The core competencies required by toxicology students in order to function effectively in a Poisons Information Centre: a Delphi study

By

Carine J Marks

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Stellenbosch University
Supervisor: Dr Alwyn JN Louw
Co-supervisor: Prof Ian Cooper

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Declaration

I the undersigned hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree

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ABSTRACT

The training of medical toxicologists in South Africa is inadequate. In developing countries, where accidental and intentional poisonings are problematic, a need exists for tuition in medical toxicology. Stellenbosch University (SU) developed a blended learning Post Graduate Diploma in Medical Toxicology (PGDip Tox) to bridge this knowledge gap. Prior to the development of the PGDip Tox, key learning outcomes were not well-defined and a need still existed to investigate the core competencies required by toxicology graduates to effectively operate in a poisons information centre.

The purpose of this study was to contribute to the wider discipline of Medical Toxicology by clearly outlining the core competencies that underpin a medical toxicology curriculum. To reach consensus on what medical toxicology graduates must know (knowledge), what they must be able to do (skills) and what dispositions they must display (attitude), a structured communication survey was developed.

With the survey, the Delphi technique was used and it included a set of carefully selected questions that were drawn from various sources. The questionnaire was distributed to participants that had a medical background as well as extensive knowledge in medical toxicology, and who were highly respected by colleagues nationally and internationally. In three iterative rounds, participants rated the relative importance of individual topics and suggested new ideas. Consensus was reached when a topic on the competency list was rated 70% or more.

Forty-eight panellists (n=48) were invited to participate in the survey. A total of 134 competencies were selected for the three rounds. In the end, consensus was reached on 118 (88%) items. Panel members agreed that 113 (96%) of these items should be incorporated into a medical toxicology curriculum, and that five (4%) should be excluded. All panellists (100%) agreed that it is important for medical toxicology graduates to:

1. be able to effectively use information technology to access, evaluate and interpret toxicology information
2. know where to look first when managing a poisoning query (databases, books, journals etc.)
3. be able to communicate effectively (verbally and in writing) with healthcare providers in a manner that they understand

4. be able to identify limitations of knowledge within themselves (e.g. when to refer an enquiry).

In summary, while knowledge forms the foundation of the toxicology service, the ultimate cornerstone of a poisons information service is communication. It is important for the medical toxicology curriculum to include a training package aimed at teaching toxicology students the skill of communication. Self-regulatory teaching should also be incorporated into the curriculum as to ensure that graduates have a better understanding of their responsibility towards patients and peers. When planning a new, or changing an existing course, a developer should not start with the curriculum design and measurable educational objectives, but instead use a consensus-based learning outcomes model. Establishing the core competencies in terms of knowledge, skills and attitude, will direct the choice of curriculum content and educational objectives.

In conclusion, the outcomes of this study can be used in future studies to assess medical toxicology curricula and to investigate if there is an alignment and synergy between goals of the educator, the needs of the students, the curriculum, the learning milieu, the teaching strategies, and the assessment procedures. Health care workers should consider the incorporation of meaningful outcomes into all future education programmes.

OPSOMMING

Die opleiding van Mediese Toksikoloë in Suid-Afrika en ander ontwikkelende lande is onvoldoende en daar is 'n behoefte vir onderrig in die behandeling van vergiftigings. Om die rede is n gemengde leermodel, 'n Nagraadse Diploma in Mediese Toksikologie, deur Stellenbosch Universiteit ontwikkel. Ongelukkig was die leeruitkomste nie voorheen duidelik geidentifiseer en gedefinieer met die ontwikkeling van die kursus nie. Die literatuur beklemtoon die belangrikheid van kernbevoegdhede in gesondheidswerkers. Dit is dus belangrik, om die nodige bevoegdhede vir suksesvolle mediese toksikoloë wat in gifinligtingsentrums werk, te bepaal.

Die studie is gebasseer op 'n gestruktureerde kommunikasieopname wat ontwikkel is om te bepaal wat pas gekwalifiseerde mediese toksikoloë moet weet (kennis), moet kan doen (vaardighede) en wat hulle ingesteldheid daarteenoor (houding) moet wees. Die doel van die opname was om konsensus te bereik oor die kernbevoegdhede wat mediese toksikoloë moet besit. Die studie dra sodoende by tot die breër spesialiteit van Mediese Toksikologie.

Hierdie studie het die Delphi-tegniek gebruik wat n stel sorgvuldige geselekteerde vrae bevat wat uit verskillende bronne geneem is. Die vraelys is versprei aan deelnemers met n mediese agtergrond en met 'n uitgebreide kennis in mediese toksikologie. Hulle kennis in die verband word nasionaal en internasionaal deur kollegas gerespekteer. In drie herhalende rondtes het deelnemers die belangrikheid van individuele onderwerpe beoordeel. Nuwe onderwerpe kon ook voorgestel word. Konsensus is bereik as n onderwerp 70% of meer op die bevoegdheidslys bereik het.

Ag-en-veertig paneellede is uitgenooi om aan die opname deel te neem. Altesaam 134 bevoegdhede is vir die drie rondtes gekies. Konsensus is bereik in 118 (88%) van die bevoegdhede. Volgens paneellede behoort 113 (96%) van die bevoegdhede in 'n kurrikulum vir Mediese Toksikologie opgeneem te word. Vyf (4%) van die bevoegdhede is uitgesluit.

Volgens deelnemers (100%) is die volgende belangrik vir gegradueerders in mediese toksikologie:

1. Inligtingtegnologie moet effektief gebruik kan word om sodoende inligting oor toksikologie te bekom, te evalueer en te interpreter.

2. Dit is nodig om te weet watter bronne om te gebruik om ‘n vergiftigings-navraag te hanteer, byvoorbeeld watter boeke, databasisse, joernale en ander relevante bronne kan gebruik word.
3. Dit is nodig om effektief (mondeling en skriftelik) te kan kommunikeer met ander gesondheidsorgwerkers op ‘n manier wat vir hulle verstaanbaar is.
4. Hulle moet hulle eie beperkinge ken en byvoorbeeld weet wanneer om ‘n navraag te verwys na n meer senior persoon.

Alhoewel kennis die basis vorm van die toksikologie diens, is die hoeksteen van die diens kommunikasie. Daarom is dit belangrik dat die kurrikulum vir Mediese Toksikologie ‘n opleidingspakket insluit wat kommunikasie-vaardigheid aanspreek. ‘n Verdere komponent van die kurrikulum is selfregulerende leer. Dit sal gegradueerders ‘n beter begrip gee van hulle verantwoordelikhede teenoor pasiënte sowel as teenoor medewerkers.

Die studie beveel aan dat ‘n konsensus-gebaseerde leeruitkomste model gebruik moet word in die beplanning van nuwe ‘n kurrikulum, of wanneer ‘n bestaande kursus verander moet word. Kernbevoeghede ten opsigte van kennis, vaardighede en houding behoort die opvoedkundige inhoud van die kurrikulum te bepaal.

Die uitkomste van die studie kan in toekomstige studies gebruik word om die kurrikulum vir Mediese Toksikologie te evalueer. Uitkomste kan ook gebruik word om die sinergie tussen die doelstellings van die opvoeder, behoefte van die student, kurrikulum, leeromgewing, onderrigstrategieë en asseseringsprosedures te ondersoek. Gesondheidsorgwerkers moet die insluiting van betekenisvolle uitkomste in alle toekomstige opleidingsprogamme oorweeg.

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5. Staff of the Poison Information Helpline of the Western Cape
6. Members of the African Network of Poison Control Centres
7. Members appointed by the World Health Organisation (WHO) to update Guidelines for Poison Control.

List of Abbreviations

Description	Abbreviation
African Network of Poison Control Centres	ANPCC
Antiretroviral	ARV
Canadian Medical Education Directions for Specialists	CanMEDS
Competency-based medical education	CBME
Isoniazid	INH
Nonsteroidal anti-inflammatory drugs	NSAIDs
Objective Structured Clinical Examination	OSCE
Poisons Information Centre	PIC
Post Graduate Diploma in Medical Toxicology	PGDip Tox
Research Electronic Data Capture	REDCap
Selective serotonin reuptake inhibitor	SSRI
Specialist in Poisons Information	SPI
Standard operating procedure	SOP
Statistical Package for the Social Sciences	SPSS
Stellenbosch University	US
World Health Organisation	WHO

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CHAPTER ONE
INTRODUCTION

1.1 Background

Poisoning exposures in Africa constitute a significant health burden (World Health Organization, 2015). However, only ten African countries have poisons information centres (PICs) (Marks, van Hoving, Edwards, *et al*., 2016). Trained medical toxicologists are limited and education in medical toxicology for healthcare professionals remains inadequate (Marks, *et al*., 2016). Due to significant technological developments, educational courses can be hosted on an online platform. Wong, Vohra, Dawson, Stolbach (2017) discussed the value of an online toxicology curriculum as an effective way to educate medical professionals in toxicology. This education tool can help bridge the knowledge gap that exists in developing countries including South Africa. Laurillard, Kennedy, Charlton, *et al.* (2018) discussed blended learning as a viable and potentially powerful pedagogical approach in which online educational materials and opportunities are combined with traditional face-to-face classroom methods. By blending time, people, location and resources, it is possible to combine content knowledge, pedagogical knowledge and technological knowledge.

In this context, Stellenbosch University started developing a curriculum for a blended learning Postgraduate Diploma in Medical Toxicology (PGDip Tox) in 2017, with the intention to commence application in 2021. The aim of this programme is to train candidates who can effectively operate as medical toxicologists in a poisons centre. This course follows a competency-based educational framework focusing on outcomes and promoting learner centeredness (Gruppen, Burkhardt, Fitzgerald, *et al*., 2016). Competencies can provide a collective way to harmonize, select and develop the curriculum. For students, well-defined competencies can offer increased engagement with the curriculum. With clear well-defined competencies, teachers can plan and design appropriate learning strategies and assessment methods (Hewitt, Roye, Gebbie *et al*., 2014). For the University, competencies can be useful to ensure effective performance, since it provides a guideline for individuals to increase their capabilities.

Competence is defined in the context of knowledge, skills, and attitude (Hunker, Gazza and Shellenberger, 2014). Knowledge implicates the understanding of facts and procedures and involves the cognitive processing of information. Under the concept of knowledge, students recall, recognise, understand, apply and evaluate information. A skill is the learning of how to do something and perform specific actions. Skills are measured in terms of technique through monitoring and observation. Attitude is a personality characteristic (e.g. self-control, self-confidence) that causes a person to behave in a certain way (Hunker, *et al*., 2014).

Prior to development of the PGDip Tox, the learning outcomes were not well-defined, and a need existed to investigate the core competencies required by toxicology graduates to effectively operate in a poisons information centre. It was important to determine what knowledge, skills and attitudes must be developed, and different methods to discover these competencies were investigated. Indeed, consensus-based approaches have been widely used to develop or review curricula (Albarqouni, Hoffman, Straus, *et al*., 2018). Consensus methods such as the Nominal Group technique or Delphi technique have been used to solve problems, generate ideas and determine priorities (McMillan, King and Tully, 2016).

To reach consensus on what medical toxicology graduates must know (knowledge), what they must be able to do (skills), and what dispositions they must display (attitude), a Delphi survey was developed. The purpose of the survey was to contribute to the wider discipline of medical toxicology by clearly outlining the core competencies that underpin a medical toxicology curriculum.

1.2 Problem statement

The curriculum of the PG DipTox was developed without gathering consensus from experts on the minimum core competencies that students require in order to become specialists in poisons information (SPI's). This in itself is a problem, and in order to ensure an effective PGDip Tox curriculum, core competencies required by students should first be established. If it is not known to what extent the student's knowledge and skills should be measured, it will also remain unclear whether the graduate has the practical skills to assist in the diagnoses and management of patients exposed to poisonous chemicals. Moreover, incompetent medical toxicologists will not function effectively in Poisons Information Centres, where they are required to advise other health care professionals on the optimal management of poisoned patients

1.3 Research Question

What are the core competencies required by medical toxicology graduates in order to practice effectively as medical toxicologists in a poisons information centre?

1.4 Aim

The aim of this study was to obtain consensus from an expert group of healthcare workers on the core competencies that a graduate should attain in order to work effectively in a poisons information centre.

1.5 Objectives

To determine a list of core competencies that is required by toxicology students in order to function effectively in a Poisons Information Centre.

To bring the current Post Graduate Diploma in Medical Toxicology offered by Stellenbosch University in alignment with the list of core competencies of this study.

To identify a framework to organise the list of competencies.

1.6 Motivation for the study

Information on the best way to assess competencies in Medical Toxicology is limited, and only a few studies have some knowledge with this topic (Barchowsky, Buckley, Carlson, *et al.*, 2012; Alsharif, 2008; Brown, Pond and Creekmore, 2011). There is a clear gap in the literature and a strong need to establish the competencies required of a student after completing a postgraduate diploma in Medical Toxicology. Students need to apply the knowledge that they gained, so that they can perform in the workplace. Patient outcomes should be the ultimate goal of the curriculum; as such, core competencies that students require should be identified before developing teaching and learning activities. Biggs (1996); Frank, Snell, Cate, *et al.* (2010) discussed the importance of coherence between outcomes, teaching strategies and assessment under the so-called constructive alignment. Hence, adopting a competency-based medical education construct is important to ensure that students develop the competencies required to fulfil patient / healthcare needs.

1.7 Thesis structure and overview

Chapter Two presents different perspectives on the value of competency-based medical education in the context of postgraduate training in Medical Toxicology. In particular, this narrative review focuses on student-centred and self-regulated learning as important educational interventions relevant to the field. In Chapter Three outline the relevant methodology used in the present study. The results from rounds one, two and three of the Delphi survey are presented in Chapter Four.

Chapter Five elaborates on the key findings evident from the study in relation to the literature, and elaborates on their value and impact. In particular, I present a consensus-based learning outcomes model to complement existing frameworks for curriculum development (Kern, 2009). Chapter Six the main points of the survey are summarized and reiterated. Chapter Seven concludes the thesis and provides references with citations of sources of information.

CHAPTER TWO
LITERATURE PERSPECTIVES

2.1 The discipline of Medical Toxicology

Toxicology is a complex interdisciplinary subject with many branches, including forensic, occupational, analytical, environmental and medical toxicology. Medical Toxicology is highly patient-centred, focusing on the diagnosis, management and prevention of poisoning cases due to pharmaceutical, non-drug chemical or biological toxin exposures (Beaucham, 2016). Medical Toxicology is constantly being updated, not only because of the general advancement of science, but also due to the discovery of new hazardous substances (Rodilla, 2007). In Africa and the Middle East, it is predicted that the growth rate for the chemical industry will continue at over 5% per year, thus exceeding that for Western Europe and North America (Global Chemicals Outlook, 2013). This massive expansion in the availability and use of chemicals has led to a steady increase, not only in the number of poisoning exposures, but also the need for qualified medical toxicologists to assist with this burden (World Health Organization, 2015).

2.1.1 The need for toxicology services

The lack of toxicology services in developing countries contributes to a knowledge gap in the management of poisonings (Thompson, 2015). Stewart (2002) described the major toxic health hazards in South Africa and the need to bring together the different fields of toxicology. Exposure to poisonous substances is a particular problem in disadvantaged communities where residents have limited access to health care facilities (Laborde, 2004).In South Africa, the need for Poisons Information Centres was documented in the Environmental Management Plan of the National Department of Health (Government Gazette, 2016). South Africa has two Poison Information Centres serving health care professionals and the general public. Both PICs (Red Cross Children’s and Tygerberg Hospital) are in the Western Cape Province and were established more than 40 years ago, with the purpose of managing and preventing acute poisoning exposures.

The burden of poisoning exposures in Africa is a major public health concern (Marks *et al*., 2016). The World Health Organisation estimated that almost a million people die each year from intentional self-poisoning. Van Hoving, Hunter, Gerber, *et al.* (2018) explored the significant burden that intentional self-poisoning put on emergency centres in South Africa. These observations support the urgent patient and societal need for qualified medical toxicologists and poison centre information specialists (SPI’s).

Of the poisoning enquiries received by SPI's working in South African poison centres, 70% are from healthcare providers, and most of the calls are made from public hospitals (Marks and van Hoving, 2016).Globally, online Medical Toxicology courses do exist. For example, Cardiff University offers medical toxicology courses for health professionals, including hospital and community doctors, pharmacists and nurses (Medical Toxicology - MSc/PGDip/PGCert at Cardiff). Sri Lanka offers a similar course (MSc/PGDIP in medical Toxicology) but only medical practitioners are eligible to apply. Currently no postgraduate training programme in toxicology exists in South Africa or other African countries covering the discipline of Medical Toxicology, portraying the need for the development of the PGDip Tox at Stellenbosch University.

2.2 The online learning environment

Busy healthcare professionals, who have an interest in the field of toxicology education, might find traditional classroom learning problematic, because of the lack of flexibility to juggle careers around a fixed schedule. Offering high-quality online education can bridge this problem and provide an invaluable method of learning (Sun and Chen, 2016). Electronic learning is also less costly to learners, since they can continue working for a salary and there is no cost for commuting. Students have the opportunity to network with peers across nations and continents, which can lead to other opportunities for collaboration. Other advantages include easy access to expertise and increased instructor-student interaction time (Arkorful and Abaidoo, 2015).

Learners often struggle in online learning environments and drop out for a variety of reasons. These include lack of time to follow through the course, insufficient prior knowledge, inability to understand course content, and having no one to ask for help (Hew and Cheung, 2014). To address this problem, the PGDip Tox at Stellenbosch University was developed to include a blended learning curriculum which comprised two, one week face-to face interactions, and longer periods of online learning. This blended learning course further advocates self-regulated learning and student-centred learning.

2.2.1 Blended learning

Blended learning promotes a paradigm shift in learning and teaching, away from more traditional approaches in favour of a more flexible, transformative, and knowledge-centred approach (Laurillard *et al.*, 2018). In particular, the integration of current pedagogies, learning styles and a variety of modes of delivery are also acknowledged. For the PGDip Tox, the curriculum developers aimed to create an opportunity for students to engage with learning technologies in ways that would not be possible in traditional face-to-face courses. This pedagogical approach could enrich the learning and teaching experience while also enhancing and developing student skills, all contributing towards a more efficient course which accommodates growing student numbers (de George-Walker and Keeffe, 2010).

2.2.2 Self-regulated learning

By blending online learning with self-regulated learning, students can become more motivated and achievement-orientated (Wong, Baars, Davis *et al.*, 2019). The self-regulation theory was defined by Zimmerman (1989) as a self-directive process by which learners transform their mental abilities into academic skills. By self-regulating their learning, students will not dive headlong into the course but will plan, set goals, and lay out strategies before taking on a module.

2.2.3 Student-centred learning

There is a need to create a student-centred learning environment online (Rayens and Ellis, 2018). In student-centred learning, the focus of instruction shifts from the educator to the student. In the PGDip Tox blended learning course, it is critical that students develop responsibility and accountability towards their own learning. Learners are encouraged to have a say in what and how they study. This would ideally be accompanied by an increased sense of autonomy that will subsequently lead to interdependence. This educational strategy of student-centred learning is underpinned by collaboration, project-based learning, technology integration, and personal and interpersonal conversation between educators and learners (Harden, Crosby and Davis, 1984). Learning in student-centred learning is active instead of passive and creates a deep approach to learning and understanding (O'Neill and McMahon, 2005).

2.3 Curriculum development

To set the parameters, directions and standards for a curriculum policy, a comprehensive framework is required. The blueprint for curriculum planning should include a needs assessment analysis, specific measurable objectives, and an alignment between the teaching strategies and assessment (Wijngaards-de Meij and Merx, 2018).

2.3.1 Needs assessment of learners

Informal discussions, formal interviews, focus group discussions, questionnaires, and examinations are important methods for collecting information regarding learner needs. It is necessary to understand the particular learning needs of the targeted learners and the institution in order to cultivate a strong argument for the need of curriculum development (Kern, 2009). Furthermore, this needs assessment helps to identify potential resources and support. Moreover, the educational purpose of the curriculum will become clear and it will be possible to determine the knowledge, skills, attitudes, and behaviour that are needed for graduates (Kern, 2009).

2.3.2 Goals and specific measurable objectives

The construct of interest being measured in a curriculum must be clearly defined and understood in terms of knowledge, skills, and attitudes (Downing and Yudkowsky, 2009). Miller's pyramid (Miller, 1990) is a useful model to use in this context. Miller (1990) ranked clinical competence both in educational settings and in the workplace and this framework distinguished between knowledge at the lower levels and action in the higher levels. Miller's pyramid has four levels, starting with the knows (knowledge), knows how (understand), shows how (demonstration) and does (performance).

Didactic face-to-face teaching focuses on the baseline knowledge that students possess and can explain the first level of Miller's pyramid. This teaching strategy stimulates interest, explains concepts, provides core knowledge, and directs student learning. During the second level, learning takes place when students actively consume information and new knowledge is linked with what is already known. Simulation training, which allows for sustained, deliberate practise in a safe environment, would be representative of Miller's third level of competencies (i.e. "shows how"). A frequently used way of assessing this third level is the objective structured clinical examination (OSCE), which measures performance and competence skills and is intended to assess clinical and theoretical knowledge (Rushforth, 2007). Duvivier, van Dalen, Muijtjens, *et al.* (2011) discussed the role of deliberate practise in the acquisition of clinical skills. Here, the student demonstrates level four of Miller's pyramid; where performance in the real world is measured. Miller's suggested four levels also relate directly with the objectives of the PGDip Tox course. An example would be a toxicology student learning about paracetamol poisoning, followed by understanding how to manage the poisoning. The student will then move on to demonstrate in assessment how to manage the poisoning and eventually will have the opportunity to handle the paracetamol poisoning in a real life situation.

2.3.3 Curriculum alignment

Education should be defined by outputs, not inputs. The educator should be interested in what learners can do, rather than what they have been taught (Morcke, Dornan and Eika, 2013). Patient outcomes should be the ultimate goal of the curriculum, and the curriculum developer should identify patient outcomes (core competencies) before developing teaching and learning activities. It is vital for the developer of the PGDip Tox course to reach consensus on these core competencies, so that alignment with teaching and assessment methods can be achieved.

Frank, Snell, Cate, *et al*. (2010) and Biggs (1996) discussed the importance of coherence between outcomes, teaching strategies, and assessment. Curriculum alignment is crucial for student's awareness of their position within the curriculum. The aim is for the teaching methods used and the assessment tasks to be aligned with the learning activities assumed in the intended outcomes. The educator must be clear on what they want students to learn, how they should learn it, and how to ascertain that learning has taken place.

2.4 Competencies of medical toxicologists

A literature search was conducted on the core competencies required by medical toxicologists. Certain key words and phrases were searched, which included curriculum, / toxicology students, / education, / poisoning, / core competencies, / poisons centre. Databases searched included Scopus, PubMed, Eric and Google Scholar. Relevant papers found were also searched in order to identify additional articles.

A paucity of literature was found on Health Professions Education and Medical Toxicology. Given its novel perspective, little information was available on the competencies of a SPI. Barchowsky *et al*. (2012) addressed the core competencies of the general toxicologist that should be an essential part of any toxicology training, but did not narrow it down to the discipline of medical toxicology. On the other hand, Nelson, Baker, Osterhoudt, *et al.* (2012) discussed the core content of a medical toxicology curriculum, but did not address core competencies. Another study by Ettlin, Bolon, Pyrah, *et al.* (2008) emphasised the universal standards defining core competencies in toxicology pathologists, and the need to improve on this.

Although information on core competencies for toxicologists is scarce, excellent frameworks have been developed on the core competencies required for effective medical doctors. The US Accreditation Council for Graduate Medical Education outcomes project described six domains of competency for resident physicians namely: 1) medical knowledge, 2) practice-based learning and improvement, 3) professionalism, 4) interpersonal and communication skills, 5) patient care, and 6) systems-based practice (Swing, 2007). Frank and Danoff (2007) developed the Canadian Medical Education Directions for Specialists (CanMEDS) initiative that specified an outcomes-based framework for physicians. Here the authors proposed that a graduate should be a medical expert, communicator, collaborator, manager, health advocate, scholar, and professional (Frank and Danoff, 2007). Similar to the abovementioned research, core competencies required by a medical toxicologist, should be predetermined because they too have an obligation to healthcare professionals, the general public and policy makers for the optimal management of poisoned patients (Beauchamp, 2016) .

Medical toxicologists that are working in a Poisons Information Centre (PIC) are called specialists in poisons information (SPI). These individuals can include among them trained nurses, medical scientists, pharmacists and physicians who have the medical knowledge and experience to assess, triage, and manage poisoning exposures (Mrvos, Dean and Krenzelok, 1994). SPIs are trained in the discipline of medical toxicology and it is vital that the core competencies needed to be an effective SPI are incorporated into a curriculum (Mrvos *et al.*, 1994). Competency embraces a student's knowledge, skills, values and attitudes and should be predetermined in the curriculum (Gruppen *et al.*, 2016). The curriculum content, teaching strategies, assessment process and curriculum timetable should therefore ideally be determined by these competencies (Harden *et al.*, 1999). In the PGDip Tox course, the developer wants to ensure that the toxicology graduate manages poisoning exposures successfully and efficiently, hence the approach to competency-based medical education (CBME) curriculum.

2.4.1 Competency-based medical education

In CBME, the focus is placed on the skills and abilities of the learners, across multiple domains of knowledge and performance, within a given context (Gruppen *et al.*, 2016). These include students' previous training and experience, their existing knowledge, attitudes and skills, as well as their preferences, perceived deficiencies and learning needs. Lecturers should take into account the competencies of learners which can be influenced by diverse backgrounds, different learning styles, and dissimilar motivation levels. Students should have the opportunity to progress through their education at their own pace, regardless of their environment. Frank, *et al.* (2010) advised a more competency-based medical education construct to ensure that students develop the competencies required to fulfil patient and healthcare needs. By adopting a CBME approach, the focus of the curriculum shifts to patient outcomes and prepares students for real world professional practice.

Reforming curricula in Medical Education has been widely discussed in the literature (Parson *et al.*, 2019). In the traditional method of teaching, the focus is on group learning, the assessment method is summative with high stakes, and the course is completed when the student passes all modules. The aim of the PGDip Tox is to train competent medical toxicologists, therefore a more competency-based instruction is needed. The teaching strategies and assessment strategies followed with this type of curriculum, will be more learner-centred, self-paced, individualized and, when completed, the student will be competent in the work place. Frank, *et al.*, (2010) stressed that CBME should focus on educational outcomes and that courses must demonstrate that the newly trained graduates are competent in all aspects of practice. CBME however does not describe how the course must be taught or how the student must learn. The desired competencies of the graduate drives the development of curricula, assessment and evaluation.

CBME furthermore promotes the progression of competence from milestone to milestone in all of the essential aspects of practice (Iobst *et al.*, 2010). These milestones should describe discrete behaviour development that, when met, allow evaluators to know that a student is truly ready to progress to the next stage of training (Iobst et al., 2010). Some students would advance more quickly, while others more slowly, therefore they should have clearly defined targets throughout the course.

For a curriculum in medical toxicology to integrate CBME, competencies must be identified and clearly specified how they will fit into a coherent and implementable curriculum structure. Currently, CBME programs have included entrustable professional activities (EPAs) as milestones in the progression towards mastering a competency (Reis, 2018). An EPA in medical toxicology would thus be an essential skill, attitude and/or behaviour, or knowledge that a SPI performs in the workplace without supervision. Knowledge refers to the practical or theoretical understanding of a subject. It is the information that one knows, including theories, facts and procedures, and the ability to apply this information (Baartman and De Bruijn, 2011). Skills are the ability acquired to carry out complex activities or job functions involving things (technical skills),ideas (cognitive skills), and people (interpersonal skills) (Baartman and De Bruijn, 2011).Attitude and/or behavior is a learned competency that leads a person to behave in a consistently favourable way with respect to a given object and is mostly subjective and attributed to a person (Shiffman and Kanuk, 2004).

2.5 Consensus development

A clear outline of core competencies in a medical curriculum is mandatory, as it informs the blueprinting of the curriculum. To determine the competencies, a definite plan needs to be determined. Starting with a literature review and leading to quorum consensus. Consensus development is important when no evidence exists for a research questions.

In determining which method to use for consensus, it is important to understand the pros and cons of each method. Kea and Sun (2015) discussed the various implicit and explicit approaches that are used to reach consensus. The implicit approach involves a simple voting procedure where the majority of votes wins and this informal consensus method is often use at conferences. In contrast, the explicit approach involves statistical methods to form consensus, and for this the Delphi Technique or Nominal Group Technique is used.

The Nominal Group Technique (Delbecq, van de Ven, and Gustafson, 1975) is a highly structured face-to-face group interaction which gives participants an opportunity to have their voices heard and opinions considered. This is similar to the Delphi technique which uses a combination of quantitative and qualitative approaches to gathers consensus on a scientific topic under investigation, especially when resources are scarce, and face-to face data collection impractical (Habibi, Sarafrazi and Izadyar, 2014). The Delphi technique has been effectively used to examine core competencies in health professions (Hewitt, *et al.,* 2014). It is commonly used to develop guidelines within health professional research and is usually directed at problem-solving, idea-generation, and determining priorities (McMillan, *et al.,* 2016). A well-prepared and detailed Delphi method has good reliability and its validity is fair (Tomasik, 2010). In a recent study Albarqouni *et al*. (2018) demonstrated the value of the Delphi study model to identify the nature and fundamental elements of a phenomenon such as core competencies.

De Villiers, De Villiers and Kent (2009) obtained consensus relating to the maintenance of competence of doctors working in district hospitals in South Africa. Their experience using the

Delphi technique is useful for other health science education researchers wishing to gain consensus on a topic. The Delphi technique pulls together the collective judgment of experts on a particular topic and was chosen in this study because there is currently no consensus with regard to the core competencies required by graduates to become effective medical toxicologists.

2.6 Summary

The purpose of this literature review was to establish if there is a current need for toxicology services in Africa and to see what is known about the core competencies of toxicology graduates. The results of this search have a direct influence on the development of the PGDip Tox that was developed by Stellenbosch University. In the literature review, the investigator synthesised relevant evidence on the discipline of Medical Toxicology, curriculum development and online learning and aligned this evidence with the development of the PGDip Tox curriculum. The need to reach consensus on the core competencies required by toxicology students in order to function effectively in a Poisons Information Centre is emphasized.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

The survey-based process used in this study entails virtual group decision making based on consensus gathered using questionnaires and providing provision feedback to participants who are also experts in their field (McMillan, *et al.*, 2016; Okoli and Pawlowski, 2004). The study method is associated with the pragmatic paradigm, because it entails data collection in a simultaneous manner, drawing from both quantitative and qualitative traditions. Pragmatism looks at the usefulness of the outcome and chooses methods appropriate to see "what works" (Parvaiz, Mufti and Wahab, 2016).

3.2 Research method

This study used the Delphi technique, originally developed by Project RAND during 1959 (Helmet O, Dalkey N, 1963). I made use of a modified Delphi technique and adopted the method used by Salmon and Tombs (2018) (Figure 1).

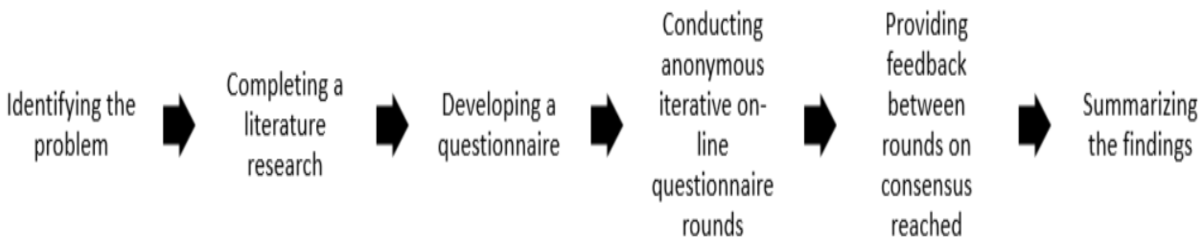

Figure 1: Steps proposed in the Delphi survey.

The Delphi survey started with a set of carefully selected questions drawn from various sources e.g. the literature review, existing curricula, and personal experience. The questionnaire was distributed to a panel of selected experts to solicit specific information about the problem. In three rounds, participants rated the relative importance of individual questions and suggested new ideas. All findings were summarized and feedback was given to all participants. In a previous study, Brady (2015) discussed the iterative nature of the Delphi method used to reach consensus, and how important this is for promoting rigor when used in research.

3.3 Sampling

The study required purposeful sampling in order to gather information from a group of people considered to be experts in the field of medical toxicology. At the time of the sampling, all prospective study participants had a medical background, extensive knowledge in medical toxicology, and their opinions were respected by colleagues nationally and internationally. To capture the collective opinion of experts in South Africa, Africa and globally, three different groups, who participated as one panel, were invited to participate in the study. The first group included sixteen Specialists in Poisons Information (SPIs) working for the National Poisons Information Helpline of South Africa. In the second group, twelve members of the African Network of Poison Control Centres (ANPCC) were approached. The third group consisted of 20 working members appointed by the World Health Organisation (WHO) to update Guidelines for Poison Control. In the latter, the members represented the American, European, Eastern Mediterranean, South East Asian, and Western Pacific Region for Poisons Control Centres. An e-mail was sent to all of the above mentioned participants, requesting their participation (Addendum 1).

3.4 Data collection and analysis

The initial questionnaire (Addendum 2) consisted of 99 items and was developed based on the curriculum content of the PGDip Tox course at Stellenbosch University, combined with a thorough literature search on the core competencies required by medical toxicologists. Competencies derived from these resources were listed under the categories of knowledge, skills and attitudes. The aim of the questionnaire was to identify if the core competencies that underpin the content and outcomes of the PGDip Tox curriculum were in alignment with the expectations of experts in the field of Medical Toxicology.

To build and manage the questionnaire, the secure Research Electronic Data Capture (REDCap) web platform (https://redcap.sun.ac.za/) was used. REDCap was developed by Vanderbilt University to create databases and projects and capture data for clinical research. Stellenbosch University has an institutional agreement with Vanderbilt University to use this web platform. An advantage of this web platform is that a participant’s anonymity can be maintained. REDCap allows the researcher to enable the participant identifier so that there is no connection between the participants email address entered and the responses collected. The system will track who has responded and who has not on the participant list page, but the researcher will not know which individual survey belongs to which respondent.

This data capture system furthermore has excellent security, privacy and data quality. On this platform it is possible to create unlimited questions and free text responses. Thematic analysis was done on the free text qualitative data where we identified and interpreted patterns of meaning. However I did not collect enough data to go through a whole process of coding and therefore did not follow the step-approach recommended by Braun and Clarke (2006). I simply just grouped the free text comments into themes and reported on the themes.

In the first round, participants were asked to rate a list of proposed core toxicology competencies in terms of their importance using a 5-point Likert-type scale (1 = unnecessary, 2 = unimportant, 3 = worth considering, 4 = important, 5 = definitely necessary). Participants were given an option to make free text comments, as well as the opportunity to suggest other core competencies that might be important or necessary. Participants were given two weeks to respond and frequent reminders were sent by email. The questionnaire responses were summarised and data from round one were exported to SPSS and then analysed. Before starting the analysis, the responses were regrouped into three groups; Unnecessary / unimportant; worth considering and important/definitely necessary. I followed the method of Salmon and Tombs (2018) and defined consensus as being reached when an item on the competency list was rated 70% or more. Items which achieved consensus (more than 70% of participants rated the item as unnecessary/unimportant or important/definitely necessary) were removed from the survey.

A second questionnaire (Addendum 3) was developed for the same respondent group based on the results of the first round, and included all items of the first questionnaire for which consensus was not reached. The second questionnaire also included extra items suggested by the participants during round one. During round two, a letter explaining the outcomes of round one (Addendum 4) and the second questionnaire (Addendum 3) was sent to all the participants who responded in the first round.

Participants were asked to re-think and re-rate each item, as well as the new core competencies that were added. During round one, respondents tended to choose the option "worth considering" when they were hesitant to answer a question. To compel respondents to choose a particular option, as was done in a study by De Villiers *et al*. (2005), the neutral middle point (worth considering) was omitted during round two and a 4-point scale was used i.e. 1 = unnecessary, 2 = unimportant, 3 = important, 4 = definitely necessary. Participants were again given an option to make free text comments after a section. During the two-week response deadline, frequent reminders were sent out via e-mail.

Consensus was not achieved on a sizeable number of items in the second round and it was necessary to develop a third questionnaire (Addendum 5). The third and final questionnaire was much shorter and consisted of fewer questions. A letter (Addendum 6) to participants was linked to this questionnaire. In the third round, participants were given only two options, i.e. "important" or "unimportant". Participants were also given an option to make free text comments after a section. They had fourteen days to complete the survey, and frequent reminders were sent to all the participants of round two.

3.5 Ethical considerations

The study was conducted in accordance with the ethical guidelines and principles of the international Declaration of Helsinki, the South African Guidelines for Good Clinical Practice (2006), the Medical Research Council, Ethical Guidelines for Research (2002), and the Department of Health Ethics in Health Research: Principles, Processes and Studies (2015). Ethical approval (Reference # S19/03/049) was obtained from the Human Research Ethics Committee of Stellenbosch University (SU), Tygerberg, Cape Town.

It was explained to invitees that different locations would be included in the study and that the geographical distribution of panellists would not pose a dilemma. Their responses would remain anonymous to the researcher and other participants. Moreover, by using anonymity in the Delphi survey, biases such as medical hierarchy, sex, ethnicity, and age would be eliminated.

Participants did not financially benefit from taking part in the research and did not receive compensation for their time, however it was explained that by participating, they would contribute to a wider recognition of the Medical Toxicology discipline. All participants would be acknowledged in publications resulting from this research.

This survey involved no particular risk to participants, as it was essentially a process of gathering expert opinion. On the contrary, this survey actually held advantages for the respondents, and they were encouraged to critically reflect and ultimately promote greater consensus in the field. The importance of the consensus concept was communicated to participants and properly defined before the initiation of the study. The views of all participants received equal weight.

CHAPTER FOUR
RESULTS

4.1 Outline of study results

Forty-eight health professionals identified in the field of medical toxicology were invited to participate in the study. Two invitees declined, because they felt that they did not have a particular view on the subject. The questionnaire in round one was thus sent to 46 participants (Figure 2) who all agreed to participate in the study. Thirty-three (72%) of the invitees completed round one. Twelve participants (26%) did not respond and one had computer difficulties and could not submit in time. The second questionnaire was sent to all responders, of whom 31 (94%) participated in the second round. In the final round, 24 of the 31 responders (77%) completed the third questionnaire.

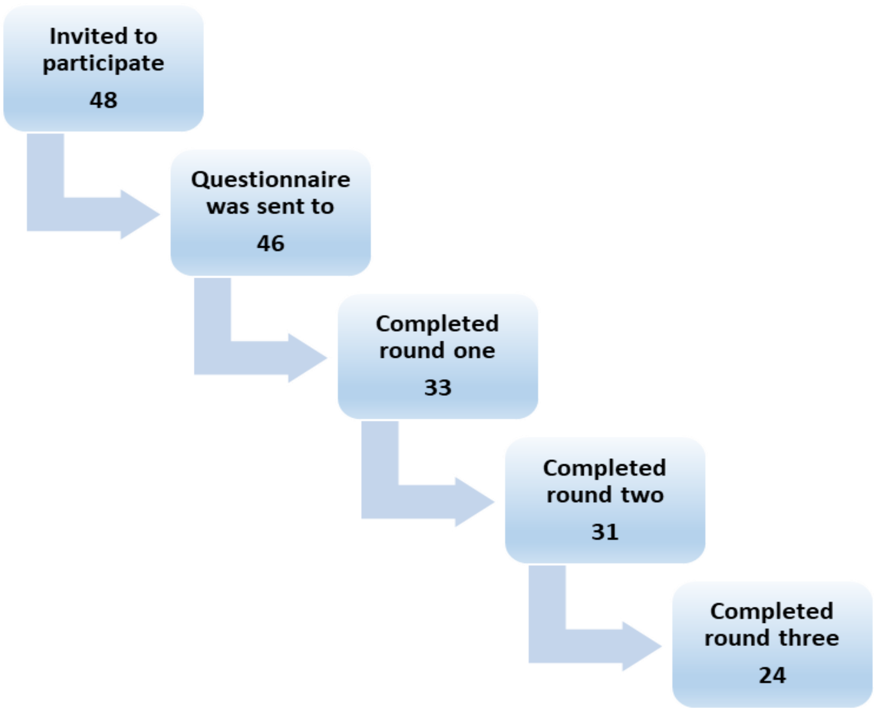

Figure 2: Number of participants invited and participating in the Delphi survey.

4.2 Round one of the Delphi survey

Both men (60%; n=20) and women participated in round one, as recommended by Boulkedid *et al.*, (2011), who stated that heterogeneity in a decision-making group may lead to better performance than homogeneity. The mean age of participants was 47 years, with the youngest participant being 29 years old and the oldest being 77 years old. Table 1 shows the demographics of the 33 participants.

Table 1: Delphi expert panel demographics

Country	Number of participants
Algeria	1
Australia	2
Brazil	1
Canada	1
Congo	1
Ethiopia	1
Ghana	1
India	1
Italy	1
Jamaica	1
Kenya	1
Lithuania	1
Malta	1
Nigeria	1
South Africa	15
Thailand	1
United Kingdom	2

Twenty-one (64%) participants were affiliated with a university, and nineteen (57%) were working in a Poisons Information Centre (PIC) at the time of the survey. Seventeen (52%) panel members were working in a hospital, one was working for the World Health Organization, one for Public Health England, and one was working independently. Some participants were affiliated with more than one institution e.g. working for both a university and PIC. Table 2 presents the profession of the participants, and Table 3 outlines their qualifications.

Table 2: Delphi expert panel professions in round one.

Profession	**Number of participants**
Medical Doctor	13
Medical Specialist	7
Pharmacist	8
Medical Scientist	5

Table 3: Delphi expert panel qualifications in round one

Qualification	**Number of participants**
PhD	8
Mmed or similar degree	3
MBChB or similar degree	10
MSc	8
BPharm	3
BSc	1

Of the 99 items in the questionnaire (round one), consensus was reached on 67 items, and all items were deemed important/necessary (see Table 4). It was not necessary to exclude any item at this point of the study. No consensus was reached on 32 items (indicated using bold text in Table 4) hence, they were included in round two of the Delphi survey.

Table 4: Results of Round One: The core competencies required by toxicology students in order to effectively function in a Poisons Information Centre
(Items on which there was not consensus are listed in bold)
(N = 33)

	Unnecessary/ unimportant		Worth considering		Important/definitely necessary	
	Count	Row N %	Count	Row N %	Count	Row N %
Acute poisoning exposures to the following chemicals:						
Paracetamol	1	3.0%	0	0.0%	32	97.0%
Salicylate	1	3.0%	4	12.1%	28	84.8%
Other NSAIDS	1	3.0%	12	36.4%	20	60.6%
Tricyclic Antidepressants	1	3.0%	1	3.0%	31	93.9%
Selective serotonin re-uptake inhibitors	1	3.0%	5	15.2%	27	81.8%
Neuroleptics	2	6.1%	2	6.1%	29	87.9%
Lithium	2	6.1%	6	18.2%	25	75.8%
Decongestants	5	15.2%	8	24.2%	20	60.6%
Antihistamines	2	6.1%	9	27.3%	22	66.7%
Calcium channel and beta blockers	1	3.0%	2	6.1%	30	90.9%
Digoxin	1	3.0%	7	21.2%	25	75.8%
Diuretics	6	18.2%	10	30.3%	17	51.5%
Theophylline	2	6.1%	5	15.2%	26	78.8%
Sleeping pills	1	3.0%	2	6.1%	30	90.9%
Antimicrobials (ARVs)	3	9.1%	12	36.4%	18	54.5%
Antimicrobials (INH)	2	6.1%	7	21.2%	24	72.7%
Antimicrobials (other)	6	18.2%	12	36.4%	15	45.5%

Antidiabetic drugs	2	6.1%	5	15.2%	26	78.8%
Drugs of abuse	1	3.0%	3	9.1%	29	87.9%
Cyanide	3	9.1%	8	24.2%	22	66.7%
Caustic and corrosive substances	2	6.1%	3	9.1%	28	84.8%
Iron	2	6.1%	3	9.1%	28	84.8%
Toxic alcohols	1	3.0%	2	6.1%	30	90.9%
Heavy metals (lead, arsenic, mercury, cadmium)	2	6.1%	7	21.2%	24	72.7%
Cholinesterase inhibitors	1	3.0%	2	6.1%	30	90.9%
Amitraz	4	12.1%	4	12.1%	25	75.8%
Rodenticides (longacting anticoagulants)	1	3.0%	3	9.1%	29	87.9%
Paraquat	2	6.1%	4	12.1%	27	81.8%
Aliphatic hydrocarbons	2	6.1%	3	9.1%	28	84.8%
Aromatic hydrocarbons	2	6.1%	3	9.1%	28	84.8%
Pyrethroids/Pyrethrins	1	3.0%	5	15.2%	27	81.8%
Mothballs	2	6.1%	6	18.2%	25	75.8%
Carbon monoxide	2	6.1%	6	18.2%	25	75.8%
Chemical warfare	8	24.2%	11	33.3%	14	42.4%
Cytotoxic snakes	1	3.0%	2	6.1%	30	90.9%
Neurotoxic snakes	1	3.0%	2	6.1%	30	90.9%
Haemotoxic snakes	1	3.0%	2	6.1%	30	90.9%
Scorpion sting	2	6.1%	3	9.1%	28	84.8%
Neurotoxic spider	2	6.1%	3	9.1%	28	84.8%

envenomation						
Cytotoxic spider envenomation	3	9.1%	4	12.1%	26	78.8%
Marine envenomation	2	6.1%	10	30.3%	21	63.6%
Marine poisoning	2	6.1%	9	27.3%	22	66.7%
Poisonous frogs	12	36.4%	11	33.3%	10	30.3%
Plants	1	3.0%	10	30.3%	22	66.7%
Mushrooms	1	3.0%	6	18.2%	26	78.8%
Insects and bee stings	1	3.0%	11	33.3%	21	63.6%
Food poisoning	5	15.2%	8	24.2%	20	60.6%
Complementary and alternative medicine	4	12.1%	14	42.4%	15	45.5%
Knowledge about the following:						
Antidotes used in poisoning	1	3.0%	1	3.0%	31	93.9%
Analytical toxicology	2	6.1%	11	33.3%	20	60.6%
Nano toxicology	9	27.3%	17	51.5%	7	21.2%
Environmental toxicology	3	9.1%	10	30.3%	20	60.6%
Occupational toxicology	3	9.1%	6	18.2%	24	72.7%
Regulatory toxicology	4	12.1%	18	54.5%	11	33.3%
Forensic toxicology	2	6.1%	16	48.5%	15	45.5%
Veterinary toxicology	5	15.2%	17	51.5%	11	33.3%
The history of toxicology	7	21.2%	14	42.4%	12	36.4%

Pharmacokinetics and pharmacodynamics	0	0.0%	6	18.2%	27	81.8%
Mechanisms and pathology of drug toxicology	0	0.0%	6	18.2%	27	81.8%
Drug-drug interactions	1	3.0%	7	21.2%	25	75.8%
Dose response	1	3.0%	7	21.2%	25	75.8%
Extracorporeal elimination	1	3.0%	7	21.2%	25	75.8%
Poisons information centres	2	6.1%	4	12.1%	27	81.8%
International programme on chemical safety	3	9.1%	13	39.4%	17	51.5%
Clinical management of the poisoned patient	1	3.0%	1	3.0%	31	93.9%
The psychiatric patient	2	6.1%	9	27.3%	22	66.7%
Be familiar with the SOPs of your Poisons Information Centre	3	9.1%	4	12.1%	26	78.8%
Able to effectively use information technology to access, evaluate and interpret toxicology information	0	0.0%	0	0.0%	33	100.0%
Know where to look first to address a poisoning query. (databases, books, journals etc.)	0	0.0%	0	0.0%	33	100.0%

Know how to calculate basic toxicology measures	0	0.0%	2	6.1%	31	93.9%
Apply evidence-based toxicology principles and knowledge for decision-making.	0	0.0%	2	6.1%	31	93.9%
Distinguish evidence-based toxicology information from opinion-based toxicology information.	1	3.0%	1	3.0%	31	93.9%
Evaluate the strengths and limitations of evidence-based toxicology articles and reports	1	3.0%	4	12.1%	28	84.8%
Identify different types of toxicology queries, such as questions about poisoning management, diagnosis, prognosis and information.	1	3.0%	3	9.1%	29	87.9%
Able to communicate effectively (verbally and in writing) with healthcare providers in a manner that they understand.	0	0.0%	0	0.0%	33	100.0%
Able to communicate effectively (verbally and in writing) with	0	0.0%	3	9.1%	30	90.9%

the general public in a manner that they understand.						
Share information with the patient, healthcare worker, media or public health authorities, respecting confidentiality	0	0.0%	2	6.1%	31	93.9%
Able to interact with the media, deliver briefings and conduct meetings	4	12.1%	14	42.4%	15	45.5%
Collaborate and consult with other healthcare professionals in a cooperative manner	0	0.0%	3	9.1%	30	90.9%
Recommend appropriate interventions on a case-by-case basis and not just apply generic advice e.g. just reading off a data base	0	0.0%	4	12.1%	29	87.9%
Maintain accurate, comprehensive and legible records/documentation	0	0.0%	1	3.0%	32	97.0%
Able to demonstrate language adaptation skills (ability to work in a setting where you are not a native speaker)	0	0.0%	9	27.3%	24	72.7%

Able to demonstrate leadership skills.	1	3.0%	15	45.5%	17	51.5%
Able to function effectively in a team	0	0.0%	4	12.1%	29	87.9%
Able to have conflict resolution skills e.g. handling agitated, anxious or rude callers	0	0.0%	5	15.2%	28	84.8%
Able to demonstrate teaching and educational skills	2	6.1%	11	33.3%	20	60.6%
Able to demonstrate research skills	2	6.1%	13	39.4%	18	54.5%
Able to demonstrate administration skills	4	12.1%	13	39.4%	16	48.5%
Able to demonstrate analytical skills	3	9.1%	10	30.3%	20	60.6%
Able to think creatively	3	9.1%	9	27.3%	21	63.6%
Able to demonstrate respect for cultural and religious beliefs and an awareness of their impact on decision making	0	0.0%	5	15.2%	28	84.8%
Able to demonstrate a capacity for compassion	1	3.0%	7	21.2%	25	75.8%
Able to demonstrate commitment to	2	6.1%	2	6.1%	29	87.9%

service						
Able to demonstrate commitment to self-directed learning	1	3.0%	3	9.1%	29	87.9%
Seek learning opportunities and integrate the knowledge into daily practice	2	6.1%	3	9.1%	28	84.8%
Respect privacy, dignity, confidentiality and legal constraints of patient data.	0	0.0%	2	6.1%	31	93.9%
Able to show the ability to interact with diverse individuals	1	3.0%	3	9.1%	29	87.9%
Able to show a passion for the discipline of medical toxicology	1	3.0%	4	12.1%	28	84.8%
Able to multitask	2	6.1%	8	24.2%	23	69.7%

Participants also made suggestions on new topics that should be included in round two (Table 5).

Table 5: New competencies suggested by panellists to be included and rated in round two of the Delphi survey.

Able to take care of drug addicts
Able to work in a multidisciplinary team, in particular across public health and environmental sectors
Able to respond to chemical accidents
Toxic exposure to Anti-malarial drugs

Antidotes mechanism of action
Toxic exposure to Asbestos
Toxic exposure to Carbamazepine
Toxic exposure to Chloralose
Toxic exposure to Chlorophenoxy herbicides
Toxic exposure to Colchicine
Common causes of acute and chronic poisoning
Data analysis
Decontamination options
Toxic exposure to Diquat
Enhanced elimination
Field of ethics
Toxic exposure to household substances
Toxic exposure to Methotrexate
On basic economic principles and public processes in the country
Toxic exposure to Organochlorines
Prevention of poisoning
Rehabilitation system in the country
Toxic exposure to street pesticides
Should be able to identify limitations of knowledge within themselves (e.g.when to refer an enquiry
Toxic exposure to Street pesticides
Toxicokinetics/ dynamics
Toxicovigilance
The components of risk assessment
The general approach to resuscitation in the poisoned patient
The International Health Regulations (IHR)
The screening of addictive substances
The Strategic Approach to International Chemicals Management (SAICM)
Toxic exposure to Valproic acid
WHO guidelines for Poison Information Centres

In round one, there was an agreement of > 90% from all the participants on 22 of the suggested competencies (table 6).

Table 6: Competencies that reached the highest agreement (>90%) by 33 participants.

Competencies	% of panellists that agreed
Able to effectively use information technology to access, evaluate and interpret toxicology information	100%
Know where to look first to address a poisoning query (databases, books, journals etc.)	100%
Able to communicate effectively (verbally and in writing) with healthcare providers in a manner that they understand.	100%
Maintain accurate, comprehensive and legible records/documentation	97%
Toxic exposure to paracetamol	97%
Respect privacy, dignity, confidentiality and legal constraints of patient data.	94%
Clinical management of the poisoned patient	94%
Know how to calculate basic toxicology measures	94%
Apply evidence-based toxicology principles and knowledge for decision-making.	94%
Distinguish evidence-based toxicology information from opinion-based toxicology information.	94%
Share information with the patient, healthcare worker, media or public health authorities, respecting confidentiality	94%
Antidotes used in poisoning	94%
Toxic exposure to Tricyclic antidepressants	94%
Collaborate and consult with other healthcare professionals in a cooperative manner	91%
Able to communicate effectively (verbally and in writing) with the general public in a manner that they understand.	91%
Toxic exposure to Toxic alcohols	91%
Toxic exposure to Cholinesterase inhibitors	91%
Toxic exposure to Cytotoxic snake bite	91%
Toxic exposure to Neurotoxic snake bite	91%
Toxic exposure to Haemotoxic snake bite	91%

Toxic exposure to calcium Channel Blockers	91%
Toxic exposure to Sleeping pills	91%

4.3 Round two of the Delhi survey:

For round two, the questionnaire consisted of 67 core competencies, consistent with the sum of items that failed to reach consensus in round one (n=32), as well as new items suggested by responders (n=35). Two of the 33 candidates who participated in round one did not respond in the second round. Consensus was reached on forty-four (66%) items, which were deemed important/necessary (see Table 7). It was therefore not necessary to exclude any item at this point in the study. Consensus was not reached for 23 (34%) core competencies (indicated using bold text in Table 7)).

Table 7: Results of round two: The core competencies required by toxicology students in order to effectively function in a Poisons Information Centre.
(N = 31)
(Items on which there was not consensus are listed in bold)

	Unnecessary/ unimportant		**Important/definitely necessary**	
	Count	Row N %	Count	Row N %
Acute poisoning exposures to the following chemicals:				
Other NSAIDS	5	16.1%	26	83.9%
Decongestants	9	29.0%	22	71.0%
Antihistamines	4	12.9%	27	87.1%
Diuretics	10	32.3%	21	67.7%
Antimicrobials (ARVs)	6	19.4%	25	80.6%
Antimicrobials (other)	11	35.5%	20	64.5%
Cyanide	3	9.7%	28	90.3%
Chemical warfare	13	41.9%	18	58.1%
Marine envenomation	2	6.5%	29	93.5%
Marine poisoning	1	3.2%	30	96.8%

	Unnecessary/ unimportant		**Important/definitely necessary**	
	Count	Row N %	Count	Row N %
Poisonous frogs	19	61.3%	12	38.7%
Plants	5	16.1%	26	83.9%
Insects and bee stings	4	12.9%	27	87.1%
Food poisoning	12	38.7%	19	61.3%
Complementary and alternative medicine	15	48.4%	16	51.6%
Colchicine	10	32.3%	21	67.7%
Carbamazepine	3	9.7%	28	90.3%
Valproic acid	4	12.9%	27	87.1%
Methotrexate	5	16.1%	26	83.9%
Anti-malarial drugs	7	22.6%	24	77.4%
Rodenticides (other than the long acting anti-coagulants for which deep knowledge is required)	2	6.5%	29	93.5%
Chlorophenoxy herbicides	10	32.3%	21	67.7%
Organochlorines	7	22.6%	24	77.4%
Asbestos	12	38.7%	19	61.3%
Chloralose	17	54.8%	14	45.2%
Diquat	9	29.0%	22	71.0%
Household substances	1	3.2%	30	96.8%
Knowledge about the following:				
Street pesticides	4	12.9%	27	87.1%
Toxicokinetics/ dynamics	2	6.5%	29	93.5%
Common causes of acute and chronic poisoning	1	3.2%	30	96.8%

	Unnecessary/ unimportant		**Important/definitely necessary**	
	Count	Row N %	Count	Row N %
Prevention of poisoning	5	16.1%	26	83.9%
Antidotes mechanism of action	3	9.7%	28	90.3%
Toxidromes	1	3.2%	30	96.8%
Enhanced elimination	3	9.7%	28	90.3%
Decontamination options	1	3.2%	30	96.8%
Analytical toxicology	8	25.8%	23	74.2%
Nano toxicology	21	67.7%	10	32.3%
Environmental toxicology	7	22.6%	24	77.4%
Regulatory toxicology	16	51.6%	15	48.4%
Forensic toxicology	9	29.0%	22	71.0%
Veterinary toxicology	13	41.9%	18	58.1%
The history of toxicology	17	54.8%	14	45.2%
International programme on chemical safety	9	29.0%	22	71.0%
The psychiatric patient	8	25.8%	23	74.2%
The screening of addictive substances	4	12.9%	27	87.1%
The components of risk assessment	8	25.8%	23	74.2%
General approach to resuscitation in the poisoned patient	1	3.2%	30	96.8%
Field of ethics	9	29.0%	22	71.0%
Toxicovigilance	5	16.1%	26	83.9%
Rehabilitation system in the country	16	51.6%	15	48.4%

	Unnecessary/ unimportant		**Important/definitely necessary**	
	Count	Row N %	Count	Row N %
WHO guidelines for Poison Information Centres	5	16.1%	26	83.9%
The Strategic Approach to International Chemicals Management	14	45.2%	17	54.8%
The International Health Regulations	16	51.6%	15	48.4%
On basic economic principles and public processes in the country	20	64.5%	11	35.5%
Data analysis	9	29.0%	22	71.0%
Able to interact with the media, deliver briefings and conduct meetings	12	38.7%	19	61.3%
Able to demonstrate leadership skills .	13	41.9%	18	58.1%
Able to demonstrate teaching and educational skills	8	25.8%	23	74.2%
Able to demonstrate research skills	9	29.0%	22	71.0%
Able to demonstrate administration skills	10	32.3%	21	67.7%
Able to demonstrate analytical skills	14	45.2%	17	54.8%
Able to think creatively	6	19.4%	25	80.6%
Able to take care of drug addicts	18	58.1%	13	41.9%
Able to work in a multidisciplinary team, in particular across public	3	9.7%	28	90.3%

	Unnecessary/ unimportant		**Important/definitely necessary**	
	Count	Row N %	Count	Row N %
health and environmental sectors				
Able to respond to chemical accidents	8	25.8%	23	74.2%
Able to multitask	7	22.6%	24	77.4%
Should be able to identify limitations of knowledge within themselves (e.g.when to refer an enquiry)	0	0.0%	31	100.0%

In round two, there was ≥ 90% agreement in 15 of the suggested competencies (table 8).

Table 8: Competencies that reached the highest agreement ≥ 90% by participants in round two.

Competencies	**% of panellists that agreed**
Should be able to identify limitations of knowledge within themselves (e.g. when to refer an enquiry)	100%
Common causes of acute and chronic poisoning	97%
The general approach to resuscitation in the poisoned patient	97%
Decontamination options	97%
Toxidromes	97%
Marine poisoning	97%
Toxic exposure to household substances	97%
Toxicokinetics/ dynamics	94%
Rodenticides (other than the long acting anti-coagulants for which deep knowledge is required)	94%
Marine envenomation	94%
Enhanced elimination	90%
Able to work in a multidisciplinary team, in particular across public health and environmental sectors	90%
Antidotes mechanism of action	90%

Toxic exposure to Carbamazepine	90%
Toxic exposure to Cyanide	90%

4.4 Round three of the Delphi survey:

Twenty-four (77%) of the 31 participants from round two also completed round three of the survey. The reason why nine panellists from seven different countries dropped out during round one and two is not known. Table 9 shows the demographics of the remaining 24 participants.

Table 9: Delphi expert panel demographics in round three of the Delphi study

Country	Number of participants
Australia	2
Brazil	1
Congo	1
Ghana	1
India	1
Italy	1
Jamaica	1
Malta	1
Nigeria	1
South Africa	12
United Kingdom	2

In round three, three medical doctors (31%), three medical specialists (57%) and one pharmacist (13%) dropped out of the study (Table 10)

Table 10: Delphi expert panel's professions in all three rounds of the Delphi study

Profession	Number of participants in round one	Number of participants in round two	Number of participants in round three
Medical Doctor	13	12	9
Medical Specialist	7	6	3
Pharmacist	8	8	7
Medical Scientist	5	5	5

The third questionnaire consisted of the items on which no consensus was reached in the previous rounds. Of the 23 items, consensus was reached on seven (30%) competencies. Participants disagreed on the importance of 16 competencies (Table 11).

Table 11: Items in round three of the Delphi survey on which no consensus was reached.

Toxic exposure to Diuretics
Toxic exposure to Antimicrobials (excluding ARVs and INH)
Toxic exposure to Chemical warfare
Food poisoning
Toxic exposure to complementary and alternative medicine
Toxic exposure to Colchicine
Toxic exposure to Chlorophenoxy herbicides
Toxic exposure to Asbestos
Regulatory toxicology
The history of toxicology
Rehabilitation system in the country
The Strategic Approach to International Chemicals Management
The International Health Regulations
Veterinary Toxicology

Able to demonstrate leadership skills
Able to interact with the media, deliver briefings and conduct meetings

4.5 Summary of the three rounds of the Delphi process

A total of 134 competencies were selected for the three rounds and in the end consensus was reached on 118 (88%) items. Panel members agreed that 113 (96%) of these items should be incorporated in a medical toxicology curriculum and five (4%) competencies should be excluded (Figure3).

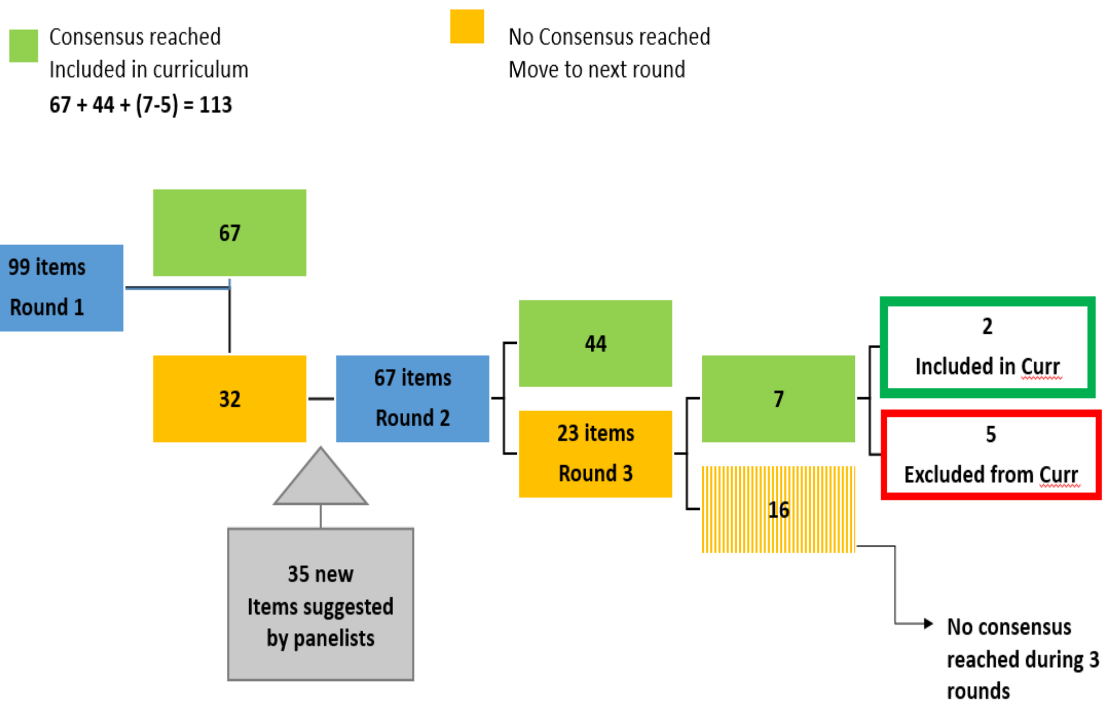

Figure 3: Summary of the three rounds in the Delphi survey (Curr = curriculum).

The five competencies that were excluded from the curriculum included information on poisonous frogs, chloralose, nano-toxicology, how to take care of drug addicts, and the importance for medical toxicology students to learn about basic economic principles and public processes in a country. Table 12 includes the core competencies (n=113) for which consensus were reached, and therefore should be incorporated into a Post Graduate curriculum for medical toxicologists. (Rated from high to low).

Table 12: The core competencies required by toxicology graduates in order to function effectively in a Poisons Information Centre: *(Red = new competencies suggested by panellists; Blue = items on which consensus was reached only in the second round; Green = items on which consensus was reached only in the third round)*

Able to effectively use information technology to access, evaluate and interpret toxicology information	100.00%
Know where to look first to address a poisoning query. (Database, books, journals etc.)	100.00%
Able to communicate effectively (verbally and in writing) with healthcare providers in a manner that they understand.	100.00%
Should be able to identify limitations of knowledge within themselves (e.g.when to refer an enquiry)	100.00%
Toxic exposure to Paracetamol	97.00%
Maintain accurate, comprehensive and legible records/documentation	97.00%
Toxic exposure to Household substances	96.80%
Common causes of acute and chronic poisoning	96.80%
Toxidromes	96.80%
Decontamination options	96.80%
The general approach to resuscitation in the poisoned patient	96.80%
Tricyclic Antidepressants	93.90%
Antidotes used in poisoning	93.90%
Clinical management of the poisoned patient	93.90%
Know how to calculate basic toxicology measures	93.90%
Apply evidence-based toxicology principles and knowledge for decision-making.	93.90%
Distinguish evidence-based toxicology information from opinion-based toxicology information.	93.90%
Share information with the patient, healthcare worker, media or public health authorities, respecting confidentiality	93.90%
Respect privacy, dignity, confidentiality and legal constraints of patient data.	93.90%
Rodenticides (other than the long acting anti-coagulants for which deep knowledge is required)	93.50%
Toxicokinetics/ dynamics	93.50%
Toxic exposure to Calcium channel and beta blockers	90.90%
Toxic exposure to Sleeping pills	90.90%

Toxic exposure to toxic alcohols	90.90%
Toxic exposure to Cholinesterase inhibitors	90.90%
Toxic exposure to Cytotoxic snake bite	90.90%
Toxic exposure to Neurotoxic snake bite	90.90%
Toxic exposure to Hemotoxic snake bite	90.90%
Able to communicate effectively (verbally and in writing) with the general public in a manner that they understand.	90.90%
Collaborate and consult with other healthcare professionals in a cooperative manner	90.90%
Toxic exposure to Carbamazepine	90.30%
Antidotes mechanism of action	90.30%
Enhanced elimination	90.30%
Able to work in a multidisciplinary team, in particular across public health and environmental sectors	90.30%
Toxic exposure to Neuroleptics	87.90%
Toxic exposure to Drugs of abuse	87.90%
Toxic exposure to Rodenticides (long acting anticoagulants)	87.90%
Identify different types of toxicology queries, such as questions about poisoning management, diagnosis, prognosis and information.	87.90%
Recommend appropriate interventions on a case-by-case basis and not just apply generic advice e.g. just reading off a data base	87.90%
Able to function effectively in a team	87.90%
Able to demonstrate commitment to service	87.90%
Able to demonstrate commitment to self-directed learning	87.90%
Able to show the ability to interact with diverse individuals	87.90%
Toxic exposure to Valproic acid	87.10%
Street pesticides	87.10%
The screening of addictive substances	87.10%
Toxic exposure to Salicylate	84.80%
Toxic exposure to Caustic and corrosive substances	84.80%
Toxic exposure to Iron	84.80%
Toxic exposure to Aliphatic hydrocarbons	84.80%

Toxic exposure to Aromatic hydrocarbons	84.80%
Scorpions sting	84.80%
Neurotoxic spider envenomation	84.80%
Evaluate the strengths and limitations of evidence-based toxicology articles and reports	84.80%
Able to have conflict resolution skills e.g. handling agitated, anxious or rude callers	84.80%
Able to demonstrate respect for cultural and religious beliefs and an awareness of their impact on decision making	84.80%
Seek learning opportunities and integrate the knowledge into daily practice	84.80%
Able to show a passion for the discipline of medical toxicology	84.80%
Toxic exposure to Methotrexate	83.90%
Prevention of poisoning	83.90%
Toxicovigilance	83.90%
WHO guidelines for Poison Information Centres	83.90%
Toxic exposure to Selective serotonin re-uptake inhibitors	81.80%
Toxic exposure to Paraquat	81.80%
Toxic exposure to Pyrethroids/Pyrethrins	81.80%
Pharmacokinetics and pharmacodynamics	81.80%
Mechanisms and pathology of drug toxicology	81.80%
Poisons information centres	81.80%
Toxic exposure to Theophylline	78.80%
Toxic exposure to Antidiabetic drugs	78.80%
Cytotoxic spider envenomation	78.80%
Toxic exposure to Mushrooms	78.80%
Be familiar with the SOPs of your Poisons Information Centre	78.80%
Toxic exposure to Anti-malarial drugs	77.40%
Toxic exposure to Organochlorines	77.40%
Toxic exposure to Lithium	75.80%
Toxic exposure to Digoxin	75.80%
Toxic exposure to Amitraz	75.80%
Toxic exposure to Mothballs	75.80%

Toxic exposure to Carbon monoxide	75.80%
Drug-drug interactions	75.80%
Dose response	75.80%
Extracorporeal elimination	75.80%
Able to demonstrate a capacity for compassion	75.80%
The components of risk assessment	74.20%
Toxic exposure to Antimicrobials (INH)	72.70%
Toxic exposure to Heavy metals (lead, arsenic, mercury, cadmium)	72.70%
Occupational toxicology	72.70%
Able to demonstrate language adaptation skills (ability to work in a setting where you are not a native speaker)	72.70%
Toxic exposure toDiquat	71.00%
Field of ethics	71.00%
Marine poisoning	96.80%
Marine envenomation	93.50%
Toxic exposure to Cyanide	90.30%
Toxic exposure to Antihistamines	87.10%
Insects and bee stings	87.10%
Toxic exposure to other NSAIDS	83.90%
Toxic exposure to Plants	83.90%
Toxic exposure to Antimicrobials (ARVs)	80.60%
Able to think creatively	80.60%
Environmental toxicology	77.40%
Able to multitask	77.40%
Analytical toxicology	74.20%
Able to demonstrate teaching and educational skills	74.20%
Able to respond to chemical accidents	74.20%
The psychiatric patient	74.20%
Toxic exposure to Decongestants	71.00%
Forensic toxicology	71.00%
International programme on chemical safety	71.00%

Data analysis	71.00%
Able to demonstrate research skills	71.00%
Able to demonstrate administration skills	75,00%
Able to demonstrate analytical skills	75,00%

4.6 Modification of an existing framework to organise the list of competencies

CanMeds is a competency-based, educational framework that describes the core knowledge, skills and abilities of specialist physicians (Frank et al., 2007) It defines seven intrinsic roles that lead to optimal health and health care outcomes: Medical Expert (central role), Communicator, Collaborator, Leader, Health Advocate, Scholar and Professional. The overarching goal of CanMeds is to improve patient care. In 2014 the Health Professions Council of South Africa endorsed a document on the core competencies for undergraduate students in clinical associate, dentistry and medical teaching and learning programmes. With permission this document was adapted from the CanMeds Physician Competency Framework (Knight, Ross and Mahomed, 2017). The authors described this learning platform as innovative and effective and I therefore decided to modify the CanMeds framework to interpret and categorise the competencies derived from my consensus survey.

Table 13: Core competencies of Medical Toxicology graduates as categorized by the CanMeds framework.

CanMeds Roles	Values of a SPI	Principles of a SPI	Core competencies
Medical Expert	Safety of patient	The safe SPI is a health care practitioner who embraces the knowledge/science of chemicals that can cause harm to the poisoned patient or affects the well-being of the patient.	**Deep knowledge on toxic exposure to**: Paracetamol Salicylate Other NSAIDs Tricyclic Antidepressants SSRI Neuroleptics Lithium Decongestants Antihistamines CCB and Beta Blockers Digoxin Diuretics Theophylline Carbamazepine

			Methotrexate Sleeping pills Antimicrobials Antidiabetic drugs Drugs of abuse Cyanide Caustic and Corrosive substances Iron Toxic alcohols Heavy metals Cholinesterase inhibitors Amitraz Rodenticides (longacting anti-coagulants) Paraquat Diquat Aliphatic hydrocarbons Aromatic hydrocarbons Pyrethroids / Pyrethrins Mothballs Carbon Monoxide Cytotoxic snakes Neurotoxic snakes Hemotoxic snakes Scorpions Neurotoxic spider envenomation Cytotoxic spider Envenomation Marine envenomation Marine poisoning Plants Mushrooms Insect and bee stings **Basic knowledge on:** Antidotes used in poisoning Common causes of acute and chronic poisoning Toxidromes Decontamination options Resuscitation of the poisoned patient Clinical management of the poisoned patient Analytical toxicology Nano toxicology Environmental toxicology Occupational Toxicology

			Regulatory Toxicology Forensic toxicology Veterinary Toxicology The history of Toxicology Pharmacokinetics and pharmacodynamics Mechanisms and pathology of drug toxicity Drug-drug interaction Dose response Extracorporeal elimination Poisons information centres International Programme on Chemical Safety Chemical warfare Clinical management of the poisoned patient The psychiatric patient (self-harm) Calculate basic toxicology measures Screening of addictive substances Field of ethics Data analysis
Communicator	Respect Accountability Transparency	The SPI effectively communicates in clear, honest and respectful dialogue about poison matters, and sees a mutual responsibility between him/her and the healthcare worker.	Able to communicate effectively (verbally and in writing) with the healthcare providers and the general public in a manner that they understand. Identify different types of toxicology queries, such as questions about poisoning management, diagnosis, prognosis and information. Recommend appropriate interventions on a case-by-case basis and not just apply generic advice e.g. just reading off a data base. Able to have conflict resolution skills e.g. handling agitated, anxious or rude callers. Able to demonstrate language adaptation skills

Collaborator	Autonomy Access Partnership Trust	The SPI recognizes the value of team work for improved patient outcomes, fewer preventable errors, reduced healthcare costs, and improved relationships with other disciplines	Share information with the patient, healthcare worker, media or public health authorities, respecting confidentiality. Collaborate and consult with other healthcare professionals in a cooperative manner. Able to work in a multidisciplinary team, in particular across public health and environmental sectors. Able to function effectively in a team. Able to multitask
Leader	Self-determination Sustainability Equity	The SPI is equipped with the attitude and experience to achieve the highest form of evidence-based practise while demonstrating cultural humility and safety.	Maintain accurate, comprehensive and legible records/documentation Able to effectively use information technology to access, evaluate and interpret toxicology information. Apply evidence-based toxicology principles and knowledge for decision-making. Able to show the ability to interact with diverse individuals. Able to demonstrate respect for cultural and religious beliefs and an awareness of their impact on decision making. Able to demonstrate a capacity for compassion. Able to think creatively.
Health Advocate	Acknowledgement Holism	A SPI should develop and deliver credible poisoning prevention outreach and educational resources. Developing skills in advocacy and	Prevention of poisoning. Toxicovigilance. WHO guidelines for PIC's. Poisons information centres. Be familiar with the SOPs of the PIC.

		community education can promote professional development through service.	The components of risk assessment. Able to respond to chemical accidents. International programme on chemical safety.
Professional	Self-regulation Transferability Self-reflection	A SPI is committed to the well-being of patients, their families, communities and cultures through ethical behaviours, compassion, integrity and respect.	Should be able to identify limitations of knowledge within themselves (e.g.when to refer an enquiry) Respect privacy, dignity, confidentiality and legal constraints of patient data. Able to demonstrate commitment to service
Scholar	Enthusiasm Foresight Evidence Shared-research	A SPI understands that medical toxicology is an integral component of medical research, education, training and practice, and that this research is based on evidence from empirical sources and critical appraisal of relevant material.	Know where to look first to address a poisoning query. Distinguish evidence-based toxicology information from opinion-based toxicology information. Able to demonstrate commitment to self-directed learning. Seek learning opportunities and integrate the knowledge into daily practice Able to show a passion for the discipline of medical toxicology Able to demonstrate teaching and educational skills. Able to demonstrate research skills. Able to demonstrate analytical skills. Able to demonstrate administration skills.

4.7 Feedback from and response to participants of the Delphi study

After the first and second round, participants of the Delphi survey were given the opportunity for free-text feedback. The feedback provided a mechanism for valuing and reconciling the different opinions of the panellists. Despite limited participant feedback, some themes stood out as needing clarification.

Firstly, panellists were not sure what was meant by the term "deep toxicology knowledge", and whether the student is expected to have this knowledge already when applying for a position at a Poisons Information Centre. In response to the need of panellists to understand the difference between general and deep knowledge, the following information was communicated:

(I) Deep toxicology knowledge (i.e. Paracetamol overdose); here the student must be able to have a discussion without consulting a text book or database.

(II) Some general basic knowledge, meaning some knowledge / background to enable the student to work in a poisons centre.

Panellists were concerned that the topics were very country-specific, and that the type of poisoning exposures that occur globally are not similar in all countries. Since most of the panellists were form South Africa, panellists thought that the main focus should be on poisoning exposures commonly seen in South Africa. This limitation was predicted before the initiation of the study. However, it was still decided to include national and international panellists. The data are richer coming from more participants with different international views. It is also very valuable, for future collaboration, to promote the study results to an international group of medical toxicologists.

One participant felt strongly that it is not the responsibility of all poisons information staff to interact with the media and that correspondence with the media should be assigned to the Director of the Poisons Centre. In the Delphi survey, the skill of dealing with the media was one of the competencies for which no consensus was reached, suggesting that interacting with the media should ideally be allocated to management.

There was the opinion that poison information toxicology could be managed by developing and using clinical pathways, so the major skill would be to recognise the type of poisoning and then fit it on the correct pathway with tailored management. In the literature, there is no evidence of clinical pathways in medical toxicology. No poisoning exposure is the same, and as proclaimed by Paracelsus, it is the dose that determines the inherent toxicity (Grandjean, 2016). Hence, the novel suggestion of developing clinical pathways in medical toxicology is challenging, needs further investigation and falls outside the scope of this survey.

It was suggested that it would have been better to group poisoning exposures and not to name specific chemicals, e.g. pyrethroids, carbamates, herbicides and fungicides should all be grouped as pesticides. However, the researcher felt it was necessary to break down categories into individual poison groups to determine if it is important for their inclusion in the curriculum.

In the third round, panellists mentioned that the term “Data analysis" was very broad and required clarification. Data analysis is different in a number of fields such as technology, finance, marketing and human resource. These fields often overlap in the discipline of medical toxicology and, depending on the SPI’s position (e.g. Director), it might be necessary to have a variety of data analysis skills. Participants might not have known this at the time of answering the question.

In the first round panellists were confused with the different options, and when it came to rating skills they would use "Unnecessary" rather than "Important". The first round Delphi started with a five-point Likert scale that allowed for degrees of opinion, and even no opinion at all. It was thought that it would increase response rate and response quality, but by the third round it was evident to reduce the response to a simple” important” or “not important” answer.

CHAPTER FIVE
DISCUSSION

This study involved an iterative process, based on three rounds of questionnaire responses, with the purpose of determining the core competencies required by a graduate to successfully and effectively function as a medical toxicologist. The final consensus set included 113 competencies and certain observations and recommendations could be derived from the results of this study.

5.1 Highest rated competencies

Competencies that reached the highest agreement (>90%) in round one included core knowledge of paracetamol, tricyclic antidepressants, cholinesterase inhibitors, and sleeping pills. This is not surprising, since Poison Centres are most commonly contacted regarding an overdose with these chemicals (Veale, Wium and Müller, 2013). All participants agreed that effective communication is an essential skill for toxicology graduates.

In round one, a new competency was suggested by the participants, *"toxicology students should be able to identify limitations of knowledge within themselves (e.g. when to refer an enquiry)."* In round two, all participants agreed that this competency is indeed an important skill. The latter implicates that when a medical toxicologist (e.g. pharmacist) is managing a case that becomes too clinical, the case should be referred to a clinician. Guidelines for poison control, developed by the WHO (International Program on Chemical Safety and World Health Organization., 1997) recommend that pharmacists and medical scientists should run the after-hours service with medical doctors second in line to give support when needed. Furthermore, when doctors experience a limitation in their knowledge, they should have access to a supervisor, such as a medical toxicology specialist. Self-regulated learning is divided into three phases, i.e. the planning phase, the performance phase and the self-reflection phase. Incorporating self-regulatory teaching in the curriculum is thus important to ensure that medical toxicology graduates can plan, perform and self-reflect on their actions. Professionalism and self-regulation are essential attributes for healthcare workers, who should be devoted to service, profession and society (Wynia, 2000).

The responders inthis survey highlighted good communication skills as a comprehensive competency. Mastering communication skills in a poisons centre means understanding the different styles of communication, engaging in active listening skills, and mastering a quality service over the phone. An aggressive communicator will dominate communication efforts, ignore the other speaker and their suggestions, or interrupt constantly. The passive communicator tends to go along with, or agree with, everything another person says. Such individuals cannot be firm enough in providing solutions on poisoning scenarios and this can be confusing to the caller. An assertive communicator has the ability to listen to the issue and will offer solutions to the problem. They are polite and courteous and won't allow themselves to be walked all over. They respect others and themselves, their abilities, and their capabilities (Eppich, Rethans, Dornan, *et al*., 2018).

The CanMEDS-framework (Frank *et al.*, 2007) identifies and describes the importance of communication as an essential skill, needed for medical education and practice. Although knowledge forms the foundation of the toxicology service, the ultimate cornerstone of the service is communication. Having excellent toxicology knowledge does not guarantee that a student will be an effective communicator. The curriculum should thus ideally include a training package to teach toxicology students the skill of effective communication. Small group role-play is an effective practical learning opportunity aimed at producing high quality communication and history taking skills in students (Keifenheim, Teufel, Ip, *et al*., 2015). In contrast, a lack of experience in telephone communication can negatively affect patient care and can lead to patient harm due to incomplete information exchange (Eppich, Rethans, Dornan, *et al*., 2018). The curriculum can address this problem by including effective pedagogy to enhance oral and written communication skills.

5.2 The CanMeds Framework

The root of the CanMeds framework is competency-based medical education (Smith, 2005). In the PGDip Toxs it will be decided that a toxicology student has become a competent SPI through structured assessments. These assessments mostly test toxicology knowledge and may not fully capture all relevant aspects of a successful SPI. Concerns around the quality, patient safety, and error raise questions and a need presented for an outcomes-based framework, which consider actual performance in practice settings. (Frank and Danoff, 2007). The CanMeds framework (Frank and Danoff, 2007) are an example of such a framework and were used to categorize the competencies of my consensus survey. The CanMeds framework has been particularly successful in this context, especially the explicit recognition of roles such as advocate and collaborator. These competencies emphasize that work as a medical toxicologist involves the social context and includes communication with colleagues and interaction with systems.

5.3 Marine toxicology

There is an overall low incidence of reporting marine envenomation and poisoning to Poisons Information Centres (Marks, van Hoving, Wium, *et al*., 2019). However, more than 90% of the panellists in the Delphi study agreed in round two that knowledge on marine envenomation and poisoning should be a priority. This result could be bias as most people are fascinated by the ocean and its creatures (Woolston, 2014). Despite this possibility for bias, it is recommended that marine toxicology should be included in the curriculum. Marks *et al.* (2019) determined that Poisons Information Centre telephonic consultations by healthcare professionals, relating to marine poisoning, were generally of a serious nature. For example: people eating contaminated mussels and consequently developing paralytic seafood poisoning, may develop respiratory failure and if not receiving endotracheal intubation may die, as has been reported to the Tygerberg Poisons Information Centre (Marks *et al*., 2019).

5.4 Street pesticides

Rother (2010) described street pesticides as pesticides that are either legal pesticides, which have been decanted and used inappropriately, or pesticides that are being used without being legally registered. Most often, these pesticides are registered for agricultural purposes, not home use and are illegally sold on the streets (Balme, Roberts, Glasstone, *et al*., 2010). In South Africa, as in many other developing countries, people live in poor and crowded areas (Statistics South Africa, 2017). These areas are an ideal breeding ground for pests. People seek cheap and effective ways to deal with the problem. The conventional anticoagulant rodenticides require that an animal eat multiple doses of the bait over several days (Murphy, 2018). Street rodenticides, on the other hand, are fast working, cheap, easily accessible, effective, and very toxic. Most of the participants in the Delphi study are from developing countries. This could explain why more than 90% of the panellists reached consensus that toxicology students require knowledge on street rodenticides (other than the long acting anti-coagulants for which deep knowledge is required). It is therefore fundamental to include street pesticides in the curriculum, especially since the course is aimed at African scholars.

5.5 Country specific poisoning exposures

Panellists suggested 35 new competencies which were included in round two. Some of the proposed topics were very specific to the geographical location of the participants. An example of this is Chloralose, a rat poison commonly used in North Africa. Another example was poisonous frogs, which occupy various habitats, commonly found in Australia. As expected, it was agreed in round three not to include these two competencies in a medical toxicology curriculum. The results might have been different if most of the participants were from North Africa or Australia. This is an example of the 'battle of curriculum design' as described by Grant (2013) where the two components of it – the structure and the content – need to be decided on. The context wherein the curriculum will be used, will determine in a certain way the content. (Grant, 2013)

Feedback from panellists indicated that the questionnaires were country-specific and not necessarily representative of all geographical locations. Exposure to snakes, spiders, scorpions, plants and mushrooms logically differ based on location. As such, treatment protocols also differ between countries. Snakebite is a major neglected tropical disease, often disabling and killing people from poor and rural communities in Latin America, Asia and Africa. Globally, there are at least 219 different medically important venomous snakes, and live-saving care must be provided to high risk populations (Geneviève et al., 2018).

Since the PG Dip Toxs curriculum was specifically develop for suitably qualified healthcare professionals from South Africa and other African countries it was decided to keep poisoning by natural toxins in the questionnaire and to advice future curriculum developers to adapt the teaching content to the specifics of their own country.

5.6 Analytical skills and administration skills

In the third round, participants agreed that only two of the twenty-three suggested items in the questionnaire were important. Both analytical skills and administration skills are seemingly recognizable skills that toxicologists should have (Employeepedia., April 2017), but this was not initially agreed upon by panellists. It took three rounds of iteration to get consensus. One explanation could be that participants confused administration skills with carrying out administrative duties such as filing, typing, copying and binding. Poisons Centres often have administrative assistants to do the latter. For a medical toxicologist, administrative skills include verbal and written communication, time management, strategic planning, resourcefulness and many other attributes (Institute of Medicine, 2004). Similar misperception could have happened where analytical skills were confused with analytical toxicology, which comprises of the detection, identification, and measurement of foreign compounds in specimens (Chatterton and Osselton, 2012). On the other hand, analytical skills refers to the ability to collect and analyse information, to make well-informed decisions and to solve problems (Institute of Medicine. 2004). It is therefore recommended that analytical skills and administrative skills should both be defined and included in the curriculum.

5.7 Drop out response rate

Waggoner, Carline and Durning (2016) mentioned that the Delphi technique can be time-consuming and laborious, as seen in this study with a 27% drop rate in response, measured between first and final round. The foremost, low response rates were seen in the group of medical specialists (57% drop rate), followed by medical doctors (31% drop rate). It can be hypothesized that health care professionals with higher qualifications have more responsibilities and are subsequently busier. This phenomenon should be taken in consideration when selecting a Delphi panel.

5.8 Absence of consensus

Although consensus was not reached on 16 competencies, it was decided not to include a fourth round in our Delphi study. Another round may have led to fatigue by respondents and increased attrition, as described by Thangaratinam and Redman (2005). Furthermore, the focus of this Delphi study was to gather opinions and to sort through the ideas and expertise of participants. Three rounds was sufficient to arrive at the core competencies shown to inform a Medical Toxicology curriculum. For more serious issues of critical importance, four and even a fifth round are recommended (Hsu and Sandford, 2010).

5.9 Consensus based learning outcomes model

By participating in a Delphi study, experts in the field of medical toxicology took on the responsibility of reaching consensus on the core competencies that toxicology graduates must acquire to successfully function in their work. The outcomes of this study are the agreed core competencies and should have been determined before developing the PG Dip Tox course. The curriculum designer used the old traditional model (Figure 4A) when developing the PGDip Tox and as determined in the survey, it would have been more coherent to use the consensus based learning outcomes model (Figure 4B). This latter model was developed while the Delphi rounds were taking place and are based on the work of Gruppen *et al*., (2016) which compared the traditional model of education with a competency-based educational model.

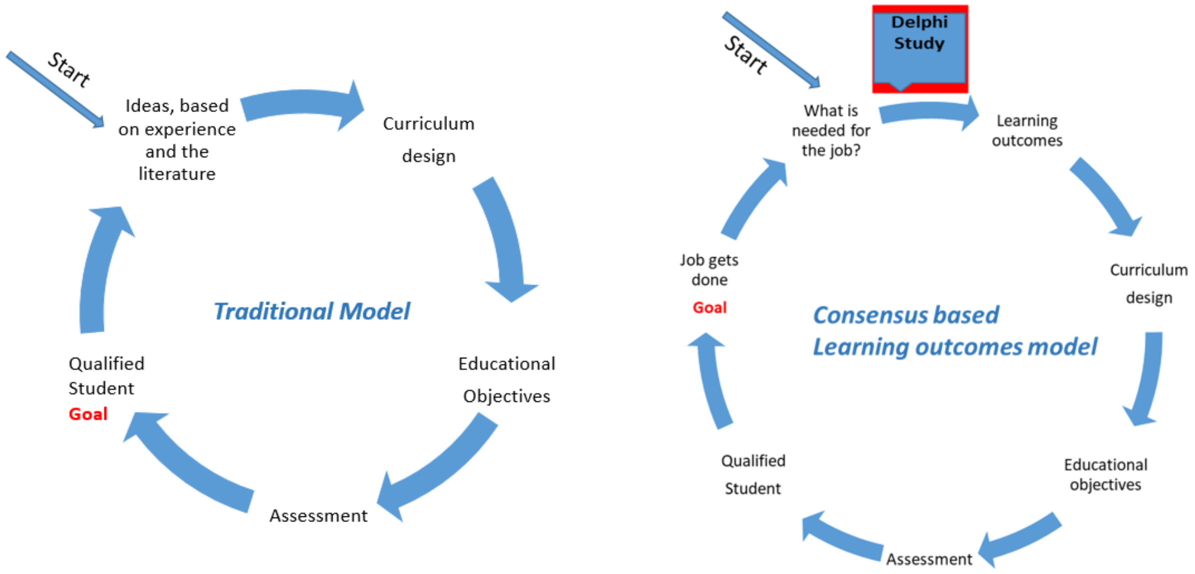

Figure 4: Traditional model of curriculum development versus a consensus based learning outcomes model of curriculum development.

When planning a new, or changing an existing course, developers should not start with the curriculum design and measurable educational objectives. Instead, they should explore what the curriculum sets out to achieve e.g. what knowledge, skills and attitudes the student should possess after successful graduation. Establishing these competencies will direct the choice of curriculum content and educational objectives.

5.10 Impact of the study

The results of this Delphi survey may prove useful by influencing decision making on an international level. Guidelines for poison control were first published by the World Health Organization (WHO) in 1997 to assist countries in strengthening facilities for the prevention and management of poisoning. Since its publication, there have been many developments in information technology and communications that have influenced the manner in which services are provided at Poisons Centres. In July 2019, an update of the Guidelines for poison control was organized by the WHO Collaborating Centre for the Public Health Management of Chemical Exposures, part of Public Health England. Most of the chapters were revised and it was highlighted that Poisons Information Centres have the educational responsibilities to train medical practitioners and other professional healthcare workers who might encounter cases of poisoning. Guidelines furthermore included advice on the training needs of Poisons Information Centres, as well as on their teaching and training functions. A request was made by WHO to include the results of this Delphi study in the updated PIC guidelines.

Poisons Information Centres, especially newly establish centres, are consulting the WHO guidelines extensively. In Sub-Saharan Africa, secondment to an existing PIC for training is recommended (World Health Organization, 2015). The PG Diploma in Medical Toxicology at Stellenbosch University will in the future attract many students from all over Africa, especially since consensus on the learning outcomes for medical toxicology graduates were established. Constructive alignment within the curriculum development, teaching strategies and subsequent assessments have now been made possible.

5.11 Limitations and strengths of the study

There are certain risks in the design, implementation, success and evolution of e-Delphi research. The methodological limitations may include internet accessibility challenges, technological difficulties and the inconvenience of entering data into computer based data screens. The researcher could have decided to use the paper-and-pencil version of the Delphi technique and in this situation, questionnaires would have been sent to participants by postal mail. This might have generated a lower and slower response rate (Kwak and Radler, 2002).

Face-to-face meetings are not possible with the e-Delphi methodology (Donohoe, Stellefson and Tennant, 2012). No discussion and debate are possible between panellists, which could resolve different opinions. Due to the several rounds of the Delphi method, attrition of participants are common. Large modifications in the questionnaire from one round to the next can lead to participant confusion. Although these problems can be avoided by face-to-face or group meetings, the e-Delphi has the advantage that ideas can be generated by members who are too geographically separated or too busy to meet face-to-face (Donohoe, Stellefson and Tennant, 2012).

The suitability of our Delphi study was not verified by measuring (e.g. Cronbach's alpha) the reliability and validity of our method. Tomasik (2010) mentioned the difficulties of determining the reliability and validity of consensus methods. He furthermore stated that the methods of determining the reliability and validity for applied consensus techniques are not well developed.

It would have been more beneficial if the consensus group in this study included a larger variety of healthcare professionals e.g. nurses. Globally, many Poisons Information Centres have nurses as part of their staff but unfortunately the three groups used as participants in this study only included doctors, pharmacists and medical scientists.

By making use of an electronic Delphi survey, the investigator assumed that all participants had internet access and could manage technological difficulties. Possible distractions and time restraints of participants, e.g. vacation periods and major conferences, were not identified before the study. The understanding that all participants in the study had a high interest in the research problem was adopted ahead of the study. Hence, no system was in place to assure participants' seriousness and honesty.

This electronic on-line Delphi study also had many strengths. The study was relatively straightforward and the design flexible and simple. Compared to face-to-face meetings, participants had freedom of expression, due to anonymity, and this phenomenon eliminated many biases such as sex and hierarchy (Colton and Hatcher, 2004). Moreover, this technique cut costs, time and effort. Geographical limitation was not a problem and panellists from different locations were included in this study.

Although the study participants were experts in the field of medical toxicology, their conscious and unconscious biases might have influence the data collected. In particular, work experiences might have influenced their responses. For example, a panellist involved in education and curriculum design might have showed more interest in the study and the questions might have been more thought provoking to them. Another potential problem could have been that participants thought the country they were from is indicative of what the world thinks on the competencies of toxicology graduates.

Due to the anonymity of the study, participants could have been less motivated, less rigorous and less serious in their contribution. The opposite can also be true that due to anonymity panellists felt more at liberty to express their opinions. The iterative Delphi study was a lengthy process, for both the researcher and the participants. To avoid panel fatigue, the study was limited to three Delphi rounds, which might have prevented panellists from changing their views to be in line with the majority opinion.

It is also important to mention that this study only reports on the competencies required by medical toxicology graduates, working in a poisons information centre, and therefore should not be generalized to professionals in other fields of toxicology.

CHAPTER SIX
CONCLUSIONS

The Delphi method, based on three iterative rounds and feedback from experts, was effective on reaching consensus on the learning outcomes of a Medical Toxicology curriculum. Many of the agreed competencies were quite predictable. However, given its novel perspective, this study is unique as this is the first time that the core competencies required by Medical Toxicology graduates were recognized.

The agreed upon competencies should inform the curriculum developers on how to adapt the PGDip Tox curriculum and bring it in alignment with the teaching strategies and assessment methods. Future studies should ideally assess Medical Toxicology curricula and investigate if there is an alignment and synergy between the needs of the students, the goals of the curriculum, the teaching strategies, the assessment procedures, and the learning milieu. Healthcare workers should consider the incorporation of meaningful outcomes into all future education programmes.

This study confirmed that the quality of Poisons Information Centre service depends on the toxicology knowledge of the toxicologist, as well as effective communication skills. It is therefore important to include a communication training package in the Medical Toxicology curriculum. Another attribute that should be included in the PGDip Tox course is student self-regulation and professionalism. With regards to administration and analytical skills, it is indeed important to include these skills in the curriculum with specific training in these areas.

The PGDip Tox course is aimed at South African students and poisoning scenarios specific to the country, e.g. marine and street pesticide poisoning should be included in the curriculum. Snake, scorpion and spider envenomations can differ between countries and it is recommended that different medical toxicology courses adapt their content to their context. The latter is also applicable to the items that did not reach consensus, since the poisoning exposure might be more relevant in specific countries.

To establish if the PGDip Tox course will lead to the qualification of highly effective medical toxicologists, further research should be conducted. Through systematic, but flexible methodology, iterative analysis, student evaluation and feedback; the curriculum could be enhanced to become the best available international curriculum for medical toxicologists working in a PIC. Therefore the PG DipTox curriculum should be intended to be a living document, keeping up with the ever-evolving pedagogy as well as the unfolding practise of Medical Toxicology.

In summary, for the PGDip Tox, an online blended learning course that follows a competency-based educational framework, clear and well-defined outcomes were needed; so that educators can align these outcomes with appropriate learning strategies and assessment methods. The Delphi study successfully identified these outcomes that can be incorporated into the curriculum. The study results will ultimately improve education in Medical Toxicology, and in the long run will lead to optimal patient care.

CHAPTER SEVEN
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Addendum 1 : Letter of invitation to participate in the on-line Delphi study

Dear __________

I am currently enrolled for the MPhil in Health Professions Education programme at Stellenbosch University, Cape Town, South Africa. As part of the degree I am conducting a Delphi study on the core competencies required by toxicology students in order to effectively function in a Poisons Information Centre.I would like to invite you to take part in this research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask me any questions about any part of this project that you do not fully understand. It is very important that you are completely satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. In other words, you may choose to take part, or you may choose not to take part. Nothing bad will come of it if you say no: it will not affect you negatively in any way whatsoever. Refusal to participate will involve no penalty or loss of benefits or reduction in the level of care to which you are otherwise entitled. You are also free to withdraw from the study at any point, even if you do agree to take part initially.

This study has been approved by the Health Research Ethics Committee at Stellenbosch University. The study will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, the South African Guidelines for Good Clinical Practice (2006), the Medical Research Council (MRC) Ethical Guidelines for Research (2002), and the Department of Health Ethics in Health Research: Principles, Processes and Studies (2015).

What is this research study all about?

This study will be conducted at the Tygerberg Poisons Information Centre, Stellenbosch University , Cape Town, South Africa. Altogether 48 people, with extensive knowledge in medical toxicology, will be asked to participate in a modified Delphi study. The Delphi technique is a research approach to gaining consensus through the utilisation of questionnaires and the provision of feedback to participants who are experts in the field.

The overarching aim of this study is to obtain consensus on the core competencies that a student should attain in order to effectively work in a poisons information centre. If it is not known what and how to measure a student's knowledge, skills and attitude, it will also not be known if the graduate has the practical skills to assist in the diagnoses and management of patients exposed to poisonous chemicals.

A questionnaire will be send electronically to all the participants. This questionnaire is based on the curriculum content of the Post Graduate Diploma in Medical Toxicology at Stellenbosch University, combined with a thorough literature search on the core competencies required by healthcare professionals to function effectively in their work environment. Competencies derived from these resources are listed under the categories of knowledge, skills and attitudes.

Participants will be asked to rate a list of proposed core toxicology competencies in terms of their importance, using a 5-point Likert-type scale i.e. 1 = unnecessary, 2 = unimportant, 3 = worth considering, 4 = important, 5 = definitely necessary. Participants will be given an option to make free text comments after rating a core competency and will also be given the opportunity to suggest other core competencies that might be important or necessary. Participants will be given two weeks to respond and frequent reminders will be sent by email.

Each participant will answer the questionnaire independently. The participant's identity will not be revealed and anonymous identity will be obtained even after the final report. Questionnaire responses will be summarized by the researcher. Feedback summary and a second questionnaire for the same respondent group will be developed to seek consensus. Consensus will be reached when an item on the competency list was rated 70% or more. A third round might be necessary if consensus was not achieved on a sizeable number of items after two rounds. A final summary report will be conducted and distributed to all panel members.

Why do we invite you to participate?

There is an urgent need to capture the collective opinion of toxicology experts in South Africa, Africa and globally, on the core competencies required by students in order to effectively work in a poisons centre. Due to your medical background and extensive knowledge in medical toxicology you are asked to voluntarily participate in this study. The on-line Delphi-method is ideal for this survey because all the participants are busy professionals and in-persons interviews will not be cost-effective. Geographical limitation will not be a problem and panellists form different locations will be included in this study. By using anonymity in the Delphi process, biases such as medical hierarchy, sex, ethnicity and age will be eliminated.

What will your responsibilities be?

In the first round you will be asked to rate a list of proposed core toxicology competencies in terms of their importance. You should allocate maximum 30 minutes of your time to complete the questionnaire and return it to the researcher who will analyse the data. Items which achieved consensus will be removed from the round two survey, and those where there were no consensus, will be re-worded based on free text comments. You will then be asked in round two to re-think and re-rate each item as well as the new core competencies that was added after round one. A third round might be necessary to reach consensus.

Will you benefit from taking part in this research?

Identifying core competencies required by toxicology students, who would be qualified SPI's after graduation, would assure constructive alignment in the curriculum design. These core competencies in knowledge, skills and attitude will determine what teaching and learning strategies to use and direct the educator to the applicable type of assessment. The outcomes of this study can be used in future studies to assess medical toxicology curriculums and to investigate if there is a balance and synergy between goals of the educator, the needs of the students, the curriculum, the learning milieu, the teaching strategies, and the assessment procedures.

Are there any risks involved in your taking part in this research?

This study has no risk to the participant. The electronic on-line Delphi technique instead of face-to-face meetings, will ensure the anonymity of participants and eliminate biases

Will you be paid to take part in this study and are there any costs involved?

If you take part in the study, there will be no cost to you. You will not receive compensation for your time, however you will contribute to a wider recognition of the Medical Toxicology discipline and define more clearly the competencies that underpin this discipline.

You will be acknowledge in publications resultant from this research.

Declaration by participant

The electronic questionnaire will prompt you to open a link to start the process. By clicking yes, you consent that you agree to take part in the research study. However, you still have the option to decline participation and it is only when you click submit that your answers become available to the researcher.

Please let the researcher know if you are willing to participate in this study.

Addendum 2: The first questionnaire:

The core competencies required by toxicology students in order to effectively function in a Poisons Information Centre.				
Core Competency	**Description of the competencies**		**Rating**	**Comment**
KNOWLEDGE	**Deep toxicology knowledge (previously acquired) specific to the following toxic exposures**			
		Paracetamol		
		Salicylate		
		Other NSAIDs		
		Tricyclic Antidepressants		
		Selective serotonin re-uptake inhibitors		
		Neuroleptics		
		Lithium		
		Decongestants		
		Antihistamines		
		Calcium Channel and Beta Blockers		
		Digoxin		
		Diuretics		
		Theophylline		
		Sleeping pills		
		Antimicrobials (INH/ARV/antifungal)		
		Antidiabetic drugs		
		Drugs of abuse		
		Cyanide		
		Caustic and Corrosive substances		
		Iron		
		Toxic alcohols		

		Heavy metals (lead, arsenic , mercury, cadmium)		
		Cholinesterase inhibitors		
		Amitraz		
		Rodenticides (longacting anti-coagulants)		
		Paraquat		
		Aliphatic hydrocarbons		
		Aromatic hydrocarbons		
		Pyrethroids / Pyrethrins		
		Mothballs		
		Carbon Monoxide		
		Chemical warfare		
		Cytotoxic snakes		
		Neurotoxic snakes		
		Hemotoxic snakes		
		Scorpions		
		Neurotoxic spider envenomation		
		Cytotoxic spider Envenomation		
		Marine envenomation		
		Marine poisoning		
		Plants		
		Poisonous frogs		
		Mushrooms		
		Insect and bee stings		
		Food poisoning		

		Complementary and Alternative Medicine		
		Antidotes used in poisoning		
	Basic general knowledge of the following			
		Analytical toxicology		
		Nano toxicology		
		Environmental toxicology		
		Occupational Toxicology		
		Regulatory Toxicology		
		Forensic toxicology		
		Veterinary Toxicology		
		The history of Toxicology		
		Pharmacokinetics and pharmacodynamics		
		Mechanisms and pathology of Drug toxicity		
		Drug-drug interaction		
		Dose response		
		Extracorporeal elimination		
		Poisons information centres		
		International Programme on Chemical Safety		
		Chemical warfare		
		Clinical management of the poisoned patient		
		The psychiatric patient		

		(self-harm)		
	Organisational knowledge			
		Be familiar with the SOP's of the national Poisons Information Centre		
SKILLS	Able to effectively use information technology to access, evaluate and interpret toxicology information			
	Know where to look first to address a poisoning query. (data base's, books, journals etc.)			
	Know how to calculate basic toxicology measures			
	Apply evidence-based toxicology principles and knowledge for decision-making.			
	Distinguish evidence-based toxicology information from opinion-based toxicology information.			
	Evaluate the strengths and limitations of evidence-based toxicology articles and reports			
	Identify different types of toxicology queries, such as questions about poisoning management, diagnosis, prognosis and information.			
	Able to communicate effectively (verbally and in writing) with healthcare providers in a manner that they understand.			
	Able to communicate effectively (verbally and in writing) with the general public in a manner that they understand.			
	Share information with the patient, healthcare worker, media or public			

	health authorities, respecting confidentiality		
	Able to interact with the media, deliver briefings and conduct meetings		
	Collaborate and consult with other healthcare professionals in a cooperative manner		
	Recommend appropriate interventions on a case-by-case basis and not just apply generic advice e.g. just reading off a data base		
	Maintain accurate, comprehensive and legible records/documentation		
	Able to demonstrate language adaptation skills (ability to work in a setting where you are not a native speaker)		
	Able to demonstrate leadership skills .		
	Able to function effectively in a team		
	Able to have conflict resolution skills e.g. handling agitated, anxious or rude callers		
	Able to demonstrate teaching and educational skills		
	Able to demonstrate research skills		
	Able to demonstrate administration skills		
	Able to demonstrate analytical skills		
	Able to think creatively		
ATTITUDE	Able to demonstrate respect for cultural and religious beliefs and an awareness of their impact on decision making		

	Able to demonstrate a capacity for compassion		
	Able to demonstrate commitment to service		
	Able to demonstrate commitment to self-directed learning		
	Seek learning opportunities and integrate the knowledge into daily practice		
	Respect privacy, dignity, confidentiality and legal constraints of patient data.		
	Able to show the ability to interact with diverse individuals		
	Able to show a passion for the discipline of medical toxicology		
	Able to multitask		
Recommendation of Additional competencies			

Addendum 3: The second questionnaire

The core competencies required by toxicology students in order to effectively function in a Poisons Information Centre.				
Core Competency	**Description of the competencies**		**Rating**	**Comment**
KNOWLEDGE	**Deep toxicology knowledge , (previously acquired) specific to the following toxic exposures**			
		Decongestants		
		Antihistamines		
		Other NSAIDs (excluding paracetamol and salicylates for which deep knowledge is required)		
		Diuretics		
		Antimicrobials (ARV's)		
		Antimicrobials (other) (excluding Isoniazid for which deep knowledge is required)		
		Cyanide		
		Chemical warfare		
		Marine envenomation		
		Marine poisoning		
		Plants		
		Insect and bee stings		
		Food poisoning		
		Complementary and Alternative Medicine		
		Colchicine		

		Carbamazepine		
		Valproic acid		
		Methotrexate		
		Anti-malarial drugs		
		Rodenticides (other than the long acting anti-coagulants for which deep knowledge is required)		
		Chlorophenoxy herbicides		
		Organochlorines		
		Asbestos		
		Chloralose		
		Diquat		
		Household substances		
		Street pesticides		
		Toxicokinetics/ dynamics		
		Common causes of acute and chronic poisoning		
		Prevention of poisoning		
		Antidotes mechanism of action		
		Toxidromes		
		Enhanced elimination		
		Decontamination options		
	Basic general knowledge of the following			
		Analytical toxicology		
		Nano toxicology		

		Environmental toxicology		
		Veterinary Toxicology		
		Regulatory Toxicology		
		Forensic toxicology		
		The screening of addictive substances		
		The history of Toxicology		
		The components of risk assessment		
		The general approach to resuscitation in the poisoned patient		
		Field of ethics		
		Toxicovigilance		
		Rehabilitation system in the country		
		International Programme on Chemical Safety		
		WHO guidelines for Poison Information Centres		
		The Strategic Approach to International Chemicals Management (SAICM)		
		The International Health Regulations (IHR)		
		On basic economic principles and public processes in the country		

		Data analysis		
		The psychiatric patient (self-harm)		
SKILLS	Able to take care of drug addicts			
	Able to work in a multidisciplinary team, in particular across public health and environmental sectors			
	Able to respond to chemical accidents			
	Able to interact with the media, deliver briefings and conduct meetings			
	Able to demonstrate leadership skills .			
	Able to demonstrate teaching and educational skills			
	Able to demonstrate research skills			
	Able to demonstrate administration skills			
	Able to demonstrate analytical skills			
	Able to think creatively			
ATTITUDE	Should be able to identify limitations of knowledge within themselves (e.g.when to refer an enquiry)			
	Able to multitask			
Comments				

Addendum 4: Letter (linked to second questionnaire) that was sent to participants of the Delphi survey.

Dear Colleague,

Thank you for participating in the Delphi study: The core competencies required by toxicology students in order to effectively function in a Poisons Information Centre.

This study investigates, by collecting expert opinion, what the student must know (knowledge); what the student must be able to do (skills) and what dispositions must the student display (attitude). The qualified student can be seen as someone going for an interview to work as a Specialist in Poisons Information (SPI) in a Poisons Information Centre.

By clicking on the link you will have access to round 2 questionnaire, and you have 10 working days to respond. Only the questions on which consensus was not reached in round one, are carried forward in this round, plus additional questions that were generated using participants suggestions.

These outlying opinions should now be carefully considered in round two. To compel respondents to choose a particular option, the neutral middle point (worth considering) will be omitted in this round. The options will be 1 = unnecessary, 2 = unimportant, 3 = important, 4 = definitely necessary. Participants will be given an option to make free text comments after a section. Consensus will be reached when 70% or more of respondents agree with a statement. Option 1 and 2 will be added together and excluded from the list, while option 3 and 4 will be added and included in the final list.

Just a reminder that under knowledge there is two sections:

(I) Deep toxicology knowledge (i.e. Paracetamol overdose) - the student must be able to have a discussion without consulting a text book or database.

(II) Some general basic knowledge, means some knowledge/ background to enable the person to work effectively in a poisons centre.

Addendum 5: The 3rd and final questionnaire

The core competencies required by toxicology graduates in order to effectively function in a Poisons Information Centre.				
Core Competency	**Description of the competencies**			
KNOWLEDGE	**Deep toxicology knowledge , (previously acquired) without consulting a database or textbook**		**important**	**not important**
		Diuretics		
		Antimicrobials (excluding Isoniazid and ARV's for which deep knowledge is required)		
		Chemical warfare		
		Poisonous frogs		
		Food poisoning		
		Complementary and Alternative Medicine		
		Colchicine		
		Chlorophenoxy herbicides		
		Asbestos		
		Chloralose		
	The graduate should have some general knowledge of the following			
		Nano toxicology		
		Veterinary Toxicology		
		Regulatory Toxicology		
		The history of Toxicology		
		Rehabilitation system in the country		

		The Strategic Approach to International Chemicals Management (SAICM)		
		The International Health Regulations (IHR)		
		On basic economic principles and public processes in the country		
	Able to interact with the media, deliver briefings and conduct meetings			
	Able to demonstrate leadership skills.			
	Able to demonstrate administration skills			
	Able to demonstrate analytical skills			
	Able to take care of drug addicts			

Addendum 6: Letter (linked to third questionnaire) sent to the participants of the Delphi survey.

Dear Colleague,

Thank you for participating in two rounds of the Delphi study: The core competencies required by toxicology graduates in order to effectively function in a Poisons Information Centre.

The questionnaires were comprised of 134 competencies that needed to be rated by you as either important (necessary) or unimportant (unnecessary) for a toxicology graduate in order to effectively function in a Poisons Information Centre.

In the first two round consensus was defined as 70% or more of respondents being in agreement with a statement. In 111 of the 134 (83%) questions, consensus was reached and all participants agreed that these competencies were important. Not a single statement was deemed unimportant.

In 23 of the 134 (17%) competencies, no consensus was reached (less than 70% of respondents were in agreement). In this next Delphi round, I am asking you to reconsider your opinion and indicate whether the competency is important or not. You will now have two options i.e. 1 = unimportant ; 2 = important. This will be a very short questionnaire and the last one that you will receive. The final results of the study will be communicated to participants, once the final data analysis is complete