility. None of the clinician physiotherapists recorded using balance (static or dynamic) exercises or peripheral or core strengthening exercises as part of patient care in the ICU.

Table 4.1: Respiratory Physiotherapy Treatment Techniques

Respiratory Treatment	Days in ICU									
	1	2	3	4	5	6	7	10	14	Number of Patients
Manual chest clearance techniques (percussion, vibration, shaking)	33	29	19	15	10	7	8	5	1	
Suction	37	0	21	17	11	7	8	4	4	
Positioning to improve Ventilation/perfusion matching	19	1	8	6	6	7	4	1	2	
Active cycle of breathing techniques	10	3	5	5	4	5	5	4	1	
Deep breathing exercises	5	5	3	3	3	0	0	0	1	
Postural drainage	4	3	2	1	1	1	0	0	0	
Forced expiratory techniques	1	4	0	0	1	1	1	0	0	
Manual hyperinflation	0	1	0	0	0	1	1	1	0	
Inspiratory muscle training	2	0	0	0	1	0	0	0	0	
Incentive Spirometry	0	0	0	0	0	0	0	0	0	
Positive expiratory pressure	0	0	0	0	0	0	0	0	0	

Table 4.2: Neuromusculoskeletal Physiotherapy Treatment Techniques

Neuromusculoskeletal Treatment	Days in ICU									
	1	2	3	4	5	6	7	10	14	Number of Patients
Joint range of movement	33	21	18	17	9	7	9	4	4	
Sitting on the edge of the bed	9	8	5	6	6	3	4	1	1	
Sit to stand	10	7	7	4	6	2	1	2	0	
Peripheral joint gravity resisted strength	3	3	5	8	6	4	5	1	2	
Marching on the spot	7	5	5	3	4	1	2	3	1	
Assisted mobility	4	2	3	4	5	4	2	2	0	
Independent mobility	7	6	2	1	3	3	1	2	0	
Rolling	2	1	2	4	1	2	2	1	1	
Laying to sitting	3	3	1	2	0	2	1	0	1	
Core strength	1	0	1	1	1	1	2	1	2	
Peripheral joint therapist resisted strength	0	0	0	0	1	3	2	1	2	
Bridge	3	0	0	1	0	0	1	0	0	
Static Balance	0	0	0	0	0	0	0	0	0	
Dynamic Balance	0	0	0	0	0	0	0	0	0	
Peripheral joint weight resisted strength	0	0	0	0	0	0	0	0	0	
Core strength weight resistance	0	0	0	0	0	0	0	0	0	

The participants presented with a median FSS-ICU score of 30.5 (IQR: 18-34) with the lowest final score at 0 (n=7; 13%) and the highest final score at 35 (n=13; 23%). Therefore, only 24% (n=13) of participants had independent functional ability upon discharge from the ICU.

There was a median MRC-SS of 42 (IQR: 36-48) with the lowest final score at 0 (n=7) and the highest final score at 60 (n=9). Forty-one participants (77.4%) presented with a final MRC-SS of ≤48 upon discharge from the ICU.

The PEF rate was only recorded for 33 (58%) participants, and the reason for this remains unknown. The mean initial PEF rate was 237.2 (±99.7) l/min, and the final mean PEF rate was 253.8 (±103.7) l/min for the 33 participants. The final PEF rate for each participant was compared to their predicted PEF rate. The mean predicted PEF rate achieved was 46% for the cohort, with a minimum of 11.6% and a maximum of 77% achieved.

4.4 COMPLICATIONS AND ADVERSE EVENTS

There were no adverse events documented by the clinician physiotherapists during the physiotherapy sessions with the participants. The complications that developed during the study period were few and included five participants (9%) who required reintubation due to OP poisoning rebound (n=2), ventilator-associated pneumonia (n=1), respiratory distress (n=1), respectively, and there was no reason recorded for one participant. Of the participants (n=56), 9% died, and no reason was recorded for three participants; one participant died from ventilator-associated pneumonia, and the other participant died from cardiac arrest.

4.5 FACTORS THAT INFLUENCED THE CLINICAL OUTCOME

For this study, the clinical outcome was determined as ICU length of stay and reintubation rate.

Table 4.3: Factors that Influenced the Clinical Outcomes

Factors that influenced the clinical outcome	*r*	p	CI
Duration of time lapse before the first physiotherapy session and patients' ICU length of stay	.176	.195	-0.099 – 0.426
Final MRC-SS at hospital discharge and ICU length of stay	.041	.772	-0.315 – 0.24
MRC-SS at hospital discharge and the need for reintubation	-	.546	-
Number of physiotherapy sessions received and the need for reintubation	-	.01	-

Table 4.3 presents the findings of the duration of time lapsed before the first physiotherapy session was delivered to the patient and the patients' ICU length of stay. There was a weak correlation (r=0.176) and the results were not statistically significant (p=0.195; 95% CI: -0.099 – 0.426). The Spearman's test presented a weak correlation (r=-0.041) for the final MRC-SS at hospital discharge and ICU length of stay, and the data showed no statistical significance (p=0.772; 95% CI: -0.315 – 0.24). For the reintubation rate, the MRC-SS at ICU discharge was tested using the Chi-Square test, showing no significant association between the category of score for the MRC-SS at hospital discharge and the need for reintubation (p=0.546). Twenty-five participants required more than five physiotherapy sessions during their ICU stay, and of these participants, five were reintubated. There was a significant association (p=0.01) between the number of physiotherapy sessions received and the need for reintubation on the Chi-squared test. This was tested further by Eta and Eta^2 calculation for nominal by interval data assessment, where the need for reintubation (No/Yes) was the independent variable and the number of physiotherapy sessions provided was the dependent variable. The Eta value of 0.361 confirms a fair association between need for reintubation and the number of physiotherapy sessions provided. The Eta^2 coefficient of determination of 0.13 shows that only 13% of the variance in need for reintubation can be accounted for by the number of physiotherapy sessions provided during participants' ICU length of stay.

4.6 CONCLUSION

In the next chapter, the results from this study will be discussed and compared to the existing evidence.

CHAPTER 5

5. DISCUSSION

5.1 INTRODUCTION

The purpose of this prospective, longitudinal, descriptive study was to report on the incidence of patients admitted with OP poisoning to TMRH ICU during the study period, their clinical outcomes, complications developed, the physiotherapy management provided to these patients during their ICU stay, and adverse events during physiotherapy sessions, and to identify factors that influenced reintubation and ICU length of stay. The findings begin to address the current gap in the existing evidence about the management of patients with OP poisoning in South Africa.

5.2 INCIDENCE OF ORGANOPHOSPHATE POISONING IN SOUTH AFRICA

During the data collection period, an 18% incidence of OP poisoning was observed at the TMRH ICU. Khonje et al. (2023) reported on 205 cases of OP poisoning that presented to the emergency department at TMRH between January 2020 and August 2021 (over 20 months). The number of patients diagnosed with OP poisoning in the ICU at TMRH in the current study was more than that of Omar et al. (2020), where 32 participants were admitted to the ICU at Chris Hani Baragwanath Academic Hospital following the diagnosis of OP poisoning over a period of two years.

5.3 PROFILE OF PATIENTS DIAGNOSED WITH ORGANOPHOSPHATE POISONING IN SOUTH AFRICA

The patients with OP poisoning in this study were young adults with a median age of 29 years. These findings are similar to those reported by Khonje et al. (2023) and Razwiedani and Rautenbach (2017). The aforementioned authors noted a higher prevalence of male admissions as compared to females, and the results from this study are similar. Of the research conducted in South Africa, Razwiedani and Rautenbach (2017) commented on the limited employment opportunities within a particular subdistrict in Tshwane as a possible reason for OP ingestion, but our study was the only one to analyse the employment status of patients in the Ekurhuleni district, where patients diagnosed with OP poisoning had an unemployment rate of 63%. This study found that most participants ingested OP poisoning intentionally. The reasons for this were not explored further, and these results correspond with the findings of other studies conducted in South Africa (Razwiedani and Rautenbach 2017; Omar et al., 2020; Laher et al., 2022; Khonje et al., 2023). The study results noted that 34% of the participants presented with accidental ingestion of OP poisoning; the reasons for this could be due to intentional harm from peers and ingesting unclean substances. Khonje et al. (2023) document that their study did not examine the causes for accidental or intentional

exposure, and Razwiedani and Rautenbach (2017) noted unknown circumstances for accidental exposure.

5.4 CLINICAL COURSE OF PATIENTS DIAGNOSED WITH ORGANOPHOSPHATE POISONING IN SOUTH AFRICA

The median ICU length of stay for the participants admitted to the ICU was seven days, and this was longer than what Bruins et al. (2019) reported (three days) for patients at Chris Hani Baragwanath Academic Hospital. The authors at Chris Hani Baragwanath Academic Hospital, Bruins et al. (2023), report on the length of stay in the ICU and High-Care area, where our study noted the length of hospital stay (nine days) in addition to the participants' length of ICU stay. The current study found that most participants required mechanical ventilation, with a median of two days spent on mechanical ventilation, and the days spent on mechanical ventilation are the same as those reported by Bruins et al. (2019).

5.5 PHYSIOTHERAPY MANAGEMENT OF PATIENTS DIAGNOSED WITH ORGANOPHOSPHATE POISONING IN SOUTH AFRICA

All patients admitted to the ICU at TMRH were screened by the treating physiotherapist for treatment and would not receive physiotherapy if they were haemodynamically unstable. The participants received their first physiotherapy session on average two days after admission to the ICU. A possible explanation is that participants could have been admitted to the ICU at a time of the day when physiotherapy services in the unit had stopped. This could have had an impact on the lapse in time until the initiation of their first physiotherapy session. Another possible explanation is the critical state of the patient (influenced by the disease pathology and pharmacological intervention) that could have rendered them unsafe for physiotherapy management. Participants received a median of four physiotherapy sessions throughout their stay in the ICU, with no bi-daily physiotherapy sessions. The results found that a small percentage of participants required reintubation, and one participant developed ventilator-associated pneumonia. These complications might have been prevented through the provision of bi-daily physiotherapy and should be tested in future research.

The localised pulmonary muscarinic effects of OP poisoning can cause respiratory failure, as noted by Robb et al. (2023). Hulse et al. (2019) report on bronchorrhea and bronchospasms as one of the initial signs and symptoms in patients diagnosed with OP poisoning. The need for respiratory physiotherapy is therefore supported by Stiller. (2013) to improve lung compliance and lung volumes and to improve clearance of retained secretions. The respiratory physiotherapy techniques used by the physiotherapy clinicians in this study included manual chest clearance techniques, oral or tracheal suction, body positioning for ventilation-perfusion matching, and the active cycle of breathing technique. These

interventions were delivered on days one to 14 of the participants' ICU stay. The aforementioned techniques were also used by physiotherapy clinicians for patient care in the ICU in the study by Skinner et al. (2015). Contrary to the findings reported by Skinner et al. (2015), the physiotherapists in this study did, however, not utilise ventilator hyperinflation, head-down tilt, positive expiratory pressure, or nebulisation with normal saline as part of patient care. In addition, they rarely documented inspiratory muscle training, incentive spirometry, and manual hyperinflation as part of their patient management. Manual hyperinflation is one of the most effective physiotherapy treatment techniques for patients in the ICU to improve lung compliance and facilitate secretion removal (Skinner, 2015), but, as noted from the results, it was rarely used by the physiotherapy clinicians at TMRH. Although Lottering and van Aswegen (2016) found that one of the most common physiotherapy techniques used in patient care in South African ICUs was incentive spirometry, our study found that this was rarely used by the physiotherapy clinicians at TMRH. The techniques rarely used by these physiotherapy clinicians could be attributed to a possible lack of equipment, the quality of training received on how to use the devices in patient care, as well as precautionary measures considered by these physiotherapy clinicians in response to the clinical presentation of their patients.

The study by Vikhe et al. (2024) highlights the importance of prescribing limb exercises, as well as mobility retraining, to prevent the complications caused by bed rest. The physiotherapy clinicians mostly reported on joint range movement exercises and functional mobility exercises (sitting on the edge of the bed, sit to stand, marching on the spot, and ambulation) during their physiotherapy sessions with the participants. The down-regulation of the nicotinic receptors at the neuromuscular junction due to OP poisoning leads to muscle weakness, muscle fasciculations, and muscle paralysis as reported by Peter et al. (2014). However, the treatment approach documented (despite its functional benefit) by the physiotherapy clinicians may not have effectively addressed the aforementioned. Treatment techniques that required weights were rarely used by these physiotherapists, such as resisted peripheral-joint weight training and resisted core strength training. A possible explanation for this finding could be the infection control measures that prohibited the usage of ward and gym exercise equipment in the TMRH ICU. Hulse et al. (2019) report on the proximal limb weakness during Type II paralysis affecting balance. It is interesting to note that the physiotherapy clinicians did not include any exercises that placed focus on the neurological system, such as exercises to address balance impairments, as part of their patient care. Proprioceptive neuromuscular facilitation and balance retraining were used in the rehabilitation of patients with OP poisoning by others (Sahoo et al., 2018, and Khan et al., 2024). This highlights a weakness in the rehabilitation provided to patients with OP poisoning in the ICU by physiotherapists in this study.

To functionally assess the effects that physiotherapy treatment had on the participants (due to the physiological impairments associated with OP poisoning, such as proximal and distal limb weakness, cranial nerve palsy, and lower limb paralysis), the physiotherapists calculated their patients' MRC-SS. At ICU discharge, seven participants had a score of zero, nine participants had full muscle strength, and the rest of the participants had a score ≤ 48.. In light of these findings, it would be reasonable to conclude that many survivors of OP poisoning admitted to TMRH ICU could benefit from referral to the outpatient division of the physiotherapy department for continued rehabilitation after hospital discharge. Each participant's FSS-ICU score was calculated at every physiotherapy session provided in the ICU. Only 24% of the participants had complete independent functional ambulation before discharge from the ICU. It is therefore noted that patients would benefit substantially from outpatient physiotherapy follow-up sessions to facilitate recovery of their functional ability. None of the patients were admitted to a rehabilitation center or were referred for outpatient physiotherapy follow-up.

There was poor compliance with calculating the PEF for participants, and the most common reported barrier to this was that the patient was on mechanical ventilation or was discharged early from the unit before assessment could be done. On average, the predicted PEF percentage achieved by those who were able to perform PEF before ICU discharge was 46% of the predicted value. This suggests impairment in their ability to forcefully exhale and may have impacted their ability to cough effectively. For some participants, this may have contributed to the development of pulmonary complications. It is not possible to report on the recovery of PEF or the incidence of respiratory infections after discharge from the ICU, as these were not included as aims of the current study, but should be investigated in future observational trials.

5.6 FACTORS THAT INFLUENCED THE CLINICAL OUTCOMES OF PATIENTS DIAGNOSED WITH ORGANOPHOSPHATE POISONING IN SOUTH AFRICA

The study results found that the duration of time until participants received their first physiotherapy session did not influence their ICU length of stay; however, there was a significant difference between the number of physiotherapy sessions received by the participant and the rate of reintubation. This finding could support a motivation for bi-daily physiotherapy sessions as it reduces the length of hospitilisation, length of stay on mechanical ventilation, and it is associated with a lower incidence of respiratory infections (Castro et al., 2012). It is noted that the deterioration of the participants' clinical condition due to complications associated with OP poisoning could also increase the need for reintubation.

The exact type of physiotherapy intervention that decreased the rate of reinitubation would require further investigation and was not reported on in this study. Previous literature has supported the need for MRC-SS assessment to determine whether the patient presents with ICU-acquired weakness, that would negatively impact their clinical outcomes (Hermans and Van den Berghe, 2015), but our study found weak correlation between the MRC-SS and ICU length of stay despite some participants presenting clinically with muscle weakness upon discharge from the unit (as determined by the MRC-SS). Additional clinical factors (unrelated to physiotherapy interventions) may have influenced the participants' ICU length of stay, requiring ongoing monitoring. In this study, the MRC-SS score had no significant association with the need for reintubation, therefore indicating that strengthening exercises alone did not influence the rate of reintubation.

During the physiotherapy sessions with the participants, no adverse events (e.g., falls, a drop in SpO_2 levels below 80%, and accidental removal of attachments) were documented. Bhakaney et al. (2024) highlight ventilator-associated pneumonia as a complication seen in patients with OP poisoning, and our study results found that of the five participants who required reintubation, one case was due to ventilator-associated pneumonia. Our study, distinct from Khonje et al. (2023), found a survival rate of 91% (compared to their survival rate of 81%) with a 9% mortality rate attributed to ventilator-associated pneumonia and cardiac arrest. Khonje et al. (2023) noted their participants' complications were associated with sepsis, cardiac arrest, and the rebound effect of OP poisoning, but the authors did not explicitly note this as a cause for mortality due to unreliable data record-keeping.

5.5 LIMITATIONS OF THE STUDY

The researcher calculated a sample size of convenience, not a formal sample size estimation, which was much higher than the actual number of participants who agreed to partake in the study, and for this reason, the data capture period was extended to 18 months instead of the initial 12-month period. The limitations of the study noted by the researcher were the inability to conduct PEF in participants who were mechanically ventilated, as the device only allowed for assessment upon extubation, and participants were discharged home before the assessment could be done. It was also noted that some patients were discharged early from the ICU to their place of residence, and this influenced the ability to adequately assess their need for outpatient physiotherapy. The data collection form designed by the researcher did not account for pensioner status under employment, and the pensioner status was commented on based on the age of the participants. In addition to the aforementioned, the form did not include patient-specific data such as auscultation findings, the amount of sputum, and information about their ability to cough effectively. This limits the interpretation of study findings. The researcher noted that a lack of availability of incentive spirometers at

TMRH influenced the physiotherapy treatment that the participants received, and this resulted in its lack of documentation on the data collection form. The patient consent form made use of medical jargon that may not have been easily understood by the potential participant.

CHAPTER 6

6. CONCLUSION

6.1 CONCLUSION

This prospective, longitudinal, descriptive study was conducted in the ICU of TMRH, situated in the Ekuhuleni District, and it aimed to describe the clinical course of patients diagnosed with OP poisoning as well as report on their physiotherapy management. The aims of the study were achieved by reporting on the incidence of OP poisoning during the study period, describing the profile of patients and their clinical course, analysing the physiotherapy treatment that they received, describing the outcome of these patients, reporting on the clinical complications and adverse events, as well as identifying any factors that influenced their clinical outcomes.

Over 18 months, 118 patients were managed in the ICU for OP poisoning, where 56 participants were eligible for participation. When reporting on the profile of patients admitted to the ICU, there were more male participants admitted for OP poisoning than females. Of the participants who agreed to partake in the study, most were unemployed and ingested OP intentionally.

Participants had a median ICU length of stay of seven days, with a median of nine days spent in the hospital after ICU discharge. Those who required mechanical ventilation were removed from ventilation after a median of two days. All participants received a median of four physiotherapy sessions during their ICU stay. The study found that no participant was admitted to a rehabilitation center after discharge from the hospital, and most participants were discharged from the ICU to their place of residence.

An analysis of the physiotherapy management found that it took a median two days before a participant received their first physiotherapy session and the most common treatment techniques used by the physiotherapy clinicians were manual chest clearance techniques, suctioning, positioning for ventilation-perfusion matching, active cycle of breathing technique, joint range of movement, sitting on the edge of the bed, sit to stand, marching on the spot and ambulation away from the bedside. There were no adverse events documented during the physiotherapy sessions, and the number of physiotherapy sessions received positively influenced the rate of reintubation for this cohort of patients.

Surprisingly, a large number of participants presented with a final MRC-SS of less than 48, which is suggestive of the presence of ICU-acquired weakness at the time of discharge from the unit but would need to be confirmed through definitive testing. Almost three-quarters of

the participants were dependent on others for functional activities (determined by the FSS-ICU) at the time of discharge from the unit. Several participants had impairments in respiratory muscle strength at the time of discharge from the ICU, confirmed by a mean predicted PEF of 46% for this cohort.

The complications and adverse events were minimal. Five participants required re-intubation due to OP poisoning rebound, ventilator-associated pneumonia, or respiratory distress. A small number of participants died before discharge from the ICU.

The ICU length of stay did not have a clinical effect on the rate of reintubation for the five participants who were reintubated, nor did the MRC-SS upon ICU discharge clinically increase or reduce the participants' ICU length of stay. As previously stated, the number of physiotherapy sessions received by participants seemed to significantly reduce the need for reintubation.

The findings from this study contribute to the limited evidence that exists in South Africa regarding the clinical course of adults diagnosed with and admitted to the ICU with OP poisoning. It makes a unique contribution to the gap in evidence regarding the physiotherapy management of these patients during their ICU stay.

6.2 RECOMMENDATIONS

6.2.1 Recommendations for Clinical Practice

The results of this study should be shared with the ICU team and physiotherapists who service the TMRH ICU to facilitate discussions around possible changes that need to be made to service delivery for patients with OP poisoning to ensure optimal patient recovery. The development of a unit-specific care pathway that addresses impairments observed in patients' general muscle strength, respiratory muscle strength, and functional activities should be encouraged.

6.2.2 Recommendations for Future Research

It is recommended that future research investigate the long-term outcome of patients diagnosed with OP poisoning by reviewing their clinical outcomes after discharge from the ICU. Future studies could investigate the use of PEF measurements in patients diagnosed with OP poisoning to identify those who present with respiratory muscle weakness and those at risk of developing respiratory complications during the step-down from ICU to ward care.

Future research could investigate the effect that employment may have on the incidence of OP ingestion, as well as the exploration of other contributing factors. Potential research could investigate the impact of bi-daily physiotherapy sessions on patient outcomes such as muscle strength and functional ability at ICU discharge, and ICU and hospital length of stay.

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APPENDIX A

- **STROBE CHECKLIST**

	Item No	Recommendation	Page Number
Title and abstract	1	Study design described in the method and type of design noted in the title of the study	2
		Abstract includes information about what was done in the method and what was found in the results	2-3
Introduction			
Background/rationale	2	Problem statement (1.2) described and reason for research documented with an appropriate research question (1.3)	4
Objectives	3	Objectives of the study clearly documented in the introduction under heading "Objectives of the study" (1.4.2).	4
Methods			
Study design	4	Study designed documented (3.1).	16
Setting	5	Study setting documented and location (3.2) Procedure and data collection period documented (3.6)	16 21
Participants	6	Source of the participants documented (3.3.1) Inclusion and exclusion criteria documented (3.3.1.1 and 3.3.1.2) Sample size and sampling method documented and explained (3.3.2)	16 16 17
Variables	7	Development of a data capture form documented **[Appendix B]** describing the information on the tool (3.4). Outcome measures used described clearly: Peak expiratory flow (3.4.1) Medical research council scale sun score (3.4.2) functional status score for the intensive care unit (3.4.3)	17 18-19 18 19 19
Data sources/ measurement	8*	Objectives for the study were the variables evaluated and analysed and were clearly documented (1.4.2)	4
Bias	9	Efforts made by the researcher to eliminate were bias described (3.7)	22
Study size	10	Study size explained in sample size and sampling method (3.3.2)	17
Quantitative variables	11	Not applicable	-
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	

	Item No	Recommendation	Page Number
Results			
Participants	13*	Participants represented in strobe flow diagram	26
		Reasons given reasons for non-participation at each stage	26
Descriptive data	14*	Characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	27
		Outcome measure (PEF) with poor compliance noted	31
Outcome data	15*	Outcome data recorded in results	28-31
Main results	16	Clear results noted in study (Chapter 4)	26-32
Discussion			
Key results	18	Summarise key results with reference to study objectives (Chapter 5)	33-36
Limitations	19	Discussion of limitations of the study	36-37
Interpretation	20	Overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence noted in Chapter 5	33-36
Generalisability	21	Discuss the generalisability (external validity) of the study results in following Chapters Chapter 5: Chapter 6:	 33-36 38-40
Other information			
Funding	22	NA	-

APPENDIX B

SURVEY DATA CAPTURE SHEET

The aim of the study is to describe the physiotherapy management received by patients with OP poisoning and review its impact on their clinical outcomes during their hospital stay . The study is for the purposes of a master's degree in Physiotherapy undertaken by Cradwin Didloff. You are kindly required to fill in the information below for all patients treated by you and who have agreed to partake in the study. The form will be collected by the researcher at the end of every week for the purpose of data collection. The participant may have more than one form, for each week of their stay in hospital, where each form will be numbered with the same hospital number and the relevant form number. Please ensure that the assessment is completed on the last day of physiotherapy management too. For additional information please contact the researcher.

Date:_____ Date of Admission:_____ Form Number:_____

Diagnosis:_____ Hospital No:_____ RN Number:_____

Please tick the relevant box in the table below and complete the information where applicable:

Gender		Age (y)	Height(cm)	Employment Status		Residence	Reason for OP Poising	
Male	Female			Employed	Unemployed		Accidental	
							Intentional	
							Forced	

Please complete the Table below, filling in the required information:

Assessment	Day 1 dd/mm/yy		Day 2 dd/mm/yy		Day 3 dd/mm/yy		Day 4 dd/mm/yy		Day 5 dd/mm/yy		Day 6 dd/mm/yy		Day 7 dd/mm/yy	
Outcome measure score	PEF		PEF		PEF		PEF		PEF		PEF		PEF	
	MRC-Sum	/60	MRC-Sum	/60	MRC-Sum	/60	MRC-Sum	/60	MRC-Sum	/60	MRC-Sum	/60	MRC-Sum	/60
	FSS-ICU	/35	FSS-ICU	/35	FSS-ICU	/35	FSS-ICU	/35	FSS-ICU	/35	FSS-ICU	/35	FSS-ICU	/35
	ICU LOS		ICU LOS		ICU LOS		ICU LOS		ICU LOS		ICU LOS		ICU LOS	
	Hosp. LOS		Hosp. LOS		Hosp. LOS		Hosp. LOS		Hosp. LOS		Hosp. LOS		Hosp. LOS	

Assessment	Day 10 dd/mm/yy		Day 14 dd/mm/yy		Discharge dd/mm/yy	
Outcome measure score	PEF		PEF		PEF	
	MRC-Sum	/60	MRC-Sum	/60	MRC-Sum	/60
	FSS-ICU	/35	FSS-ICU	/35	FSS-ICU	/35
	ICU LOS		ICU LOS		ICU LOS	
	Hosp. LOS		Hosp. LOS		Hosp. LOS	

Please fill in the table below indicating the treatment given to the patient, using the abbreviation in bold text:

Indicate if treatment was received once per day (daily) or twice per day (bidaily)

Respiratory: Active cycle of breathing technique **(ACBT)**; Deep breathing exercises **(DBE)**; Forced expiratory technique **(FET)**; Manual chest therapy techniques **(MCT)**; suction **(Sx)**; Manual hyperinflation/ambubagging **(MHI)**; Incentive spirometry **(IS)**; Positive expiratory pressure **(PEP)**; postural drainage positioning **(PD)**; body positioning for ventilation-perfusion matching **(V/Q)**; Inspiratory muscle training **(IMT)**; Mobility: rolling **(R)**; bridge and shift **(BS)**; laying to sitting **(LTS)**; sitting on edge of bed **(SOEB)**; sit to stand **(STS)**; marching on spot **(MOS)**; mobilize assisted **(Mob-A)**; mobilize independent **(MOB-I)**; joint range of motion exercises **(ROM)**; Static balance exercises **(STB)**; Dynamic balance exercise **(DNB)**; Strength: Peripheral gravity resisted **(P-GR)**; peripheral therapist resisted **(P-TR)**; peripheral weight resisted **(P-WR)**; core strength **(CS)**; core weight resisted **(C-WR)**

	Day 1 dd/mm/yy		Day 2 dd/mm/yy		Day 3 dd/mm/yy		Day 4 dd/mm/yy		Day 5 dd/mm/yy		Day 6 dd/mm/yy		Day 7 dd/mm/yy	
	Daily		Daily		Daily		Daily		Daily		Daily		Daily	
	Bi-daily		Bi-daily		Bi-daily		Bi-daily		Bi-daily		Bi-daily		Bi-daily	
Treatment														

	Day 10 dd/mm/yy		Day 14 dd/mm/yy		Discharge dd/mm/yy	
	Daily		Daily		Daily	
	Bi-daily		Bi-daily		Bi-daily	
Treatment						

Please complete the table below, providing the date and reason if and where applicable:

Complication	dd/mm/yy	dd/mm/yy	dd/mm/yy	dd/mm/yy	dd/mm/yy	dd/mm/yy	dd/mm/yy
Reintubation							
ICU readmission							
Reason							

Please fill in the table below and tick if and where applicable:

Adverse Event	Day 1 dd/mm/yy	Day 2 dd/mm/yy	Day 3 dd/mm/yy	Day 4 dd/mm/yy	Day 5 dd/mm/yy	Day 6 dd/mm/yy	Day 7 dd/mm/yy
Fall							
Desaturation during therapy							
Accidental removal of attachments during therapy							

Adverse Event	Day 10 dd/mm/yy	Day 14 dd/mm/yy	Discharge dd/mm/yy
Fall			
Desaturation during therapy			
Accidental removal of attachments during therapy			

Please complete the clinical outcome table below **where applicable** and fill the relevant information in over greyed out wording:

Mortality		Discharge from Hospital		Discharge from Physio		Follow-up physio		Discharge Destination	
Date:		Date:		Date:		Date:		Home	Rehabilitation Centre

Date of Treatment Termination:_____ Reason for Termination:_____

APPENDIX C

- **ETHICAL CLEARANCE CERTIFICATE**

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Ms CD Didloff

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M211166

NAME: (Principal Investigator)	Ms CD Didloff
DEPARTMENT:	School of Therapeutic Sciences Department of Physiotherapy Medical School University
PROJECT TITLE:	*The clinical outcomes and physiotherapy management of patients with organophosphate poisoning: a prospective longitudinal descriptive study*
DATE CONSIDERED:	2021/11/26
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Professor H van Aswegen
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2022/08/08

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **November** and therefore reports and re-certification will be due in the month of **November** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator Date

APPENDIX D

- **PERMISSION FROM THE CEO'S OFFICE AT TMRH TO CONDUCT RESEARCH**

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Enquiries: P/N Mabizela/P/N L. Mogoai
Directorate: Staff Development
Telephone number: (011) 8917109
Email: Thandiwe. Mabizela @gauteng.gov.za

26 October 2021

Miss: Cradwin Didloff

Thelle Mogoerane Regional Hospital Management Team is pleased to grant you permission to conduct your research on **Clinical outcomes and Physiotherapy management of patients with organophosphate poisoning at Thelle Mogoerane Hospital . Your** data will be conducted through obtaining information through **"Prospective data collection'** 'in your protocol for which you will obtain the ethics clearance certificate from University of Witwatersrand

The following condition must be adhered to:

- Once the research is finalized the results and recommendations of the research should be submitted to Staff development Department.

Dr M.M.Malaka
Chief Executive Officer
Thelle Mogoerane Regional Hospital
Date: ..28/10/2021.....

Thelle Mogoerane Regional Hospital
Office of the CEO
28 -10- 2021
12390 Nguza Str, Vosloorus, 1475
Private Bag X01, Alrode, 1451
South Africa

"To be the best provider of quality health care services to the people of Gauteng"

APPENDIX E

- **PERMISSION LETTER FROM THE HEAD OF THE PHYSIOTHERAPY DEPARTMENT FOR RESEARCH STUDY**

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

THELLE MOGOERANE REGIONAL HOSPITAL
Physiotherapy Department
12390 Nguza Street
Vosloorus Ext 14
1745
011 891 7000/7145
22/03/2022

To: Whom it may concern.

RE: Permission to conduct research at the physiotherapy department of Thelle Mogoerane Regional Hospital.

Dear Sir/ Madam,

This letter serves to confirm that Ms. Cradwin Diandra Didloff (ID no: 9409090116082) with persal no: 28666861, Grade 1 Physiotherapist at Thelle Mogoerane Regional Hospital, has been granted permission to conduct research on 'Current physiotherapy management of patients with organophosphate poisoning and their clinical course: a descriptive, longitudinal, prospective study'.

The following condition must be adhered to:
Once the research is finalised the results and recommendations of the research should be submitted to the Physiotherapy Department as well as the Staff Development Department.

Regards

Mr M.C Rangata
H.O.D
Physiotherapy Department
Thelle Mogoerane Regional Hospital

22/03/2022
Date

APPENDIX F

- **INTRODUCTION TO RESEARCH ETHICS CERTIFICATE**

Zertifikat Certificado
Certificat Certificate

TRREE

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Clinical Trials Centre
The University of Hong Kong

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Cradwin Didloff

a complété avec succès - has successfully completed

Introduction to Research Ethics

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2021/05/19
CID : AV59R7072

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

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[REV : 20170310]

APPENDIX G

- **PARTICIPANT INFORMATION**

INFORMATION SHEET FOR PATIENTS PARTICIPATING IN PROSPECTIVE DESCRIPTIVE STUDY

Study title: The clinical outcomes and physiotherapy management of patients with organophosphate poisoning: a prospective longitudinal descriptive study.

Dear potential participant,

My name is Cradwin Didloff and I am a physiotherapy clinician at Thelle Mogoerane Regional Hospital, working in the cardiopulmonary unit. I am registered at the University of the Witwatersrand (Faculty Of Health Sciences) as a postgraduate student for a master's degree in physiotherapy. Part of the requirements for completion of the degree is to conduct research in the field of study. I am therefore conducting a research study entitled "The clinical outcomes and physiotherapy management of patients with organophosphate poisoning: a prospective longitudinal descriptive study". The purpose of this study is to describe the physiotherapy management received by patients with organophosphate poisoning and review their clinical outcomes.

Why am I being asked to participate?

- You have been diagnosed with organophosphate poisoning.
- Your participation in this study is voluntary and if you decide to not participate you will not be penalised and you will continue to receive the usual medical, physiotherapy and nursing care provided for patients with organophosphate poisoning in the ICU and wards at Thelle Mogoerane Regional Hospital.

What does the study involve?

In this study you will receive the standard physiotherapy care that all patients receive from the physiotherapists at Thelle Mogoerane Regional Hospital. You will be assessed and based on your needs you will be given the type of standard treatment that you require. The physiotherapist will measure how you respond to physiotherapy treatment using peak expiratory flow (cough strength), MRC-sum score (muscle strength), FSS-ICU (functionality on the ward), ICU length of stay and hospital length of stay. You will receive physiotherapy treatment every day during your time in ICU. Your response to treatment will be recorded on days one to seven, then again on day 10, day 14 and on the day of your discharge from the hospital.

What are the benefits of participation?

Your participation in this study will not hold any direct benefits to you but it will help the physiotherapy profession to review the standard physiotherapy care received by patients with organophosphate poisoning at Thelle Mogoerane Regional Hospital. It will help us review the effects that physiotherapy may or may not have on patients with organophosphate poisoning. In doing so, the physiotherapist may develop a standard care physiotherapy intervention supported by literature. In this manner you and other patients may receive benefit from physiotherapy care for organophosphate poisoning should you return for further management of organophosphate poisoning.

What are the risks?

There are no known risks to participating in the study.

What is the cost?

There are no known costs that you may incur. The physiotherapy management that you receive in hospital will not be billed to you.

Confidentiality and anonymity:

All participants' information and documentation will remain anonymous. The information obtained from the study will only be used for statistical analysis. Each participant will get a research number and only the researcher will have access to the password protected document that has your personal details linked to it. These details will not be shared with anyone else.

What are your rights?

You may withdraw your consent for participating in the study at any stage. No questions will be asked regarding your decision nor will you be penalised.

Contact details:

If you have any further queries or questions pertaining to the study, please contact me on 0833107474. The email addresses for the Wits ethics committee secretariat are: zanele.ndlovu@wits.ac.za and rhulani.mkansi@wits.ac.za. If you wish to report any complaints or problems you can contact the Human Research Ethics Committee of the University of the Witwatersrand by emailing clement.penny@wits.ac.za

APPENDIX H

- **INFORMED CONSENT FORM**

Study title: The clinical outcomes and physiotherapy management of patients with organophosphate poisoning: a prospective longitudinal descriptive study

I_____(email:_____
and cell phone number:_____) hereby agree to participate in the study as described to me in the information sheet. I hereby agree to be assessed and treated by a physiotherapist and have the data from my hospital records captured for research purposes.

I am aware that I will not be exposed to any additional risks, that my information will be protected according to the POPIA Act of South Africa (No.4 of 2013) and that I can withdraw from the study at any time without suffering any repercussions. I understand that there are no monetary rewards for my participation and that participation is voluntary and I am not in any way obliged to take part in the above-mentioned research study.

Signature for temporary Consent _____

Signature of participant _____

Date _____

Date _____

Relation to participant: _____

Signature of researcher _____

For office use only:

GP/GT/GE number:_____

APPENDIX I

- **TURN-IT-IN REPORT**

Masters Research Report

ORIGINALITY REPORT

11%	6%	9%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	hdl.handle.net Internet Source	1%
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