African Journal of Emergency Medicine 10 (2020) 173–180

Contents lists available at ScienceDirect

African Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/afjem

Original article

Core competencies required by toxicology graduates in order to function effectively in a Poisons Information Centre: A Delphi study

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A R T I C L E I N F O

Keywords:
Medical Toxicology
Health Professions Education
Curriculum development
Poison
Information Specialists
Delphi-study
Core competencies

A B S T R A C T

Introduction: The availability of trained Medical Toxicologists in developing countries is limited and education in Medical Toxicology remains inadequate. The lack of toxicology services contributes to a knowledge gap in the management of poisonings. A need existed to investigate the core competencies required by toxicology graduates to effectively operate in a Poisons Information Centre. The aim of this study was to obtain consensus from an expert group of health care workers on these core competencies. This was done by making use of the Delphi technique.

Methodology: The Delphi survey started with a set of carefully selected questions drawn from various sources including a literature review and exploration of existing curricula. To capture the collective opinion of experts in South Africa, Africa and also globally, three different groups were invited to participate in the study. To build and manage the questionnaire, the secure Research Electronic Data Capture (REDCap) web platform was used.

Results: 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%) should be excluded.

Discussion: All participants agreed that effective communication is an essential skill for toxicology graduates. The curriculum can address this problem by including effective pedagogy to enhance oral and written communication skills.

Feedback from panellists indicated that the questionnaires were country-specific and not necessarily representative of all geographical locations. This is an example of the 'battle of curriculum design' where the context in which the curriculum will be used, will determine the content.

Conclusion: The Delphi method, based on three iterative rounds and feedback from experts, was effective in reaching consensus on the learning outcomes of a Medical Toxicology curriculum. The study results will ultimately improve education in Medical Toxicology.

African relevance

- Toxicology education is needed in Africa to reduce morbidity rates caused by poisonings.
- The rapid growth of the chemicals industry in Africa increases the need for qualified toxicologists.
- Healthcare professionals in Africa should know about the post-graduate training programme covering the discipline of Medical Toxicology.
- The core competencies required by toxicology graduates to effectively operate in a Poisons Centre in Africa should be recognised.

Introduction

The burden of poisoning exposures in Africa is a major public health concern. Availability of trained Medical Toxicologists is limited and education in Medical Toxicology for healthcare professionals remains inadequate [1]. The lack of toxicology services in developing countries contributes to a knowledge gap in the management of poisonings [2]. In South Africa, the need for a Poisons Information Centre (PIC) was documented in the Environmental Management Plan of the National Department of Health [3]. The significant burden that intentional self-poisoning put on emergency centres in South Africa have been discussed in the literature [4]. The Poison Information Helpline of the

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https://doi.org/10.1016/j.afjem.2020.05.011
Received 18 March 2020; Received in revised form 27 May 2020; Accepted 27 May 2020
Available online 06 July 2020

Western Cape reported that 69% of their calls were received from health care professionals and this further emphasise the toxicological needs of the country [5]. Observations support the urgent patient and societal need for qualified Medical Toxicologists and Poison Centre Information Specialists (SPI's). Currently no postgraduate training programme exists in South Africa or other African countries covering the discipline of Medical Toxicology.

In this context, Stellenbosch University developed a blended learning curriculum for a Postgraduate Diploma in Medical Toxicology with the intention to commence student enrolment in 2021. The aim of this programme is to train candidates who can effectively operate as Medical Toxicologists in a PIC. Prior to development of the Postgraduate Diploma in Medical Toxicology, 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 PIC. Competencies provide a way to harmonize, select and develop the curriculum. With clear, well-defined competencies, teachers can plan and design appropriate learning strategies and assessment methods [6].

Competence is defined in the context of knowledge, skills, and attitude [7]. 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 [7].

A paucity of literature was found on Health Professions Education and Medical Toxicology. Given its novel perspective, little information is available on the competencies of a SPI. The core competencies of the general toxicologist that should be an essential part of any toxicology training have been explored [8] but this study did not narrow it down to the discipline of Medical Toxicology. The general toxicologist has a scientific background and typically works in a laboratory, testing chemicals and other substances to determine if they are toxic or harmful. A Medical Toxicologist provides information on the diagnosis, management, and prevention of poisoning. In another study, the core content of a Medical Toxicology curriculum was investigated, but the study did not address core competencies [9].

The need to determine a list of core competencies that will enable toxicology graduates to function effectively in a PIC is evident. The aim of this study was to obtain consensus from an expert group of health care workers on these core competencies. This was done by making use of the Delphi technique. The Delphi technique has been frequently used in the past to develop guidelines within health professional research and is usually directed at problem-solving, idea-generation, and determining priorities [10–11].

Methods

The Delphi technique was originally developed by Project RAND during 1959 [12]. The 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" [13]. Ethical approval (Reference # S19/03/049) for this study was obtained from the Human Research Ethics Committee of Stellenbosch University, Cape Town.

The initial questionnaire was developed based on the curriculum content of the Postgraduate 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. In the literature search key words and phrases included, curriculum/toxicology students/education/poisoning/core competencies/Poisons Information Centre. Databases searched were Scopus, PubMed, Eric and Google Scholar. The reference lists of relevant papers found were also reviewed in order to identify additional articles.

To capture the collective opinion of experts in South Africa, Africa and also globally, three different groups were invited to participate in the study. The first group included sixteen Specialists in Poisons Information working for the Poisons Information Helpline of South Africa. In the second group, twelve members of the African Network of Poison Control Centres were approached. The third group consisted of 20 working members appointed by the World Health Organization 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 Information Centres.

An e-mail was sent to all of the above mentioned participants, requesting their participation. At the time of the sampling, all prospective study participants had a medical background and extensive knowledge in Medical Toxicology, and their opinions were respected by colleagues nationally and internationally. All participants were combined into one Delphi panel of experts. The initial questionnaire consisted of 99 items, listed under the categories of knowledge, skills and attitudes. To build and manage the questionnaire, the secure Research Electronic Data Capture (REDCap) web platform (https://redcap.sun.ac.za/) was used.

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. Thematic analysis was done on the free text qualitative data where we identified and interpreted patterns of meaning. 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. We followed the method of Salmon and Tombs [14] and defined consensus as being reached when an item on the competency list was rated 70% or more. Items which achieved consensus ($>$ 70% of participants rated the item as unnecessary/unimportant or important/definitely necessary) were removed from the survey.

A second questionnaire 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 the round and the second questionnaire was sent to all the participants who responded in the first round.

Participants were asked to re-consider 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. [15] 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. The third and final questionnaire was much shorter and consisted of fewer questions. 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.

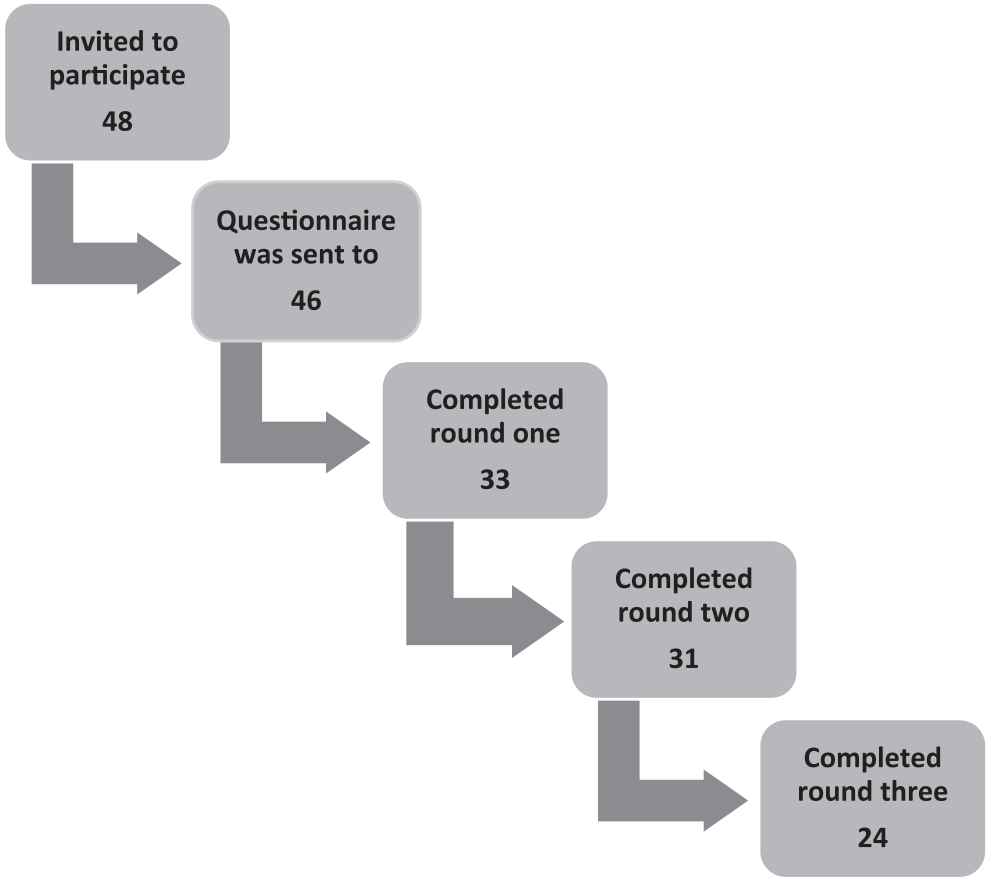

Fig. 1. Number of participants invited and participating in the Delphi survey.

Results

Forty-eight health professionals identified in the field of Medical Toxicology were invited to participate in the study. Two invitees declined and the questionnaire was sent to 46 participants (Fig. 1).Thirty-three (72%) of the invitees completed round one. 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.

Both men (60%, $n = 20$) and women participated in round one and the mean age of participants was 47 years, with the youngest participant being 29 years old and the oldest being 77 years old.

Twenty-one (64%) participants were affiliated with a university, and nineteen (57%) were working in a Poisons Information Centre 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 1 presents the profession of the participants and outlines their qualifications.

Table 1
Delphi expert panel professions and highest qualifications in round one.

Profession n		Qualification n	
Medical Doctor	13	PhD	8
Medical Specialist	7	MMed or similar degree	3
Pharmacist	8	MBChB or similar degree	10
Medical Scientist	5	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. It was not necessary to exclude any item at this point of the study. No consensus was reached on 32 items, hence they were included in round two of the Delphi survey. Although participants supplied free text suggestions they never commented on items that did not reach consensus.

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. It was therefore not necessary to exclude any item at this point in the study. Consensus was not reached for 23 (34%) core competencies and again participants did not comment on these competencies.

In round three, three medical doctors (31%), three medical specialists (57%) and one pharmacist (13%) dropped out of the study. 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 but did not make any free text comments on the non-convergent items.

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 (Table 2) and five (4%) competencies should be excluded (Fig. 2).

They are exposure to poisonous frogs, poisoning with Chloralose, knowledge in nano-toxicology, how to take care of drug addicts, and the importance for toxicology students to learn about basic economic

Table 2
The core competencies required by toxicology graduates in order to function effectively in a Poisons Information Centre: (Bold = new competencies suggested by panellists; Cursive = items on which consensus was reached only in the second round; Capital letters = items on which consensus was reached only in the third round).

Competency	Consensus	Knowledge (K) Skills (S) Attitude (A)
The ability to use information technology effectively to access, evaluate and interpret toxicology information.	100.00%	S
Know where to look first to address a poisoning query. (Database, books, journals etc.)	100.00%	S
Able to communicate effectively (verbally and in writing) with healthcare providers in a manner that they understand.	100.00%	S
Should be able to identify limitations of knowledge within themselves (**e.g. when to refer an enquiry**).	100.00%	S
Toxic exposure to paracetamol.	97.00%	K
Maintain accurate, comprehensive and legible records/documentation.	97.00%	S
Toxic exposure to household substances.	96.80%	K
Common causes of acute and chronic poisoning.	96.80%	K
Toxidromes	96.80%	K
Decontamination options	96.80%	K
The general approach to resuscitation in the poisoned patient.	96.80%	K
Toxic exposure to tricyclic antidepressants.	93.90%	K
Antidotes used in poisoning.	93.90%	K
Clinical management of the poisoned patient.	93.90%	K
Know how to calculate basic toxicology measures.	93.90%	K
Apply evidence-based toxicology principles and knowledge for decision-making.	93.90%	S
Distinguish evidence-based toxicology information from opinion-based toxicology information.	93.90%	S
Share information with the patient, healthcare worker, media or public health authorities, respecting confidentiality.	93.90%	A
Respect privacy, dignity, confidentiality and legal constraints of patient data.	93.90%	A
Rodenticides (**other than the long acting anti-coagulants for which deep knowledge is required**).	93.50%	K
Toxicokinetics/dynamics	93.50%	K
Toxic exposure to calcium channel and beta blockers.	90.90%	K
Toxic exposure to sleeping pills.	90.90%	K
Toxic exposure to toxic alcohols.	90.90%	K
Toxic exposure to cholinesterase inhibitors.	90.90%	K
Toxic exposure to cytotoxic snakebite.	90.90%	K
Toxic exposure to neurotoxic snakebite.	90.90%	K
Toxic exposure to hemotoxic snakebite.	90.90%	K
Able to communicate effectively (verbally and in writing) with the general public in a manner that they understand.	90.90%	S
Collaborate and consult with other healthcare professionals in a cooperative manner.	90.90%	S
Toxic exposure to carbamazepine.	90.30%	K
Antidotes mechanism of action.	90.30%	K
Enhanced elimination	90.30%	K
Able to work in a multidisciplinary team, **in particular across public health and environmental sectors**	90.30%	S
Toxic exposure to neuroleptics.	87.90%	K
Toxic exposure to drugs of abuse.	87.90%	K
Toxic exposure to long acting anticoagulant rodenticides.	87.90%	K
Identify different types of toxicology queries, such as questions about poisoning management, diagnosis, prognosis and information.	87.90%	S
Recommend appropriate interventions on a case-by-case basis and not just apply generic advice e.g. just reading off a database.	87.90%	S
Able to function effectively in a team.	87.90%	A
Able to demonstrate commitment to service.	87.90%	A
Able to demonstrate commitment to self-directed learning.	87.90%	A
Able to show the ability to interact with diverse individuals.	87.90%	A
Toxic exposure to valproic acid.	87.10%	K
Toxic exposures to street pesticides	87.10%	K
The screening of addictive substances.	87.10%	K
Toxic exposure to salicylate.	84.80%	K
Toxic exposure to caustic and corrosive substances.	84.80%	K
Toxic exposure to iron.	84.80%	K
Toxic exposure to aliphatic hydrocarbons.	84.80%	K
Toxic exposure to aromatic hydrocarbons.	84.80%	K
Scorpion envenomation	84.80%	K
Neurotoxic spider envenomation	84.80%	K
Evaluate the strengths and limitations of evidence-based toxicology articles and reports.	84.80%	S
Able to have conflict resolution skills e.g. handling agitated, anxious or rude callers.	84.80%	S
Able to demonstrate respect for cultural and religious beliefs and an awareness of their impact on decision-making.	84.80%	A
Seek learning opportunities and integrate the knowledge into daily practice.	84.80%	S
Able to show a passion for the discipline of Medical Toxicology.	84.80%	A
Toxic exposure to methotrexate	83.90%	K
Prevention of poisoning	83.90%	K
Toxicovigilance	83.90%	K
WHO guidelines for Poison Information Centres.	83.90%	K
Toxic exposure to selective serotonin re-uptake inhibitors	81.80%	K
Toxic exposure to paraquat	81.80%	K
Toxic exposure to pyrethroids/pyrethrins	81.80%	K
Pharmacokinetics and pharmacodynamics	81.80%	K
Mechanisms and pathology of drug toxicity.	81.80%	K
Knowledge on Poisons Information Centres.	81.80%	K
Toxic exposure to theophylline.	78.80%	K
Toxic exposure to antidiabetic drugs	78.80%	K

(*continued on next page*)

Table 2 (*continued*)

Competency	Consensus	Knowledge (K) Skills (S) Attitude (A)
Cytotoxic spider envenomation.	78.80%	K
Toxic exposure to mushrooms.	78.80%	K
Be familiar with the SOPs of your Poisons Information Centre.	78.80%	K
Toxic exposure to anti-malarial drugs.	77.40%	K
Toxic exposure to organochlorines.	77.40%	K
Toxic exposure to lithium.	75.80%	K
Toxic exposure to digoxin.	75.80%	K
Toxic exposure to amitraz.	75.80%	K
Toxic exposure to mothballs.	75.80%	K
Toxic exposure to carbon monoxide.	75.80%	K
Drug-drug interactions.	75.80%	K
Dose response in toxicology.	75.80%	K
Extracorporeal elimination.	75.80%	K
Able to demonstrate a capacity for compassion.	75.80%	A
The components of risk assessment.	74.20%	K
Toxic exposure to antimicrobials (INH)	72.70%	K
Toxic exposure to heavy metals (lead, arsenic, mercury, cadmium).	72.70%	K
Occupational toxicology.	72.70%	K
Able to demonstrate language adaptation skills (ability to work in a setting where you are not a native speaker).	72.70%	S
Toxic exposure to diquat.	71.00%	K
Field of ethics.	71.00%	K
Marine poisoning	96.80%	K
Marine envenomation	93.50%	K
Toxic exposure to cyanide.	90.30%	K
Toxic exposure to antihistamines.	87.10%	K
Insects and bee sting envenomation.	87.10%	K
Toxic exposure to other NSAIDS.	83.90%	K
Toxic exposure to plants.	83.90%	K
Toxic exposure to antimicrobials (ARVs).	80.60%	K
Able to think creatively.	80.60%	S
Environmental toxicology	77.40%	K
Able to multitask.	77.40%	S
Analytical toxicology	74.20%	K
Able to demonstrate teaching and educational skills.	74.20%	S
Able to respond to chemical accidents.	74.20%	K
The psychiatric patient.	74.20%	K
Toxic exposure to decongestants.	71.00%	K
Forensic toxicology	71.00%	K
International programme on chemical safety.	71.00%	K
Data analysis	71.00%	S
Able to demonstrate research skills.	71.00%	S
ABLE TO DEMONSTRATE ADMINISTRATION SKILLS.	75,00%	S
ABLE TO DEMONSTRATE ANALYTICAL SKILLS.	75,00%	S

principles and public processes in a country.

Discussion

The Delphi study contributed to the wider discipline of Medical Toxicology by clearly outlining the core competencies that underpin a Medical Toxicology curriculum. Competencies that reached the highest agreement (> 90%) in round one included core knowledge of toxic exposure to Paracetamol, Tricyclic antidepressants, Cholinesterase inhibitors, and Sleeping pills. This is not surprising, since Poisons Information Centres are most commonly contacted regarding an overdose with these chemicals [16].

All participants agreed that effective communication is an essential skill for toxicology graduates. The CanMEDS-framework identifies and describes the importance of communication as an essential skill, needed for medical education and practice [17]. 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 [18]. 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 [19]. The curriculum can address this problem by including effective pedagogy to enhance oral and written communication skills.

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 recommend that pharmacists and medical scientists should run the after-hours service with medical doctors second in line to give support when needed [20]. Furthermore, when doctors experience a limitation in their knowledge, they should have access to a supervisor, such as a Medical Toxicology specialist.

There is an overall low incidence of reporting marine envenomation and poisoning to Poisons Information Centres [21]. However, > 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 biased as most people are fascinated by the ocean and its creatures [22]. Despite this possibility for bias, it is recommended that

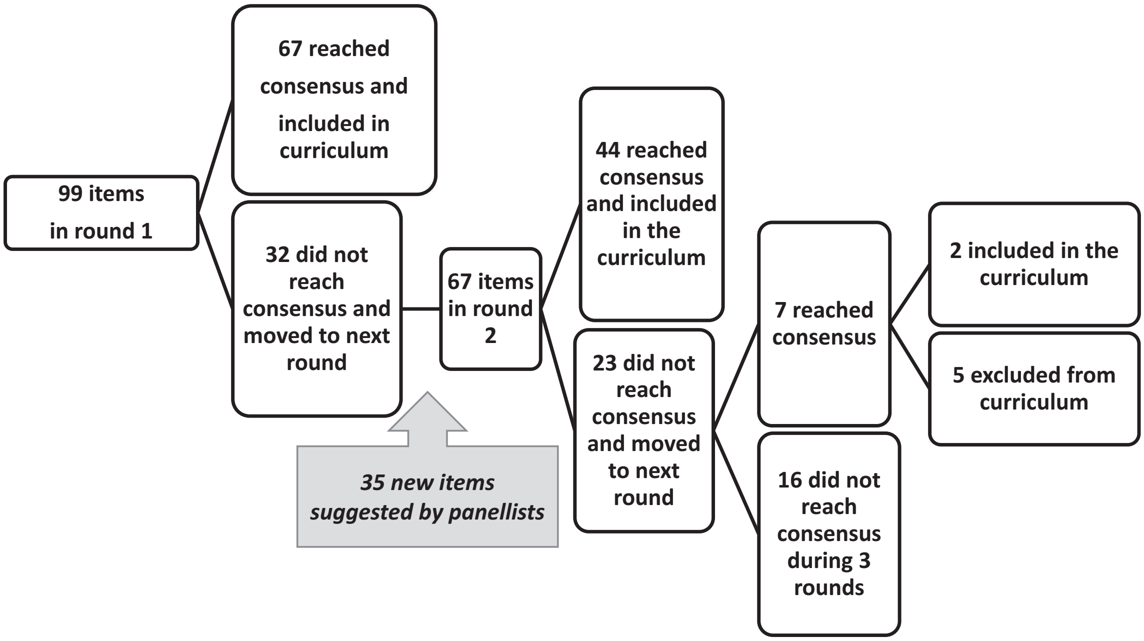

Fig. 2. Summary of the three rounds in the Delphi survey.

marine toxicology should be included in the curriculum. It has been determined that Poisons Information Centre telephonic consultations by healthcare professionals, relating to marine poisoning, were generally of a serious nature [21]. 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 [21].

Street pesticides are either legal pesticides, which have been decanted and used inappropriately, or pesticides that are being used without being legally registered [23]. Most often, these pesticides are registered for agricultural purposes, not home use and are illegally sold on the streets [24]. In South Africa, as in many other developing countries, people live in poor and crowded areas. 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 [25]. 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 > 90% of the panellists agreed that toxicology students require knowledge on street rodenticides (other than the long acting anti-coagulants for which deep knowledge is required).

Feedback from panellists indicated that the questionnaires were country-specific and not necessarily representative of all geographical locations. An example of this is Chloralose poisoning, a rat poison commonly used in North Africa. Another example was exposure to 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' where the two components of it – the structure and the content – need to be decided on [26]. The context in which the curriculum will be used, will determine the content [26].

The Delphi technique can be time-consuming and laborious, as seen in the literature [27] and 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.

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 previously described [28]. 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 [29].

The outcomes of this study are the agreed core competencies and should have been determined before developing the Postgraduate Diploma in Medical Toxicology. The curriculum designer used the old traditional model (Fig. 3A) when developing the course and as determined in the survey, it would have been more coherent to use the consensus based learning outcomes model (Fig. 3B). This latter model was developed while the Delphi rounds were taking place and are based on the work of Gruppen et al., which compared the traditional model of education with a competency-based educational model [30]. When planning a new course or changing an existing one, 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.

There were certain limitations in this study. Face-to-face meetings for discussion and debate were not possible between panellists, which could have resolved different opinions. However, the e-Delphi had the advantage that ideas were generated by members who are too geographically separated or too busy to meet face-to-face. 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.

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

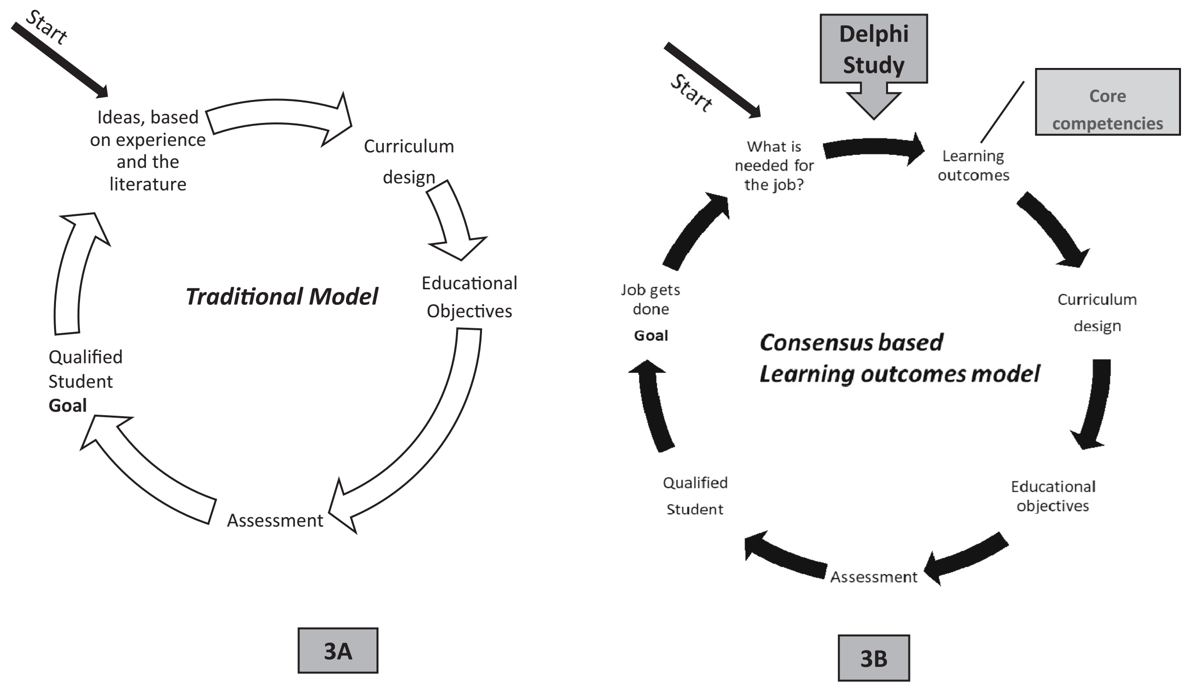

Fig. 3. Traditional model of curriculum development versus a consensus based learning outcomes model of curriculum development.

education and curriculum design might have showed more interest in the study and the questions might have been more thought provoking to them. Diversity of the selected panellists would have been more beneficial such as including a larger variety of healthcare professionals e.g. nurses. However, three different groups of participants (from SA, Africa and global) were invited, specifically to get broader representation. 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.

The Delphi method, based on three iterative rounds and feedback from experts, was effective in 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 study results may prove useful by influencing decision making on an international level. It will ultimately improve education in Medical Toxicology, and in the long run will lead to better patient care.

Dissemination of results

The results of the Delphi Survey was conveyed to the experts who were participating in the three rounds and will also be circulated to the World Health Organization.

Authors' contribution

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: CM contributed 60%; AL 20%; IC 20%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of competing interest

The authors declared no conflicts of interest.

Acknowledgements

Staff of the Poisons Information Centre of the Western Cape, South Africa.

Members of the African Network of Poison Control Centres.

Members appointed by the World Health Organisation (WHO) to update Guidelines for Poisons Control.

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