PRE-HOSPITAL EMERGENCY CARE STUDENT EXPERIENCE WITH PAEDIATRIC EMERGENCY CASES IN JOHANNESBURG, GAUTENG

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DECLARATION

I, Christopher Owen Alexander Stein, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Medicine in Emergency Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

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_______ day of ________________ 2010

DEDICATION

All things come at a price. For Leonie, Coleen, Ryan and Euan who put up with my absence during the hours devoted to this work.

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.
T. S. Eliot

PUBLICATIONS AND PRESENTATIONS ARISING FROM THIS STUDY

An abstract based on this study, entitled “Exposure of University Pre-hospital Emergency Care Students to Paediatric Emergency Cases and Clinical Skills”, was presented as a poster at the 13th International Conference on Emergency Medicine held in Singapore on 9 - 12 June 2010.

ABSTRACT

Adequate exposure to paediatric pre-hospital emergency cases for students undertaking clinical learning is a key component of preparation for independent practise. Both clinical reasoning and psychomotor skills require practise in a realistic environment in order to best equip the qualifying practitioner for demands of the real world of pre-hospital emergency care. The aim of this study was to retrospectively describe the exposure of pre-hospital emergency care students in the University of Johannesburg's National Diploma in Emergency Medical Care programme to emergencies involving paediatric patients in the Greater Johannesburg Metropolitan area over a continuous eight year period, between 1 January 2001 and 31 December 2008. Patient care records contained in an electronic clinical learning management information system entered over the eight-year study period were analysed in order to characterise the exposure of students to paediatric emergency cases in general, and clinical skills performed during this exposure. Results showed that, with the exception of infants and children seen by first year students, median exposure to paediatric emergency cases for students in all academic years was below 50%. Exposure to emergencies involving younger patients was generally lower than that for older patients, however the acuity of patients increased with decreasing age. Exposure to most clinical skills also decreased with decreasing patient age. Opportunities for students to practise critical or invasive skills were relatively rare. Suggestions for the improvement of student exposure to paediatric emergency cases and clinical skills include a period of internship and greater utilisation of hospital-based clinical skills exposure and practice.

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NOMENCLATURE

Advanced Life Support (ALS)

Advanced life support is a level of patient care determined primarily by a subset of clinical procedures. These clinical procedures are generally of an advanced or invasive and technically complex nature. Examples include advanced airway management (endotracheal intubation and surgical airway techniques such as cricothyroidotomy), advanced vascular access techniques (femoral, central or intraosseous), synchronised cardioversion, transcutaneous pacing, use of various medications for sedation, arrhythmia control or blood pressure support, and several others. Although used frequently in a way that would suggest a uniform definition, clinical procedures defining this term vary to some extent throughout the world.

Basic Life Support (BLS)

Similar to the definition of ALS above, BLS is defined in relation to a subset of clinical procedures. In contrast to ALS, however, the clinical skills in this case are the least invasive or technically complex and are generally slightly more than what could be expected at an advanced first aid level (e.g. bandaging, splinting, administration of oxygen and some other oral medications, cardiopulmonary resuscitation).

Bachelor of Technology in Emergency Medical Care (BTEMC)

The BTEMC degree programme is offered in two forms. The first is a part-time programme for those already holding the National Diploma in Emergency Medical Care and the second is a four year full-time programme, currently only offered at the University of Johannesburg. Both programmes prepare graduates for work at ALS level in the pre-hospital emergency care environment in South Africa and are associated with registration at the Health Professions Council of South Africa as an Emergency Care Practitioner. In future, the BTEMC will be replaced by a professional degree programme (level 8 on the National Qualification Framework).

Cardiac Arrest

The cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.

Critical Care Assistant (CCA)

A nine to 12-month short course offered at Provincial (Further Education and Training) Emergency Care Colleges. This is the highest qualification in a three-tiered hierarchy of short courses and leads to registration at the Health Professions Council of South Africa as an ALS paramedic.

Emergency Care Practitioner (ECP)

A category of Health Professions Council of South Africa registration for those holding a Bachelor's degree in Emergency Medical Care.

Emergency Department (ED)

A hospital department specialising in the provision of emergency care to acutely ill or injured patients. The ED is virtually always the destination for patients assessed and treated by various types of emergency care personnel in the pre-hospital environment. In South Africa, the ED has commonly been referred to as the 'casualty' department, but this term is no longer used.

Emergency Medical Database and Analysis System (EMDATA)

An electronic clinical learning management information system developed and used by the Department of Emergency Medical Care at the University of Johannesburg (UJ).

Emergency Medical Service(s) (EMS)

A service, comprised of a despatch centre, vehicles, appropriately qualified personnel and other infrastructural and logistical support services, that exists to provide pre-hospital emergency medical care (defined below) to a defined geographic population (provincial services) or client-base (private services).

Emergency Medical Technician (EMT)

Non-physician personnel providing pre-hospital emergency care in the USA are referred to as Emergency Medical Technicians. There are three levels of EMT qualification: EMT basic (EMT-B), EMT intermediate (EMT-I) and EMT paramedic (EMT-P). These three short course-based qualifications are aligned with BLS, ILS and ALS levels of care in the USA.

Further Education and Training (FET)

A band of the National Qualifications Framework (NQF; defined below) including adult basic education and training, school education and further education qualifications offered at technical or other colleges.

Higher Education (HE)

A band of the NQF including qualifications offered at Universities and Universities of Technology.

Higher Education Qualifications Framework (HEQF)

A sub-section of the NQF (defined below) outlining the hierarchical structure of HE qualifications.

Health Professions Council of South Africa (HPCSA)

A statutory body regulating the practice of health-related professions in South Africa.

Intermediate Life Support (ILS)

A level of patient care determined primarily by a subset of clinical procedures intermediate between that of BLS and ALS (defined above). Typically, the clinical procedures include basic intravenous access and fluid administration, additional airway management procedures or adjuncts and a limited range of medications.

National Diploma in Emergency Medical Care (NDEMC)

A three-year full-time qualification preparing graduates for work at ALS level in the pre-hospital emergency care environment in South Africa. The scope of practice associated with NDEMC is narrower than that associated with the BTEMC programme (defined above). This qualification is associated with registration at the Health Professions Council of South Africa as an ALS paramedic (the same registration as that associated with CCA, defined above).

National Qualification Framework (NQF)

A framework regulated and maintained by the South African Qualifications Authority (SAQA) listing the hierarchical relationships and credit weightings of all SAQA-registered qualifications. The NQF is divided into basic education, further education and training, and higher education components.

Paediatric

Essentially, the term ‘paediatric’ refers to non-adults. However the exact age boundary between adult and paediatric patients varies greatly. For the purposes of this study, the following categories are used (these are the definitions used by students when they captured data at the point-of-care):

i) Neonate (from birth until 30 days of age, including pre-term neonates);
ii) Infant (from 30 days of age until one year of age);
iii) Child (from one year of age until any signs of puberty);

Paramedic

In South Africa, the term paramedic refers to pre-hospital emergency care providers registered on the ALS register at the HPCSA. The term ALS is defined above.

Patient Care Record (PCR)

A paper-based form comprised of variables that are documented at the point-of-care by pre-hospital emergency care students during clinical learning. Each PCR represents the demographic and clinical variables of one patient (a blank PCR from is attached as Appendix D). These data are later entered into an electronic clinical learning management information system at the UJ called the Emergency Medical Database and Analysis System (defined above). In the context of this study, ‘PCR’ refers specifically to the electronic form of these data, unless stated otherwise.

Pre-hospital Emergency Medical Care

Emergency care provided in the field. The HPCSA define emergency care as “the rescue, evaluation, treatment and care of an ill or injured person in an emergency care situation and the continuation of treatment and care during the transportation of such person to or between health establishment(s)". (Professional Board for Emergency Care, 2006). In the majority of cases patients treated in the field are transported to a hospital, but there are sometimes exceptions (patients who refuse transportation or patients who are declared dead in the field).

Pre-hospital Emergency Medical Care Student

Any student undertaking study towards a pre-hospital emergency care qualification. As discussed above, there is a range of qualifications both in the FET and HE bands of the NQF. For the purposes of this study, only students in the HE band are referred to, specifically those studying towards the NDEMC at the UJ.

Structured Query Language (SQL)

A high-level relational database software language composed of commands that enable users to create database and table structures, perform various types of data manipulation and data administration, and query the database to extract useful information. (Rob & Coronel, 2002:825).

CHAPTER 1: INTRODUCTION

1.1. Background

The purpose of any emergency medical service (EMS) is to render pre-hospital emergency medical care to a defined population. In order to do this, the personnel providing this care must be adequately trained. In South Africa, the first training programmes in pre-hospital emergency care were offered in the 1970s and were structured in the form of in-service training ‘short courses’ of several weeks duration. The level of training first offered was what would later be termed ‘basic life support’ (BLS).

Over time, and as pre-hospital emergency care evolved in other countries such as the USA, additional levels of training were added to the existing BLS level in South Africa and were largely modelled on the content and educational approaches used in these countries. Because early pre-hospital emergency care training approaches in countries like the USA focused mainly on resuscitation from cardiac arrest and the treatment of injury (particularly injury caused by motor vehicle accidents), there was initially almost no consideration of, or training for, emergencies in any paediatric age group. Pre-hospital emergency care in the 1970s and 1980s, when most of the training courses were first established, was focused almost entirely on the treatment of adults.

In the late 1980s, a parallel stream of pre-hospital emergency care education in South Africa was established at higher education level in the form of a three-year National Diploma in Emergency Medical Care (NDEMC; then referred to as the National Diploma in Ambulance and Emergency Technology). Despite the shift to higher education, most of the learning objectives included in the NDEMC were geared towards the same clinical focus areas as previous pre-hospital emergency care training courses, the result being a relatively small paediatric emergency care component.

From the earliest developments in pre-hospital emergency care training, including both the basic and more advanced 'short courses' as well as the NDEMC, clinical learning has been considered an important component. Clinical learning activities are intended to mirror and support theoretical and practical learning outcomes and give students an opportunity to practice clinical skills under supervision, and obtain some experience in these skills before qualification. This 'hands on' approach in the real world of emergency care is seen educationally as an important learning opportunity for students, allowing them to gain insight and understanding in a way that cannot be reproduced in the classroom.

The greatest difficulty in arranging clinical learning is to ensure adequate exposure to a range of clinical skills for all students. This is particularly difficult in the context of emergency care where processes leading to the occurrence of an emergency, particularly those of a life-threatening nature, are largely chance or random events and are thus unpredictable. In the case of paediatric emergencies, the problem is even more acute; a small minority of the total case-load in most emergency services involves seriously ill or injured children. This would be expected to significantly decrease the chances of students completing clinical learning in these services to encounter opportunities to practice paediatric emergency care clinical skills, particularly the most invasive skills typically reserved for the most acutely ill or injured children.

University of Johannesburg (UJ) NDEMC student exposure to paediatric emergency cases, and clinical skills associated with them, is the focus of this study. The literature review which follows will contextualise this by examining the nature of paediatric emergency care in the pre-hospital environment from available published data. This will be followed by an appraisal of the goals of clinical learning and brief commentary on the assessment of clinical learning in order to frame the assertion that clinical learning in the specific context of pre-hospital emergency care is vitally important in developing balanced, capable practitioners.

Finally, the review of literature below will assess the nature of international approaches to education and assessment in paediatric pre-hospital emergency care. This will be followed by a brief overview of the South African pre-hospital emergency care qualification structure and a more detailed description of the approach to paediatric pre-hospital care education in the NDEMC programme at the UJ. A background will thus be provided allowing balanced insight into this study's aim, which is to describe the nature of UJ NDEMC student experience with paediatric emergency cases retrospectively, over a continuous eight year-period.

1.2. Literature Review

1.2.1. The Nature of Paediatric Pre-hospital Emergency Care

It is necessary to analyse the nature of paediatric pre-hospital emergency care in order to contextualise the current study. Unfortunately, no local information on this area of emergency care has been published. Deficiencies in pre-hospital care for paediatric patients in the USA were identified more than 25 years ago. Perhaps because of this focus, and efforts to improve the situation, published data come exclusively from North American EMS systems.

One of the earliest and also the most cited and influential studies assessing factors determining the quality of paediatric pre-hospital emergency care in the USA was that published in the mid-1980s by Seidel et al. (1984). The finding that mortality rates from accidental injury were higher amongst children than adults prompted questions in this publication regarding the pre-hospital emergency care needs of children, and whether these were being met at the time.

Two years later, another report took these initial questions further and focused specifically on training and equipment for paramedics providing pre-hospital emergency care to sick and injured children. (Seidel, 1986). The educational dimension of this study will be examined in greater detail in 1.2.3 below, however this work was the first to seriously question the preparedness of paramedics in the USA to effectively provide pre-hospital emergency care for children, and probably provided the stimulus for later research examining the nature of this type of care.

Most studies examining aspects of pre-hospital emergency care provided to children focus on procedures. Two studies in the early 1990s assessed various procedures carried out by BLS and ALS paramedics in large urban centres. (Lavery, Tortella, & Griffin, 1992; Lillis & Jaffe, 1992). The study by Lavery et al. (1992) involved assessment of a broad range of procedures in a cohort of 458 injured paediatric patients. The most commonly performed procedures were the most basic (splinting of fractures and administration of supplemental oxygen). Intravenous (IV) access was attempted in 231 patients with a 97% success rate. Endotracheal intubation (ETI) was rarely attempted and had a much lower success rate of 79%. Medications (naloxone, adrenaline, atropine and sodium bicarbonate) were administered to 15 patients (3%).

Lillis & Jaffe's study (1992) was limited to investigating intravenous access amongst a group of 513 Canadian paediatric patients between the ages of birth and 18 years. The overall success rate was 84%. Of all the patients meeting one or more criteria for IV access determined by record review, 80% had IV access attempted and in 68% this was successful. Age of the patients seemed to play a role in success of IV access in this study – only half of patients under the age of six years who required IV access had an IV placed successfully.

In a pattern similar to that observed by Lavery et al. (1992), Joyce, Brown, & Nelson (1996) determined that most procedures performed on a cohort of 61,132 paediatric patients were of a basic nature, including spinal immobilisation, administration of oxygen and haemorrhage control. Of all callouts where ALS qualified paramedics were present (62% of total), ALS level procedures were performed in 14%. These procedures included, in descending order of frequency, IV access and fluid administration (8%), endotracheal intubation (2%), intraosseous infusion (1%) and needle thoracostomy (0.2%). Medications were administered to paediatric patients in 5% of ALS callouts, with bronchodilators, adrenaline, atropine, diazepam and dextrose administered most frequently.

Very similar results were obtained from another smaller retrospective case review conducted in Michigan State, USA. (Reisdorff et al., 1998). The three most commonly performed procedures were identical to those identified by Joyce et al. (1996) (spinal immobilisation, oxygen administration and haemorrhage control/wound care), but medications were administered to three times as many patients (15%). In contrast to the data presented by Joyce et al. (1996), no patient received an intraosseous line and no patient was intubated. The overall proportion of paediatric patients on whom advanced skills were performed by paramedics in this study was 19%, highlighting the limited opportunities for these practitioners to perform them.

In a study aimed at determining whether trauma resuscitation skills were used more frequently for adults than for children, Su, Mann, McCall, & Hedges (1997) conducted a retrospective analysis of major injury cases treated by ALS paramedics in Oregon, USA. In this particular study, patients aged 12 years or less (“paediatric”) were compared with those older than 12 years. Of the total number of cases analysed, 8% were paediatric. The only resuscitation skill with a significant difference in terms of frequency was IV access, which was performed four times more frequently on older patients. Subgroup analysis showed that in older and paediatric patients with tachycardia and hypotension, significantly fewer paediatric patients received IV lines and fluid resuscitation.

The frequency of basic and advanced life support skills performance was described in 1,377 patients under the age of 12 years in Ottawa, Canada. (Richard, Osmond, Nesbitt, & Stiell, 2006). The same “top three” basic skills identified previously (Lavery et al., 1992; Reisdorff et al., 1998) were observed here. Basic ventilation skills (bag-valve-mask ventilation) were performed on 0.3% of patients. From an ALS perspective, IV access was attempted in 10% of patients (and was successful in 78%) and ETI was performed on only one patient. No BLS or ALS skills were performed on 44% of patients. The authors conclude that opportunities to practice ALS skills on paediatric patients are rare in this population, a factor which may have implications for skill retention.

In a comparative study aimed at assessing the effect of on-line medical direction on appropriateness of paediatric emergency treatment, Scribano, Baker, Holmes, & Shaw (2000) found that the administration of oxygen and other medications was relatively under-utilised, and the use of IV lines was over-utilised, in the treatment of children with respiratory distress. Of the total number of patients identified who required assisted ventilation, 50% did not receive this intervention. A significantly lower prevalence of skill performance on younger children led the authors to conclude that many paramedics lack confidence when assessing and treating younger children. This is attributed to a combination of low exposure to paediatric emergencies leading to a lack of experience, and inadequacies in the coverage of paediatric emergencies in many paramedic education curricula in the USA.

Finally, in a review of pre-hospital paediatric emergency care, Babl, Vinci, Bauchner, & Mottley (2001) studied ALS level care of 555 paediatric emergency cases over a 12-month period. These authors convey frequency of skill performance in an alternative way, by calculating skills per paramedic per year. This analysis revealed that only IV access had a skill rate per paramedic per year greater than one (3.7). Airway and ventilation-related skills (bag-valve-mask ventilation and ETI) were associated with very low rates (0.6 and 0.3 respectively) as was intraosseous access (0.5). Although 95% of IV attempts were successful, only 73% of ETI attempts were, a proportion similar to that identified in another retrospective series. (Lavery et al., 1992). Roughly half of all patients received medication with brochodilators, adrenaline and diazepam again being the most frequently administered.

In summary, this part of the literature review has focused on the nature of pre-hospital emergency care delivered to paediatric patients, exclusively in North American EMS systems. The studies appraised here are exclusively retrospective case reviews and concentrate on describing the type and frequency of procedures performed during the course of pre-hospital treatment of paediatric patients. Two consistent themes have emerged from these data. Firstly, the vast majority of patient care is of a basic nature and does not need to be performed by the most highly qualified paramedics. Secondly, and related to the first theme, paramedics practising at ALS level have relatively few opportunities to perform more advanced and invasive procedures. This may have implications for the proficiency with which some of these procedures are carried out (such as ETI, with a relatively high failure rate in two studies), and also for opportunities for students working under supervision in the clinical environment to practise these important skills.

1.2.2. Preparation for Practice: Clinical Learning in Health Sciences Education

The focus of this literature review so far has been the “real world” of paediatric pre-hospital emergency care: characteristics of the nature of emergency assessment and treatment provided by those tasked with the pre-hospital care of paediatric patients. However this study is aimed at describing the clinical experiences of students within the broader context of paediatric pre-hospital emergency care. It is thus necessary to spend some time considering the goals and principles of clinical learning in general, after which published data on educational approaches in paediatric pre-hospital emergency care from other countries will be reviewed.

In order to finally contextualise the research problem, an overview will be given of the South African pre-hospital emergency care educational qualification structure and local approaches to paediatric emergency care teaching and learning, and in particular clinical learning.

The Role and Importance of Clinical Learning

Two important goals of clinical learning, that is learning taking place in the clinical practice environment, are the development of knowledge and clinical reasoning abilities. The former is seen as an essential foundation for the latter, making the two entities interdependent. (Higgs & Titchen, 2000).

Knowledge may be considered as being of two types. Propositional knowledge is often more simply described as “knowing that”. In other words, propositional knowledge is factual knowledge obtained mainly through research and scholarship. The main source of this propositional, research-based knowledge is scientific enquiry in the empirico-analytical paradigm, with emphasis on cause and effect relationships and the generalisation of findings. Other research paradigms also play an important foundational role in the generation of propositional knowledge. These include the interpretive paradigm, producing practical knowledge grounded in human interaction, and the critical paradigm producing emancipatory knowledge aimed at changing structures or relationships. Propositional knowledge may also arise from deductive reasoning, based on assumed or defined truths. (Higgs & Titchen, 2000; Higgs, 2009).

Non-propositional knowledge, on the other hand, is concerned with “knowing how”. This category of knowledge is divided into two main forms by Higgs & Titchen (2000:27): professional craft knowledge and personal knowledge. Professional craft knowledge can be considered as a type of intuitive knowledge, described further by Higgs & Titchen (2000:28) as “learned awareness or contextual receptivity”. These authors draw on the work of a number of others to emphasise the importance of this type of knowledge in the shaping of “outstanding practitioners” and in acknowledging that there is more to sound clinical practice than technical knowledge alone.

Personal knowledge is defined by Higgs & Titchen (2000:28) as “the unique frame of reference and knowledge of self which is central to the individual’s sense of self”. This form of knowledge arises from personal experiences, and reflections on these experiences, but is also influenced by the community and culture in which the learner lives and in which the learning experiences are embedded. (Higgs, 2009:33). The frame of reference produced by personal experience powerfully shapes how the learner translates scientific and professional (propositional) knowledge into clinical practice decisions. Clearly, personal knowledge is a key factor in shaping a learner’s clinical practice style and ability.

Importance of the non-propositional form of knowing has been emphasised, in the area of diagnostic error, by the way in which “knowing that” and “knowing how” relate to two different forms of clinical reasoning. Croskerry (2009) gives a clear account of the background, evidence and prevailing ideas concerning dual process theory, and the important role that this plays in clinical decision making. The dual cognitive processes described, one intuitive and one analytical, have a striking resemblance to the two forms of knowing discussed above.

Reliance is often made on both during clinical reasoning, particularly with regard to diagnostic processes.

Central to the application of both intuitive and analytical types of clinical reasoning in diagnosis, is the role of pattern recognition. (Croskerry, 2009:30). Considering that pattern recognition is a skill developed from patient contact and experience in the clinical environment, the importance of real-world clinical exposure in developing this ability, and that of intuitive clinical reasoning, underscores the importance of clinical learning.

This brief review of knowledge and reasoning related to clinical practice lends support to the notion that clinical learning is an essential part of the global learning approach in any health science-related field. Propositional knowledge, and the deductive reasoning that often gives rise to it, can be effectively learned in the classroom. “Knowing how”, and applying non-propositional knowledge in sound clinical reasoning and decision making, cannot be learned without exposure to the clinical environment and meaningful contact with patients in a realistic context.

The Assessment of Clinical Learning

Assessment exists for several purposes: to certify competence, to identify underperformance and focus remediation, to provide feedback to learners and to detail levels of knowledge, skill or performance associated with a specific unit of learning. By giving clear direction and an accurate idea of the level of performance required, and opportunities for feedback, it is clear that assessment drives learning. (Keating, Dalton, & Davidson, 2009:148).

In health sciences education, the most frequently adopted hierarchical framework for assessment is that proposed by Miller (1990). Miller’s pyramid consists of four levels:

KNOWS: At the base of the pyramid, this is the level of assessment of knowledge, as defined earlier in this review. Following the approach used in the discussion above, this could be rephrased as assessing “knows what” (propositional knowledge).

KNOWS HOW: This level of assessment focuses on competence. Miller (1990) describes this as the skill set including acquisition of information, analysing and interpreting it and forming a sound diagnostic or management plan based on it. Although probably not intended to be analogous, this level of assessment should address the type of knowledge referred to above as non-propositional because functional adequacy is dependent on it.

SHOWS HOW: Performance is assessed at this third hierarchical level. Behaviour, as evidenced by observed performance in standardised tasks, is the key factor at this level, rather than pure cognitive function. Patient simulations and objective structured clinical evaluations (OSCEs) are assessment tools commonly used.

DOES: The keyword at this apical level of assessment is “action”. This involves observed performance, but in practice instead of in a simulated environment. (Wass, Van Der Vleuten, Shatzer, & Jones, 2001).

Interestingly, Rethans et al. (2002) propose a slightly different usage of the terms “competence” and “performance” to most other authors, including Miller. They define competence assessment as assessment conducted in controlled representations of professional practice and performance assessment as assessment conducted in actual professional practice. Regardless of how these definitions map to Miller’s original framework, the important distinction is that moving from competence assessment to performance assessment involves a shift from the known to the unknown. Competence assessment involves known contexts, equipment and approaches while performance assessment involves unknown situations, adaptations of known methods and changing conditions. (Keating et al., 2009).

There seems to be broad agreement that, although assessment of competence is easier, more practical and less resource-intensive, there is a dire need for more robust assessment of what learners actually do in authentic practice environments under uncertain conditions. (Keating et al., 2009; Rethans J. et al., 2002; Wass et al., 2001). This approach is essential both for driving patient-centred learning and to certify a minimum level of acceptable clinical skills performance prior to qualification. Unfortunately, as described below, few educational programmes focusing on paediatric pre-hospital emergency care involve clinical learning or any form of performance assessment.

1.2.3. Paediatric Pre-hospital Emergency Care Education Programmes: International Perspectives

In 1966, a landmark report on the state of emergency care entitled "Accidental Death and Disability: The Neglected Disease of Modern Society" was published by the US National Academy of Sciences. (Committee On The Future Of Emergency Care In The United States Health System, 2007; Foltin et al., 1998). This report drew attention to the problem of disorganised and ineffective emergency care in the USA at the time, both in the pre-hospital and hospital settings. The response to identification of this problem over the ensuing decade was a structured network of EMS systems throughout the USA - systems that provided acceptable levels of pre-hospital emergency care, but that largely ignored the needs of sick and injured children.

Seidel et al. (1984) were the first authors to draw attention to the problem of inadequate pre-hospital emergency care for children in the USA. As described previously in this review, these authors identified a greater death rate for children following injury than for adults and suggested that this was a symptom of EMS systems not geared to the effective care of paediatric patients.

A second article by Seidel (1986) took the previously identified problem a step further. This work described the nature of paediatric pre-hospital emergency care education for paramedics and paediatric emergency care equipment on emergency service vehicles in order to understand if and where deficiencies in these resources could be affecting the quality of delivered pre-hospital emergency care for children. Questionnaires were sent to a random sample of 98 Emergency Medical Technician (EMT) training programmes representing every state in the USA. Education-related questions asked about types of training offered, duration spent on each type and whether or not 20 specific areas of paediatric emergency care were addressed during training.

Results of this study showed that 41% of training programmes had 10 or less didactic hours devoted to paediatric emergencies with an average of 15 hours devoted to this area. Five percent of programmes had no paediatric emergency care training at all. In 21% of programmes there was no clinical learning of any description, more than half of all programmes (55%) had no preceptorships and there was no simulation training in 50% of the programmes. A relatively large proportion (24% - 45%) of programmes offered no coverage at all of some important topics in paediatric emergency care such as shock, unconsciousness, drowning and sexual abuse. (Seidel, 1986).

A more comprehensive review on the state of paediatric pre-hospital emergency care in the USA was published in 1993 by the Institute of Medicine's Committee on Pediatric Emergency Medical Services. (Committee On Pediatric Emergency Medical Services, 1993). This work essentially reinforced Seidel's earlier results, but also drew attention to deficiencies in the paediatric emergency care education and exposure of emergency department residents and nursing staff.

At the time of the Committee's report pre-hospital paediatric emergency care was either taught as part of the EMT curriculum, with deficiencies as noted above, or in the form of two additional courses: Pediatric Advanced Life Support (PALS), developed by the American Heart Association and Advanced Pediatric Life Support (APLS), developed by the American Academy of Pediatrics and the American College of Emergency Physicians. Paramedics were able to complete both PALS and APLS, and undoubtedly both filled an unmet training need at the time. However neither course was designed for pre-hospital emergency care and neither course had any associated clinical learning component. The view was expressed that paediatric training for paramedics at the time was of a "patchwork" nature. (Committee On Pediatric Emergency Medical Services, 1993).

Perhaps the most significant development in paediatric pre-hospital emergency care education in the USA occurred in 1995 with the introduction of a new course designed specifically for the pre-hospital environment: Pediatric Education for Prehospital Providers (PEPP). Developed by the American Academy of Pediatrics, PEPP is comprised of 13 hours of didactic and skill training time covering a wide range of emergency care topics directly relevant to the pre-hospital environment. Although a step forward in terms of focus, PEPP contains no clinical learning component and no assessment of performance, as defined under 1.2.2 above. (Committee On The Future Of Emergency Care In The United States Health System, 2007).

In 1998 the US National Department of Transport's EMT-P (paramedic) National Standard Curriculum was revised and substantial changes were made to the sections dealing with neonatal resuscitation and paediatric emergencies. These changes in both learning objectives and methodologies originated largely from a Pediatric Education Task Force comprised of members from the Child Health Bureau, National Highway Traffic Safety Administration and Emergency Medical Services for Children programme. A report from this Task Force contains a comprehensive listing of essential topics and skills for paediatric pre-hospital emergency care. (Gausche, Henderson, Brownstein, & Foltin, 1998:60). Although significant guidance is provided in this report on educational methodologies seen as ideal within the context of this kind of training, no mention is made at all of clinical learning or performance assessment. (Gausche et al., 1998:62).

The only other published data dealing with the nature of paediatric pre-hospital emergency care education comes from the UK. A postal survey conducted in 2001 investigated the nature of pre-hospital paediatric emergency care training programmes in 41 National Health Service (NHS) ambulance trusts. Average didactic time spent on paediatric emergencies was only six hours with 12% of trusts having no paediatric module in their educational programmes at all. Although these programmes involve a six month period of field work, no indication was given in the survey of the structure or nature of this or of possible exposure of students to paediatric emergencies during this clinical learning component. (Johnson & Gaffney, 2001).

The review above, addressing the development and current nature of paediatric pre-hospital emergency care education in the USA and UK, has shown that much progress has been made in this regard, specifically in the USA. Despite what could only be described as a highly organised and purposeful development process in the USA, reference is still made to the incomplete progress in this area and the amount and complexity of effort needed in the future, with many paramedics still relying on continuing education activities for their paediatric emergency care knowledge and skills. (Committee On The Future Of Emergency Care In The United States Health System, 2007; Glaeser, Linzer, Tunik, Henderson, & Ball, 2000; Zaveri & Agrawal, 2006).

Three main themes emerge from the published data discussed above. Firstly, that little time is generally spent in pre-hospital emergency care educational programmes on paediatric care. Although there has been significant improvement in this regard in the USA since the mid-1980s, solutions seem to be mainly in the form of short course training which seldom involves a total duration of more than two days. Secondly, although there is a National Standard Curriculum for education of paramedics in the USA, not all states adhere to this. (Committee On The Future Of Emergency Care In The United States Health System, 2007). This may perhaps explain the focus on stand-alone short courses for paediatric pre-hospital emergency care, although state EMS agencies have freedom to choose how they incorporate these into their training programmes, if at all.

The third and most relevant theme in the context of this study is that there is typically little emphasis, and frequently no mention, of clinical learning as a component of paediatric pre-hospital emergency care education in the available data from the USA and UK. The learning programmes and courses reviewed above (EMT-P, PALS, APLS, PEPP) generally make use of lectures, case-based learning, practical skill stations and sometimes patient simulations together with assessments of knowledge, understanding and competence. Perhaps because of the rare nature of paediatric emergencies in most EMS systems, or because of the complexity of assessing performance, there appears to be no clear place for clinical learning in the educational programmes reviewed here.

In order to understand how educational programmes for South African paediatric pre-hospital emergency care are structured, and to compare the nature of these programmes with those described in the review above, it is necessary to first present an overview of the general architecture of South African pre-hospital emergency care qualifications.

1.2.4. Pre-hospital Emergency Care Education Structures in South Africa

In South Africa, pre-hospital emergency care qualifications fall within the Further Education and Training (FET) and Higher Education (HE) bands of the National Qualifications Framework (NQF). (South African Qualifications Authority, 2010). The FET qualifications are traditionally referred to as 'short-courses' and range from one to 12 months in duration encompassing BLS, ILS and ALS levels of care. These courses are offered mainly in the form of in-service training for EMS personnel wishing to improve their emergency care qualifications. (Health Professions Council of South Africa, 1999).

The first FET courses were designed and implemented in the late 1970s, based mainly upon BLS level emergency care courses offered at the time in the USA. The focus was initially on very basic forms of treatment, not much more advanced than first aid-level care. Within the space of a few years, more and more advanced skills were being added to the repertoire of these early emergency care providers. This was mainly because of international developments of a similar nature, where a number of procedures performed exclusively in hospitals (such as IV access, fluid administration and ETI) were "migrated" to the pre-hospital environment in order to make them available as early as possible to patients with life-threatening conditions.

Progressive widening of the pre-hospital emergency care scope of practice lead to new qualifications being added, until a three-tiered qualification structure comprising BLS, ILS and ALS levels was in place by the late 1980s. Subsequent to this, in the early 1990s, the regulation of both training and practice within the pre-hospital emergency care arena was placed under control of the then-Medical and Dental Council (MDC) of South Africa.

In parallel to the FET qualifications mentioned above, a HE pre-hospital emergency care qualification was established in the mid-1980s. This qualification, then called the National Diploma in Ambulance and Emergency Technology, (NDAET) was offered at two Technikons in South Africa (Witwatersrand and Natal). The NDAET was a three-year full-time qualification and led to registration with the MDC on the same register as the ALS-level FET qualification (Critical Care Assistant, of six months duration at the time). In reality, much of the emergency care training for the NDAET was actually done at the Provincial Ambulance Training (FET) Colleges in Johannesburg and Durban, and was no different from the FET training occurring at the same time, while basic science and other supporting subjects were completed at the Technikons. The NDAET was recurriculated in 1991 and again in 2000 and underwent a name change to become the National Diploma in Emergency Medical Care. (South African Qualifications Authority, 2009b).

In 1992 the NDAET offered at Technikon Witwatersrand severed its close association with the Provincial Ambulance Training College in Johannesburg and a similar process occurred in KwaZulu-Natal in 2000. Introduction of the Higher Education Act of 1995 brought about a restructuring of the academic architecture of many Technikon programmes and the advent of a Bachelor's degree specific to this stratum of higher education (the Bachelor of Technology degree). The Bachelor of Technology degree in Emergency Medical Care (BTEMC) was introduced in 2001, initially as a two-year part-time programme for those already holding the NDEMC. (South African Qualifications Authority, 2009a).

The NDEMC was phased out at the UJ [§] in 2008 where it has been replaced by a full-time, four-year BTEMC programme. Phasing out of the NDEMC is in line with a long-term restructuring of HE emergency care qualifications – thus far only the UJ has completed this transition. The NDEMC is still offered at the Durban University of Technology, Central University of Technology and Cape Peninsula University of Technology, but will be phased out in favour of the BTEMC qualification at these institutions in the near future. Appendix A gives a diagrammatic overview of the current FET and HE emergency care qualifications and their associated HPCSA registers. Masters and doctoral level qualifications in emergency medical care are also available, but these are purely research-based and will thus not be considered any further here.

The BTEMC programme, although originally introduced as an “add-on” to the NDEMC, has now become one of two tiers in the National Department of Health’s vision for a new pre-hospital emergency care educational structure. The BTEMC will fulfil the role of a professional qualification with a first tier, mid-level worker qualification called the Emergency Care Technician (ECT). In keeping with the introduction of a two-tiered mid- and professional-level hierarchy in many other health-related disciplines, this new architecture will see the ECT qualification (two-years, full-time) being offered at the provincial emergency care colleges, with the BTEMC continuing to be offered at Universities and Universities of Technology. It is also envisaged that there will be articulation, with suitable bridging, between the ECT qualification and the third year of study of the BTEMC qualification. Human resources needs of EMS systems will be met mainly by ECT-qualified personnel, while those with the BTEMC will offer a more specialised level of care for the sickest or most severely injured patients and those in special environments (such as the aeromedical environment).

[§] The University of Johannesburg has existed since 1 January 2005 after a merger of Technikon Witwatersrand, Rand Afrikaans University and part of Vista University.

1.2.5. Paediatric Pre-hospital Emergency Care Education in South Africa

In order to place the aim of this study into context, and fully appreciate the research problem from which it arises, it is necessary to understand how paediatric emergency care has been structured within the NDEMC programme.

The NDEMC programme was offered in a three-year full-time format (the past tense is used here because the UJ has, since 2008, phased out the NDEMC but the focus of this study is on data derived from UJ NDEMC students). The high-level structure of this programme was based on a progression from learning exclusively new, basic information in first year to the integration and application of existing knowledge in third year. The duration and complexity of clinical learning also followed an ascending progression from first year (predominantly BLS-level care) through to third year (predominantly ALS-level care).

Paediatric emergency care was represented in one form or another in each of the three years of study. In first year students learned the most fundamental paediatric emergency care skills such as basic airway management and ventilation, together with cardio-pulmonary resuscitation in infants and children. The bulk of first year learning outcomes was aimed at the basic management of common emergencies in adults, and on the basic sciences.

In second year, learning outcomes related to paediatric emergency care were also limited. The theory and practice of basic neonatal resuscitation were covered as part of an obstetrics and neonatology learning unit. Theoretical aspects of paediatric clinical assessment and child abuse were also covered in this year of study.

The majority of paediatric emergency care learning outcomes were addressed in third year, probably because historically most forms of paediatric emergency care had always been considered to be at ALS level. Contact learning time comprised roughly 10 hours and addressed topics such as paediatric and newborn resuscitation, advanced airway management, ventilation and monitoring, trauma and burns resuscitation, intravenous fluid therapy, disorders of the most relevant systems (e.g. respiratory, cardiovascular) and paediatric medication dosing and administration. (University of Johannesburg, 2008). Paediatric clinical skills and simulation learning time comprised a further 15 hours. Clinical skills mirrored theoretical learning outcomes and included, among others, resuscitation skills, advanced airway management (ETI), intravenous and intraosseous access, defibrillation, cardioversion and external pacing. Simulated paediatric emergency care learning was accomplished in the form of scenarios representing common paediatric emergencies. (University of Johannesburg, 2008).

Clinical learning was represented in all three academic years of the NDEMC programme. This involved working in either the pre-hospital environment or various specialised hospital units, such as trauma units, emergency departments or surgical departments (for airway management practice under anaesthetist supervision in the operating room). No placement of students in paediatrics departments was undertaken in the NDEMC programme.

Pre-hospital clinical learning was implemented by placing students at various private and provincial EMS in the Greater Johannesburg Metropolitan area. During pre-hospital clinical learning time, students worked with a mixture of BLS-, ILS- and ALS-qualified personnel, but exclusively ALS-qualified personnel in third year. In first and second year, students completed roughly 400 hours of pre-hospital clinical learning time in each year. In third year this was increased to roughly 500 hours. During this time students were exposed to the case mix prevalent at the EMS where they worked, which included both adult and paediatric emergency cases.

1.2.6. Summary of the Literature Review

The review of literature presented above has given a contextual background to the basis for this study. The nature of paediatric pre-hospital emergency care has been described in order to provide an understanding of the environment shaping clinical learning dynamics. Although the literature presented is based on studies exclusively from North American EMS systems, it does give some indication of the characteristics of paediatric emergencies and the nature of related emergency care that is probably not very different from that occurring in other parts of the world.

The nature and importance of clinical learning has been discussed in the second part of this review. This has been done by providing brief explanations of types of knowledge and focusing on the importance of clinically-derived non-propositional ("knows how") knowledge in clinical reasoning. Miller's framework of assessment in clinical learning has been used as an outline in order to show both the place and the importance of clinical learning in the broader schema of health-sciences education.

Finally, this review has described the available literature dealing with the historical origins, structure and deficiencies of paediatric pre-hospital emergency care education in the USA and the UK. For purposes of comparison, a short overview has been given of the South African pre-hospital emergency care qualification structure, and components of paediatric pre-hospital emergency care forming part of the NDEMC qualification at the UJ - the focus of this study. Below, the research problem driving this inquiry will be set out, followed by the study aim and objectives.

1.3. Problem Statement

The NDEMC programme at the UJ has contained theoretical, practical and clinical learning outcomes for paediatric pre-hospital emergency care. Students in all three academic years have completed clinical learning at EMS in the Greater Johannesburg Metropolitan area, where they have been exposed to a mix of both adult and paediatric emergency cases.

In order for students to gain any value from this clinical exposure, they must have opportunities to practice clinical skills and reasoning related to paediatric emergencies. The extent to which this exposure has occurred in the past is unknown, and it is thus impossible to get an impression of the appropriateness of these qualifying learners' opportunities to gain clinical experience prior to practising independently. This information is important because it may facilitate future changes in the organisation and implementation of clinical learning, in order to optimise exposure to paediatric emergency cases.

1.4. Study Aim and Objectives

1.4.1. Aim

The aim of this study was to retrospectively describe the exposure of pre-hospital emergency care students in the UJ's NDEMC programme to emergencies involving paediatric patients in the Greater Johannesburg Metropolitan area over a continuous eight year period, between 1 January 2001 and 31 December 2008.

1.4.2. Objectives

i) To describe, for each year of the review period:

- The numbers and characteristics of paediatric emergency cases seen by each student in their 1st, 2nd and 3rd year of study.
- The number of students in their 1st, 2nd and 3rd year of study who were exposed to no paediatric emergency cases at all.
- The comparison of exposure amongst those students who were exposed to paediatric emergencies, within each academic year of study.

ii) To describe, for each year of the review period:

- The numbers and characteristics of paediatric clinical skills performed by each student in their 1st, 2nd and 3rd year of study.
- The comparison of opportunities to practice clinical skills amongst those students who were exposed to paediatric emergencies, within each academic year of study.

iii) To assess the relationships between exposure to paediatric emergency cases and academic year of study.

1.5. Source of Study Data

1.5.1. Background and Purpose

The Emergency Medical Database and Analysis System (EMDATA) was conceived and initially designed and implemented in the Department of Emergency Medical Care at the UJ between 1999 and 2001. It was intended to function as a clinical learning information system, containing patient care records (PCRs) completed by all students during the course of their clinical learning, a core component in each of the three academic years of the NDEMC programme.

The NDEMC programme had, since its inception in 1986, always contained a clinical learning component in each academic year of study. During clinical learning time, students were required to document each patient interaction on a paper PCR which would serve as a record of both patient clinical data and learning activities relevant to a particular case (Appendix D). Submission of these paper PCRs, documenting minimum numbers of specific clinical skills in each year of study, was a requirement for final practical examination eligibility.

Although student numbers in the NDEMC programme have never been large, a typical year of clinical learning PCR forms would require a lecturer to manually check up to 2000 forms in the course of determining examination eligibility for a group of students. This was not only tedious, but also an error-prone process. An inability to effectively aggregate and summarise clinical learning data not only made the job of quality control difficult, but it also prevented lecturers from gaining any meaningful understanding of what experiences their students were having during clinical learning.

The rationale for implementing an electronic clinical learning management information system was thus to make quality control and management of these activities more efficient and less error-prone. Once in electronic format, PCR data can be very easily and efficiently summarised in order to produce an accurate impression of compliance with clinical skill requirements. Many other aspects of clinical learning activity also become easy to characterise with electronic data manipulation and summary, leading to many new insights into the quantity and nature of patient interactions experienced by individuals or groups of students.

First used by students in 2001, EMDATA was designed as a web application that could be accessed from any computer with an internet browser. The system was built on an Active Server Pages 3.0 platform (Microsoft Corporation, Washington, USA) and used a file-based relational database system for data storage and manipulation (Microsoft Access 2000, Microsoft Corporation, Washington, USA). The system was custom-designed to support clinical learning within the Department and the electronic data set was based on the already-existing paper PCR. All design, development and maintenance was carried out by the researcher.

1.5.2. Patient Care Record Data Collection Process

Students in all three academic years of study completing clinical learning are placed at private and local authority EMSs in the Greater Johannesburg Metropolitan area and work under the close supervision of a qualified practitioner. Each student will typically be ‘paired’ with a specific practitioner for the duration of a 12-hour shift and will accompany this practitioner in responding to all emergency cases during this time. The level of student involvement in each case, and the clinical skills performed under supervision are left to the discretion of the supervising practitioner, with the understanding that students should be allowed to obtain as much clinical experience in both patient assessment and treatment as any given situation allows.

Collection of data during clinical learning follows the same process for all students:

i) A paper PCR is completed at point-of-care. This form is checked and signed by the supervising practitioner and retained by the student. Clinical data for continuation of care at the receiving hospital and for medico-legal purposes are recorded on a separate emergency service patient care record, a copy of which is left on the patient's file at the receiving hospital.

ii) On return of the student to campus, the paper PCR is entered into EMDATA by the student. A dedicated computer laboratory has been provided by the Department for this purpose. Initially, before the computer laboratory was available, EMDATA was accessible via the internet (students could enter data from any computer with internet access). Since provision of the computer laboratory in 2005, the system has been run as an intranet and is accessible only from the laboratory.

iii) Students hand in the paper PCR forms containing data already entered into EMDATA towards the end of the academic year (i.e. during early- to mid-October of each year). Each paper PCR contains a PCR identifier obtained from EMDATA during data input and written on the form by the student allowing linkage between paper and electronic records.

In each academic year of study, students have a list of clinical skills, and associated numbers for each skill, which are related to their theoretical and practical learning outcomes. Due to the unpredictable nature of emergencies it is often not possible to make completion of a given number of clinical skills mandatory. For example, if a student does not encounter a specific number of patients in cardiac arrest with a shockable rhythm, then they will not be able to perform defibrillation the required number of times. For this reason, the list of clinical skills for each academic year of study is divided into those skills considered mandatory (skills such as history taking or vital signs assessment, for which it is certain that there will be enough opportunities) and those skills considered desirable (to be performed and documented if an opportunity presents itself).

Although the clinical skills relevant to a student's particular year of study are of prime importance as part of the PCR, each record is intended to be a comprehensive representation of the incident and patient, including:

i) Incident details, such as location of the incident and all relevant time intervals;
ii) Personal details of the patient, such as name, gender and age;
iii) Emergency service details, such as the name of the service where the incident took place, the name of the service transporting the patient to hospital, the name of the receiving hospital and the name and qualifications of the supervising practitioner;
iv) Clinical data, such as history, clinical features, mechanisms of injury (if applicable) and vital signs;
v) All other clinical interventions, not only those that the student is required or expected to document;

1.5.3. Quality Control and Data Validity

As with all studies utilising a retrospective design, there may be missing or incorrectly entered data. As described in 2.2.2 above, during clinical learning NDEMC students are required to participate in the assessment and treatment of each emergency case encountered, at the discretion of the supervising practitioner. Furthermore, Departmental regulations require each patient encounter to be fully documented on a PCR form and later entered into EMDATA. In order to prevent PCR forms from being discarded, each form is uniquely numbered. A record of PCR form numbers allocated to each student is kept and the student must enter one of these allocated unique numbers during electronic data input. In this way every PCR form issued to a student can be accounted for and discarded forms can be identified and tracked.

In the flow-diagram depicted in Appendix B, points A and B indicate possible sources of data capture error. These errors are minimised at point A by the checking of completed PCRs by the supervising practitioner. At point B there are several ways in which data capture errors are minimised. The user interface of EMDATA has been designed and constructed to validate input in order to prevent overt errors at this stage. In addition, all the PCRs of third year students are manually validated. This involves a lecturer carrying out an itemised comparison of each paper-based and electronic PCR to ensure that the electronic version is a true reflection of data captured at the point of care. Signatures of supervising practitioners authenticating the completion of procedures are also checked. In the case of first and second year students, manual validation of a randomly selected sample of PCRs is conducted in the same way as that described above.

From the description given above it can be seen that NDEMC students are expected to interact with every patient encountered by them during clinical learning. This occurs at the discretion of the supervising practitioner with whom each student completes their clinical learning. Although it is possible that a student may not complete a PCR form for a particular patient from time to time, this should be a rare occurrence and should not result in any significant under-representation of paediatric emergency cases in EMDATA.
Additionally, the description above shows that data are validated at two points in the clinical learning process, although in the case of second and third year students this is random and not exhaustive. Thus it is theoretically possible that some data entered into the system could have evaded the various validation checks, but this is unlikely and would at most represent a very small proportion of PCRs.

1.6. Conclusion

This chapter has provided a background for the study by clarifying the nature and structure of pre-hospital emergency care, and in particular paediatric emergency care. The review of literature has clarified the nature of paediatric emergencies and emergency care from the available literature. Because the main focus of this study relates to clinical learning of paediatric emergency care, some background has been given on the goals, assessment and importance of clinical learning in producing well-rounded qualifying practitioners.

In order to contextualise the international data presented, the structure of South African pre-hospital emergency care qualifications has been outlined and the nature of paediatric pre-hospital emergency care learning activities in the NDEMC programme at the UJ has been discussed. This has lead naturally to a statement of the problem, related to NDEMC students' exposure to clinical learning opportunities in the area of paediatric emergency care, and the aim and objectives driving the study. The following chapter will address the methodology employed and will provide finer detail regarding the clinical learning activities of UJ NDEMC students from a more operational perspective.

CHAPTER 2: MATERIALS AND METHODS

2.1. Introduction

This study retrospectively describes paediatric pre-hospital emergency care clinical learning data accumulated in an electronic clinical learning management information system over an eight-year period. In this chapter, some background is given regarding the structure and function of this information system, and the processes followed by students collecting data during their clinical learning. Points in these processes where the validity of data could be threatened, and the steps taken to counteract these threats, will be described in support of the assertion that the data used for analysis in this study are of adequate validity.

In the latter part of this chapter, the processes used for extraction of data from the registry will be described, as will the methods of data analysis and the statistical approaches used. Lastly, relevant ethical consideration will be reviewed and the processes followed in order to obtain ethical approval for this study will be briefly described.

2.2. Data Extraction

Although the database design used in EMDATA is normalised and thus fairly complex, the general pattern is that each row in the main database table represents a PCR, and each column represents a data field, or variable, such as the PCR identifier, age, gender etc. Data on students resides in a separate table where each row represents a student and each column represents a data field such as student number, last name, academic year of study etc. The main database table and student table are linked by the PCR identifier field which is common to both. Data extraction was focused on selecting specific subsets of PCRs, and related student records in order to extract data satisfying the study objectives as set out in Chapter 1.

Data are selected from a relational database such as EMDATA through the use of a standardised data manipulation language called structured query language (SQL; p. XVI).

Each SQL statement consists of keywords and identifiers which, when used together, specify which rows and which columns to display, and from which table or tables of data. Various operators and functions are also included in the syntax of SQL and these allow for very detailed and powerful statements to be written, facilitating the application of virtually any selection constraints on one or more tables of data.

Two main types of SQL statement were used for data extraction. The first type was used to simply isolate the required data from one or more tables and display each row. The second, more useful type, allowed for the inclusion of aggregate functions to group data into categories and calculate counts, totals and maximum values (among others) within the SQL statement itself. All SQL statements were constructed using the SQL editor in Microsoft Access 2003.

After execution of SQL statements, result sets were copied from Microsoft Access and pasted into a spreadsheet application (Microsoft Excel 2003, Microsoft Corporation, Washington, USA) and then imported into a statistical analysis application (SPSS, version 15.0, SPSS Science, Chicago, USA) for further manipulation.

2.3. Data Analysis

For the purposes of this study, exposure to paediatric emergency cases is defined as the proportion of students in a particular group (e.g. all first year students) who have experienced any contact with a paediatric patient in any age group or in a specific age group, depending on the context. ‘Any contact’ means one or more instances of patient care involving assessment, treatment and transportation to a hospital, or any combination of these. Similarly, exposure to paediatric clinical skills is defined as the proportion of students in a particular group who have had at least one opportunity to perform a clinical skills on a paediatric patient in any age group or in a specific age group, depending on the context.

In keeping with the aim of this study, data analysis was mainly descriptive in nature. This involved the calculation of frequencies and proportions for categorical data. The median and interquartile range was used as a measure of central tendency for any continuous variable that appeared asymmetrically distributed on visual inspection. Descriptive data were displayed using tables or charts, as appropriate.

One-way Analysis of Variance was used to compare mean exposure between academic years of study while dependence between these groups and paediatric emergency exposure was assessed using the Chi-square test of independence and Cramer's V statistic. The Chi-square test assumes a null hypothesis of independence between row and column variables in a contingency table, which may be rejected in the case of a p-value less than 0.05 (assuming that this is the value selected for α, as is conventionally the case). However this does not give any indication of the strength of dependence between the variables under consideration if the null hypothesis is rejected. In such cases, Cramer's V statistic (a symmetric measure of association) can give an indication of this, ranging between 0 (very weak dependence) and 1 (very strong dependence). Cramer's V statistic is only of relevance if the associated Chi-square test yields a result showing that the null hypothesis may be rejected. (Norusis, 2002). Odds ratios were used as an estimate of relative risk for exposure to paediatric emergency cases in various clusters of academic year groupings. SPSS (version 15.0, SPSS Science, Chicago, USA) was used for data analysis and $p < 0.05$ was considered significant for all hypothesis tests.

2.4. Ethical Considerations

Due to the retrospective nature of this study over a period spanning eight consecutive years, it was not possible to obtain consent from any of the patients or their guardians. Patient identity was protected as no identifying data were disclosed in this report and will not be disclosed in any other publication arising from this study. All data were treated as strictly confidential and all data files were password protected and encrypted on disk (AxCrypt version 2.0, Axantum Software AB, Sweden) when not being used for data manipulation or analysis.

Permission was obtained from the Department of Emergency Medical Care at the UJ to access data used in this study (Appendix C). The protocol for this study was approved by the Human Ethics Research Committee (Medical) at the University of the Witwatersrand on 28 August 2009 (clearance certificate M090804).

2.5. Conclusion

This chapter has provided a detailed explanation of the source of data for this study, and how these data were extracted and analysed. A background to EMDATA, the electronic clinical learning management information system used as the sole origin of data, was given along with a step-by-step account of the processes followed by students in collecting and capturing data during and after clinical learning. Although sources of potential error exist at two main points during data input, procedures established by the Department of Emergency Medical Care minimise the impact of these. Results arising from analysis of extracted data, as described above, will be presented in the next chapter.

CHAPTER 3: RESULTS

3.1. Introduction

This study aimed to retrospectively describe paediatric pre-hospital emergency care clinical learning data accumulated in an electronic clinical learning management information system over an eight-year period. Flowing from this aim were three main objectives: (i) to describe the exposure that NDEMC students had to paediatric emergency cases, (ii) to describe the exposure that NDEMC students had to a variety of paediatric emergency-related clinical skills and (iii) to assess the relationship between student academic year of study and exposure to paediatric emergency cases and clinical skills.

This chapter conveys the results of data analysis related to the objectives delineated above. Initially, characteristics of the paediatric emergency cases will be discussed. Student exposure to paediatric emergency cases will be described next, followed by a more detailed depiction of student experiences with regard to specific clinical skills and factors influencing this.

3.2. Characteristics of the Paediatric Emergency Cases

Although the focus of this study is on student experiences related to the practise of pre-hospital paediatric emergency care, this section begins with some results characterising the nature of the paediatric emergency cases themselves. This provides some contextual background against which to consider the nature of the students' experiences.

A total of 20,745 PCRs were entered into EMDATA between 1 January 2001 and 31 December 2008. Of these, 1,605 (7.7%) were paediatric cases, as defined on p. XV. An overview of age, gender and emergency type category distributions for these data are given in 3.2.1 below, followed by summary data on emergency case priorities and final outcomes of some of the more serious cases.

3.2.1. *Age Group, Gender and Emergency Type Distributions*

Age group category distributions for the 1,605 paediatric emergency cases are shown in Table 1 (age group definitions used are those given on p. XV). Children comprised almost two-thirds of the total number of cases, while infants accounted for a quarter and neonates slightly more than one-tenth.

Table 1: Age Category Distribution: All Cases

Paediatric Age Category	Count	%
Child	993	62%
Infant	409	25%
Neonate	203	13%
	1605	100%

In cases where the actual age (rather than the age category) of a patient is known, this is recorded in a separate database field. Summary data for recorded ages are shown in Table 2, indicating the number and proportion of cases where actual age was not recorded, and the median age and interquartile range for actual age in each category taken from available data.

Table 2: Recorded Age Data Summary: All Cases

Paediatric Age Category	Count	No Age Recorded§	Median Age	IQR
Child	993	43 (4.3%)	15.0 years	15.0; 16.0
Infant	409	216 (52.8%)	2.0 months	1.0; 3.0
Neonate	203	178 (87.7%)	0.0 days	0.0; 0.0
	1605	437 (27.2%)		

IQR = interquartile range; § = The age categories of all patients were known and recorded even though for some patients actual ages (in years, months or days) were not known.

The distribution of all cases across categories of gender is shown in Table 3.The ratio of close to 1.3:1 males to females seen here is also roughly approximated in each of the individual paediatric age categories, as shown in the 100% stacked bar chart of Fig. 1 (below).

Table 3: Gender Category Distribution: All Cases

Gender Category	Count	%
Male	912	57%
Female	693	43%
	1605	100%

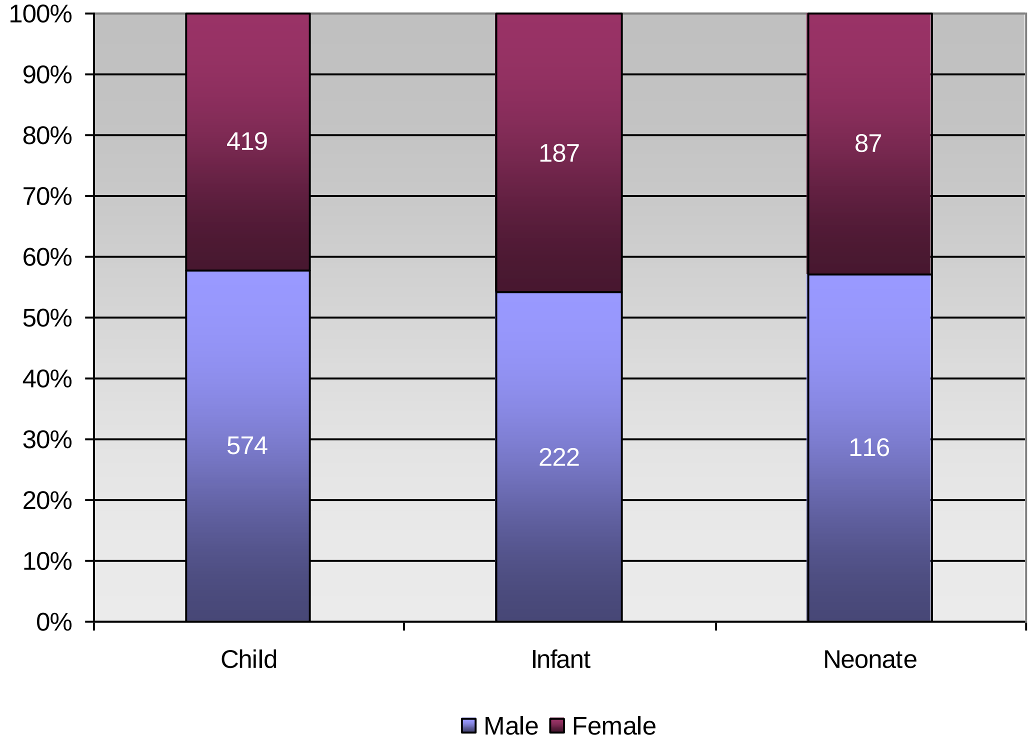


Figure 1: Gender Distribution Across Age Categories: All Cases

During input of PCR data, students are required to select an emergency type for each record. The emergency type is not a detailed descriptor of the patient's condition, but rather a broad depiction of the category of emergency or injury that best fits a given patient. Because the listing of emergency types is not exhaustive, an 'emergency not listed' option is also available. Students who select this option are required to enter a free text descriptor which then replaces the standard emergency type as part of that specific patient care record.

The student-assigned emergency types described above are grouped into broader emergency categories. This grouping is assigned by the EMDATA system and represents an additional table of emergency categories to which each of the emergency types maps (except 'emergency not listed'). Each of these categories in turn can be placed into a trauma (injury) or medical (non-injury) grouping. Of the 1,373 cases that were assigned emergency types by students (i.e. excluding all of the 'emergency not listed' cases), 832 (61%) were medical (non-injury-related) and 541 (39%) were trauma (injury-related). The top ten emergency category counts and proportions, comprising 87% of these 1,373 cases are listed in Table 4 below.

Table 4: Top 10 Emergency Categories

Emergency Category	Count	% [1]
Respiratory	191	16.0%
Musculo-skeletal Trauma	188	15.7%
General [2]	170	14.2%
Neurological	137	11.5%
Head Trauma	128	10.7%
General Trauma [3]	114	9.5%
Perinatal	75	6.3%
Gastro-intestinal	68	5.7%
Burns	63	5.3%
Cardiac [4]	61	5.1%
	1195	100%

1 = Proportion of top ten categories; 2 = Undifferentiated conditions, where the patient was categorised as such; 3 = Trauma to specific regions not listed, or to more than one region (polytrauma) including cardiac arrest caused by trauma; 4 = Includes cardiac arrest of any aetiology other than trauma.

Medical and trauma categories accounted for 493 (41%) and 702 (59%) respectively of the total top 10 emergency categories, a distribution very similar to that for all of the 1,373 cases discussed in the previous paragraph .

3.2.2. Priorities and Final Outcomes

Students are required to assign a priority to each PCR when they complete the associated documentation at the point-of-care. A priority is a numerical category conveying an impression of the urgency or seriousness of a given patient’s condition. Priority categories in common usage by emergency services in the Greater Johannesburg Metropolitan area, and used by students when assigning a priority to a PCR, are as follows:

Priority 1 (P1): A patient with an acutely limb- or life-threatening condition. There is usually an actual or imminent threat to the airway and often severe abnormalities of vital homeostatic functions such as pulmonary gas exchange, fluid, electrolyte and acid-base balance or cardiac rhythm and tissue perfusion.

Priority 2 (P2): A patient who has a potential limb- or life-threatening condition, but who is currently stable and able to compensate physiologically, with or without treatment such as supplemental oxygen, intravenous fluids or other medication, including intravenous analgaesia.

Priority 3 (P3): A patient who has a minor condition or injury and is currently stable and very unlikely to become unstable or deteriorate in the short term. These patients seldom require any more than very basic pre-hospital treatment.

Priority 4 (P4): A patient satisfying the conditions for declaration of death in the pre-hospital environment, according to advanced life support protocols published by the Health Professions Council of South Africa (HPCSA). (Professional Board for Emergency Care, 2006).

The priorities assigned to each PCR by students, in accordance with the categories defined above, are final priorities assigned when the patient is handed over at a receiving hospital or when care is terminated in the field. Table 5 shows the distribution of priorities for all 1,605 emergency cases.

Table 5: Patient Priority Distribution: All Cases

Patient Priority	Count	%
Priority 1	279	17%
Priority 2	735	46%
Priority 3	480	30%
Priority 4	111	7%
	1605	100%

The distribution of priorities across age group categories for all cases is shown in Fig. 2 below.

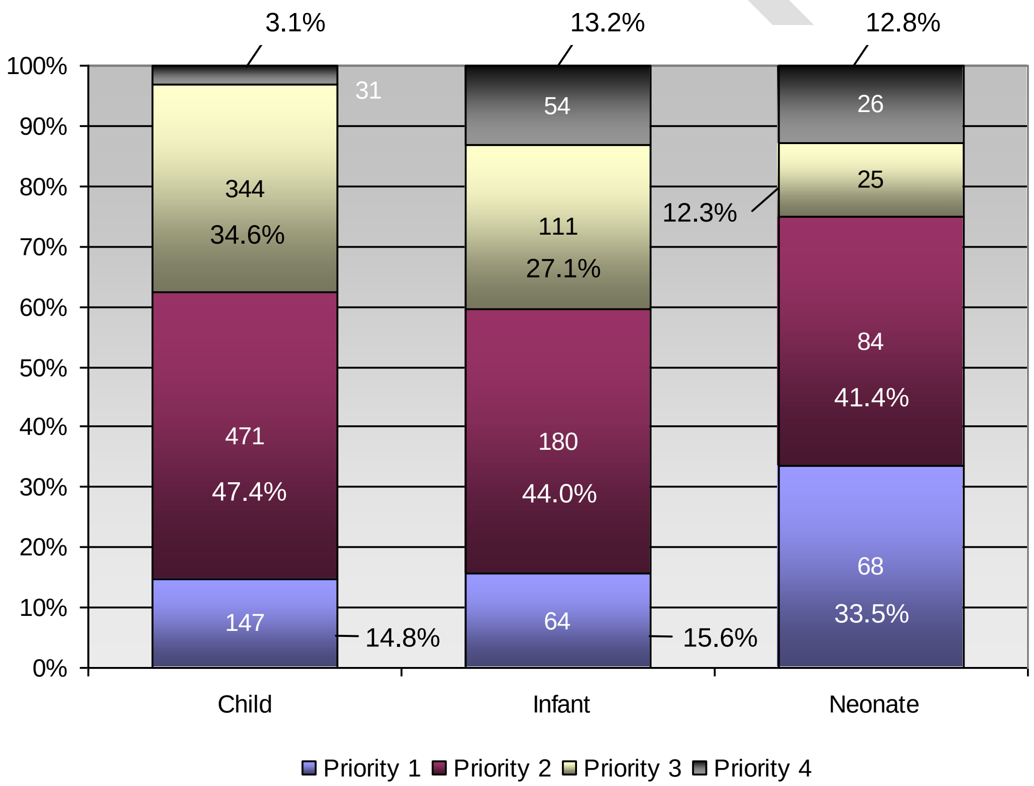


Figure 2: Priority Distribution Across Age Categories: All Cases

The proportion of P1 and P4 cases is smallest amongst children, but the proportion of infant and neonatal P4 cases is roughly three times that seen amongst children. In the neonatal age category, the proportion of P4 patients is very similar to that in the infant category, but the proportion of P1 patients is slightly more than double that seen in both the infant and child categories. Clearly, the greatest proportion of severely ill or injured patients encountered by NDEMC students during clinical learning is found in the youngest category by age.

For all P1 patients surviving to hospital admission, students are required to perform follow-ups until a final outcome for each patient is known. These data, together with pre-hospital mortality data, are shown in Table 6.

Table 6: Survival for P1 Cases with Follow-up Data

Survival Category	Count	%
Died Pre-hospital	23	11%
Died in the ED	19	9%
Died in the Ward/ICU	25	11%
Survived with Disability	37	17%
Survived without Disability	114	52%
	218	100%

ED = Emergency Department; ICU = Intensive Care Unit

Of all 279 P1 cases in Table 5, 218 (78.1%) had associated final outcome data, meaning that 61 (21.9%) were lost to follow-up. There may be several reasons for this including indeterminate outcomes at the time that students had to follow these patients up and hand in their PCRs, or difficulty in tracing patients and obtaining final outcome information once they had been admitted to hospitals. These outcome data suggest that roughly one-third of priority one patients seen by students during clinical learning die, and roughly one third of these deaths occur outside of the hospital.

The description of paediatric emergency cases given in 3.2.1 and 3.2.2 above reveals that NDEMC students completing clinical learning did not often encounter these patients in the pre-hospital environment. When they did, the majority of cases were older children falling into the P2 and P3 groupings, and most were the victims of respiratory disorders. When younger children were encountered, they tended to be more acutely ill or injured and had a greater pre-hospital mortality than older children. The following sections of this chapter investigate the exposure of students to paediatric emergency cases, and associated opportunities to perform clinical skills in more detail.

3.3. Student Exposure to Paediatric Emergency Cases

At the broadest level of analysis (dealt with in section 3.3.1) the specific context of patient contact is not detailed. The question asked is: ‘What proportion of students in a particular grouping had any contact with any number of paediatric patients in any context?’ At a finer-grained level of analysis (dealt with in section 3.3.2) two more detailed questions are asked: ‘With what frequency do those students who are exposed have contact with patients, and what is the condition (as determined by the priority) of the patients seen by those students who are exposed?’ Analysis of these two levels of student exposure to paediatric emergency cases follows below.

3.3.1. Student Exposure – One or More Cases

By calculating the proportion of students registered for clinical learning who entered one or more PCRs describing patients in each of the paediatric age groups, an estimate of exposure to paediatric emergency cases can be obtained. Box plots summarising these data over the eight year study period, grouped by academic year and patient age category, are shown in Fig. 3 (below).

The aggregated data presented in Fig. 3 clearly indicate that median exposure tended to decrease from the first to second year student groups in all age categories, but increased slightly from the second to third year student groups. In contrast to the general pattern identified above, median exposure of students to patients in the neonatal age group was greater in the third year student group than in any other.

Median paediatric emergency case exposure below 50% was seen in the neonatal age category for first year students and in both the infant and neonatal age categories for second and third year students. The greatest degree of variation between exposure in paediatric age categories occurred in the first year group and the least variation in the third year group.

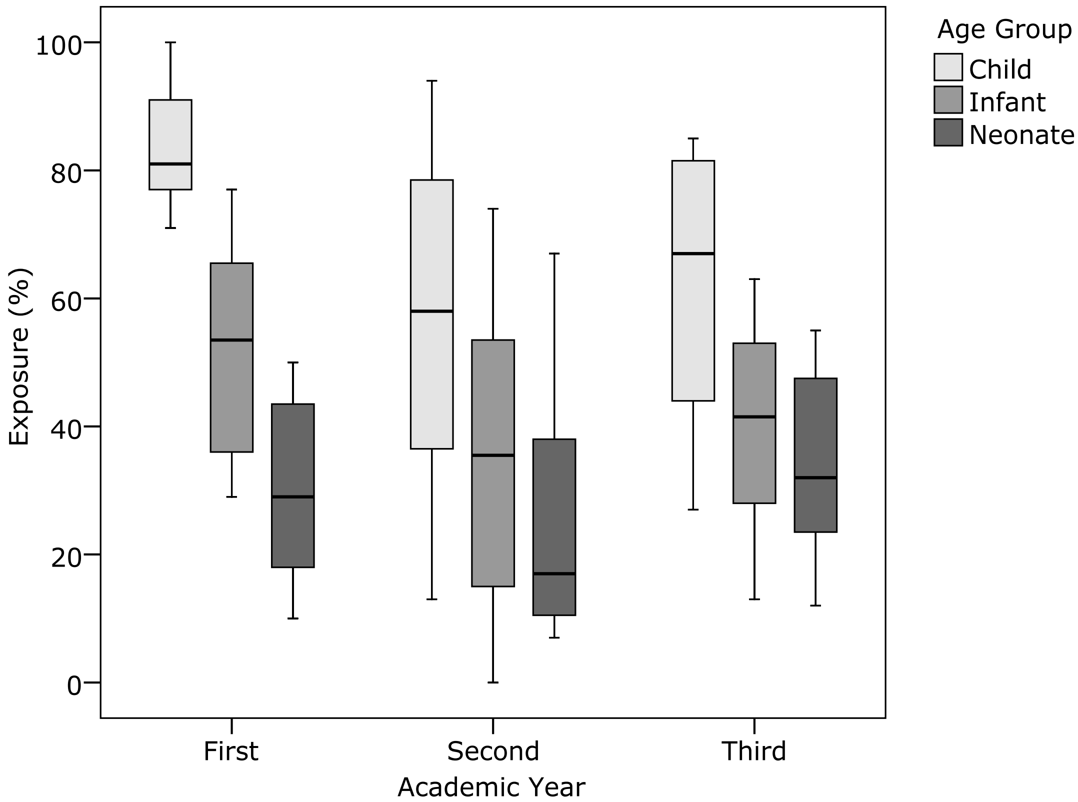


Figure 3: Student Exposure to Paediatric Emergency Cases: 2001-2008

When data in all patient age groups were pooled, every student in each academic year of study had some exposure to paediatric patients in at least one age group, with the exception of the second year groups in 2001, 2002, 2004 and 2008, and the third year group in 2001. The lowest exposure of all of these was the second year group in 2002, where only 45% had some exposure to patients from any paediatric age group.

The observations above do not take into consideration the priority of patients, nor the procedures carried out on them. Although a greater median proportion of first year students had contact with paediatric patients over the eight year study period, it is quite likely that these patients were not as severely ill or injured as the smaller proportion seen by second, and particularly by third year students. A more detailed analysis of both frequency of exposure and patient priority will follow in 3.2.2 below. In addition, section 3.4 and relevant subsections will detail the exposure of students to individual clinical skills.

3.3.2. Student Exposure – Frequency of Contact and Priority of Cases

In order to appreciate some of the more subtle differences in paediatric patient exposure amongst student groups, two levels of detail will be explored in this section. Firstly, frequencies of student contact with paediatric patients will be described. The previous section provided an answer to the question of how many students had *any* exposure to paediatric patients. This section asks the next logical question in summary form: ‘How many patient contacts did each of the exposed students have?’

The second level of detail given in this section will explore the nature of students’ exposure to patients. It will address the deficiency identified in the last paragraph of the previous section and give an indication of the quality of exposure, as judged by the priority of patients encountered.

Frequency of Student Exposure

In order to convey in summary form the frequency of patient contacts experienced by students, comparative histograms are presented for students in each academic year of study. The frequencies displayed are patient contacts aggregated for exposed students over the eight year study period, for each patient age category. These data are shown in Fig. 4 through to Fig. 6.

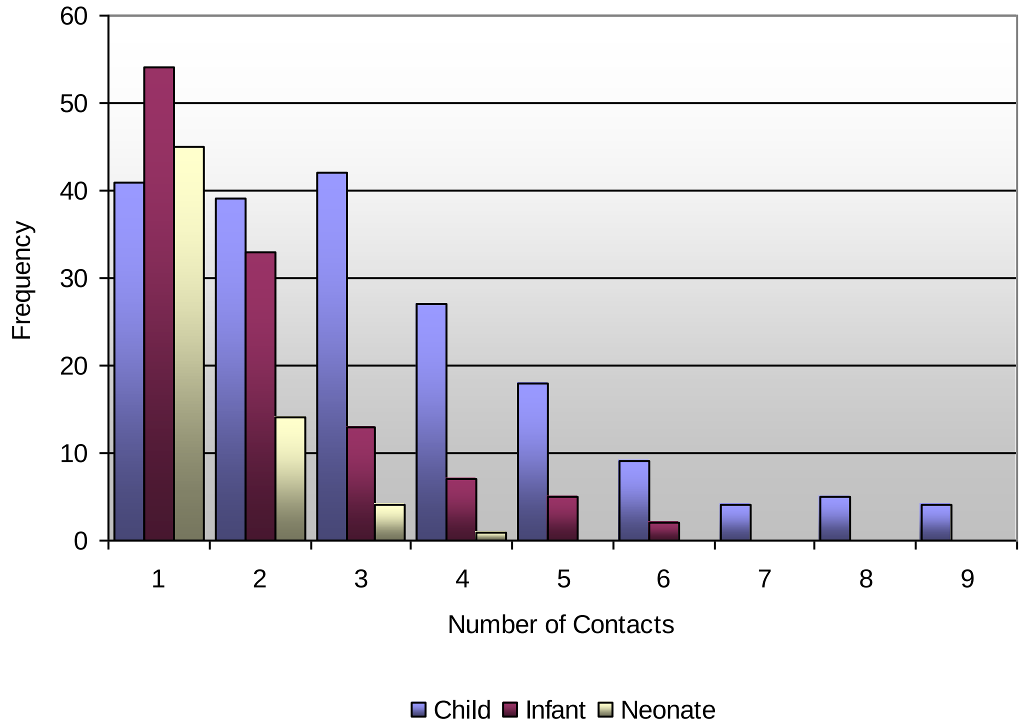


Figure 4: Comparative Histogram: First Year Patient Contacts:2001-2008

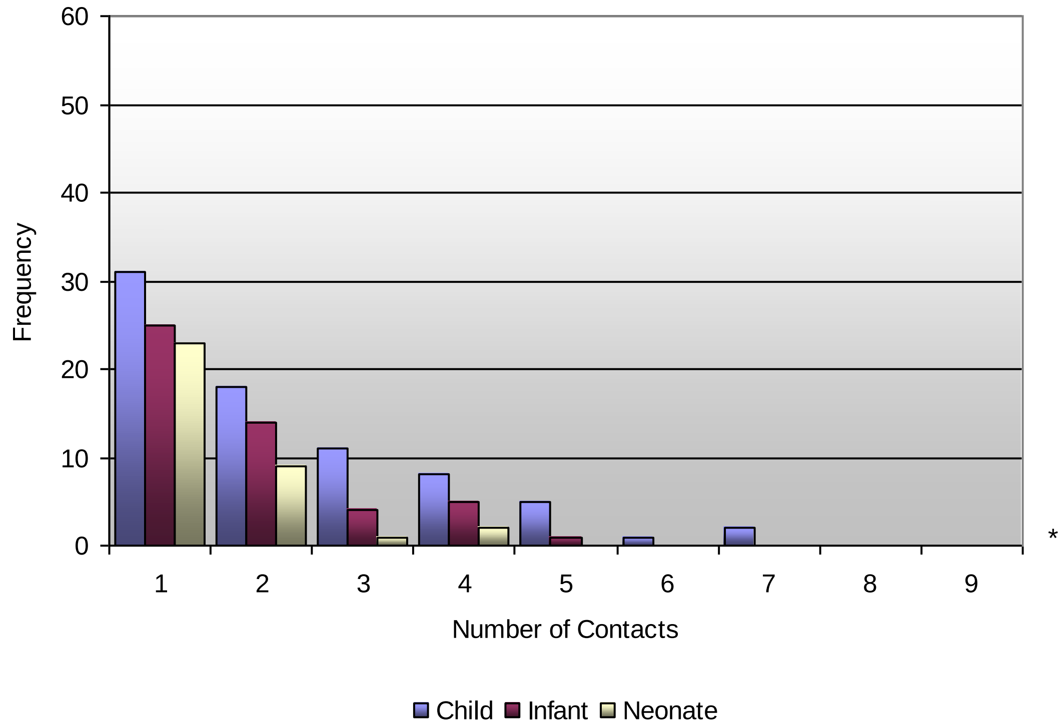


Figure 5: Comparative Histogram: Second Year Patient Contacts: 2001-2008
*One extreme value of 17 patient contacts has been omitted from this chart

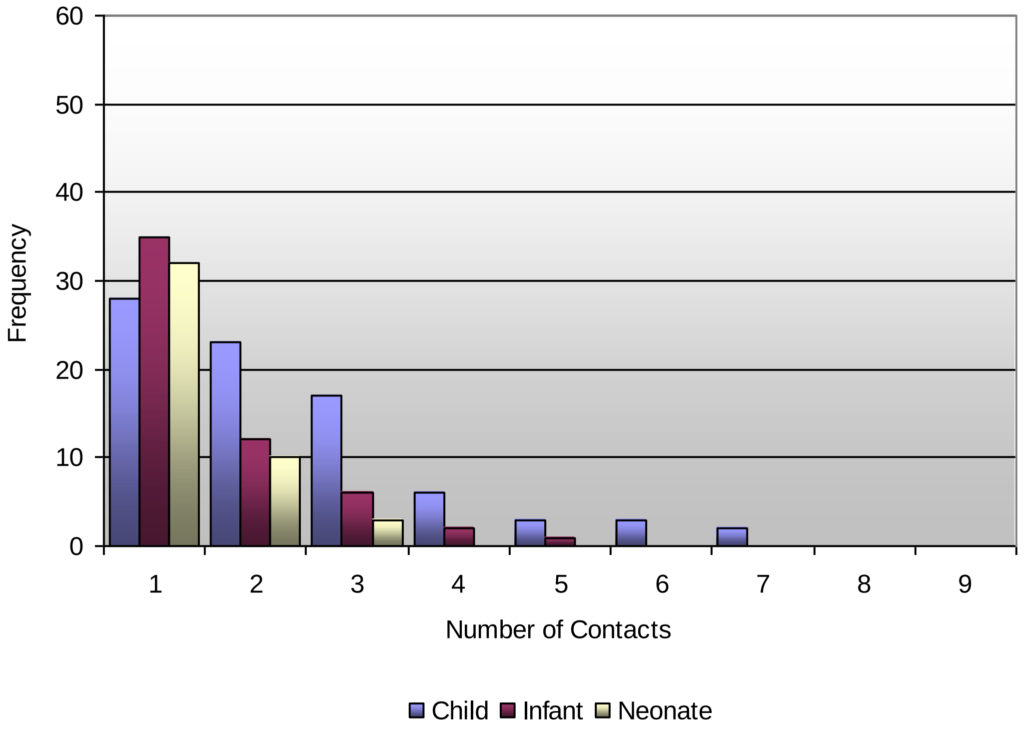


Figure 6: Comparative Histogram: Third Year Patient Contacts: 2001-2008

The frequency of patient contacts shown above follows similar patterns in first and third year. In the case of single contacts, in both years there are greater frequencies in the infant and neonatal age categories than in the child age category. For patient contacts greater than one, this pattern disappears and the infant and neonate frequencies are consistently less than those in the child age category. This latter pattern is seen in all categories of patient contact in the second year group. The median frequency of patient contact was 3, 2 and 1 in the first year child, infant and neonatal age categories respectively, and 2,1 and 1 in the child, infant and neonate age categories respectively in both second and third year groups.

There is a noticeably greater spread of patient contact categories and greater frequencies within each category in the first year group, compared to both the second and third year groups. As noted previously, in 3.3.1, the current form of analysis does not attempt to differentiate between more or less serious cases, and thus the greater frequency of multiple patient contacts per exposed student in first year may not necessarily translate into more valuable experience of emergency care practice amongst these students.

Priority of Cases

As described previously in categorising the priorities used by students to rank the seriousness of each patient, higher priority patients (i.e. smaller priority numbers) are sicker, less stable physiologically and require a greater variety and urgency of intervention. Although lower priority patients still require thorough assessment and appropriate treatment, the higher priority patients typically are associated with the most valuable clinical learning experience in emergency care.

In the previous section, patient contact frequency distributions were given for all students exposed to paediatric patients over the eight year study period. However these data do not shed any light on the nature of the patients that students were exposed to, nor the type of clinical learning experience that the involved students would have encountered. In order to better understand this, Fig. 7 shows the distribution of patient priority median frequencies by academic year over the eight year study period.

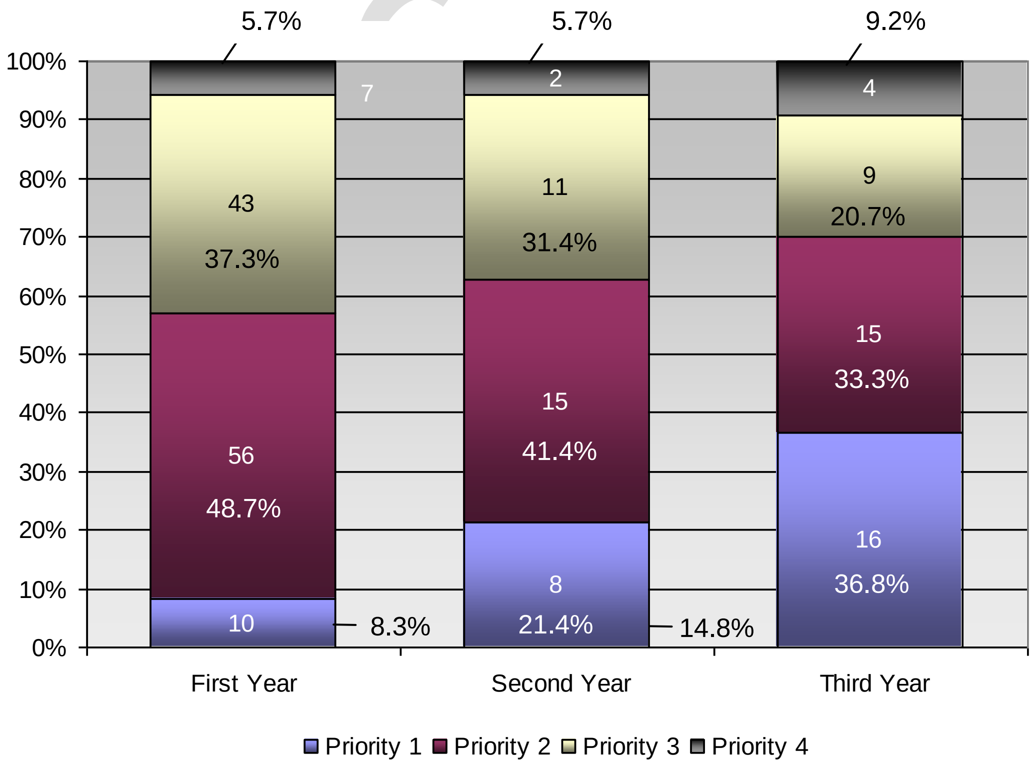


Figure 7: Priority Median Frequency Distribution Across Academic Years: All Patient Age Categories: 2001-2008

The proportion of P2 and P3 cases can be clearly observed to decrease progressively from first year through to third year, while the proportion of P1 cases increases more than four-fold from roughly 8% in first year to roughly 36% in third year.

3.4. Student Exposure to Paediatric Emergency Clinical Skills

The previous section focused on student exposure to paediatric emergency cases. Two views were taken – one more basic, describing exposure of any number and type, and one more in-depth, describing in more detail the frequency of exposure and priority of patients. A natural question, following the information presented above, is: ‘What was the nature of student experiences during these interactions?’ In other words, what were the characteristics of clinical skills performed by the students exposed to these paediatric emergency cases?

This section will detail the exposure of students to a variety of clinical skills. The clinical skills chosen represent a cross-section of important, and in many cases potentially life-saving, procedures that require repeated practice for safe and effective performance. In 3.4.1 below, some attention will be given to clinical assessment skills. This will be followed in 3.4.2 by a range of fairly invasive clinical skills employed in the treatment of a variety of emergency conditions.

3.4.1. Clinical Assessment Skills

History Taking

The ability to effectively take a structured medical history from a patient (or in the paediatric context, from a family member or care-giver) is an important clinical skill to learn. Much of the decision-making employed in determining treatment strategies is based on information derived from the history, together with observations obtained during the physical examination. Taking a history from paediatric patients requires consideration of many subtle differences in comparison to the adult case, and is a clinical skill that all students should ideally be able to practise under supervision a number of times. Table 7 shows the exposure of students in all academic years to opportunities to perform this skill over the eight year study period.

Table 7: Exposure and Frequency: History Taking

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	First	77.5	73.3; 90.0	4.0	2.0; 5.0
	Second	30.5	1.3; 64.2	2.0	1.0; 4;0
	Third	32.5	18.0; 44.0	1.0	1.0; 2.0
Infant	First	47.5	31.3; 62.3	2.0	2.0; 3.0
	Second	12.5	0.0; 34.25	1.0	1.0; 3.0
	Third	13.0	1.5; 22.8	2.0	1.0; 3.0
Neonate	First	17.5	12.3; 34.3	1.0	1.0; 2.0
	Second	6.5	1.3; 23.8	1.0	1.0; 1.0
	Third	5.5	1.3; 12.3	1.0	1.0; 2.0

IQR = interquartile range; [1] Median over the eight-year review period

Measurement of Vital Signs

Measurement and assessment of vital signs (such as heart rate, blood pressure, respiratory rate and arterial oxygen saturation) is a fundamental, yet crucially important, clinical skill in any patient care environment. This is true when vital signs are assessed both as a baseline determination of patient condition and more importantly, as a means of gauging changes in a patient's condition or response to treatment. As with history taking, there are important differences in vital signs measurement to be appreciated in paediatric patients and every student should ideally be able to practise this basic skill several times.

The pre-hospital environment, with noise, poor lighting and other limitations, presents unique challenges in the accurate performance of this skill and practice in this setting is thus very important. Table 8 shows the exposure of students in all academic years to opportunities to measure one or more vital signs over the eight year study period.

Table 8: Exposure and Frequency: Vital Signs

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	First	80.5	74.3; 89.0	3.5	2.0; 5.0
	Second	34.0	3.0; 59.0	1.5	1.0; 2.0
	Third	32.5	19.3; 40.3	1.0	1.0; 3.0
Infant	First	45.0	32.8; 63.0	2.0	1.0; 3.0
	Second	9.5	0.0; 36.3	1.5	1.0; 2.0
	Third	12.0	5.3; 22.8	1.0	1.0; 2.3
Neonate	First	20.0	13.5; 34.5	1.0	1.0; 2.0
	Second	6.5	1.3; 28.3	1.0	1.0; 1.0
	Third	9.5	5.3; 13.8	1.0	1.0; 2.0

[1] Median over the eight-year review period

In the student exposure to both clinical assessment skills shown in Table 7 and Table 8 above, a pattern similar to that observed in Fig. 3 is seen, with exposure being greatest in the first year group (in all paediatric age categories). Exposure in the second and third year groups is very similar and often follows Fig. 3's trend of marginally greater exposure in the third year group than the second year group.

The similarity between exposure statistics in Table 7 and Table 8, and in Fig. 3 is logical. Virtually every paediatric patient seen would have had a history taken (either from the patient or a parent or care-giver) and vital signs assessed, so it would be expected that the exposure of students to these skills would be similar to overall paediatric emergency case exposure. Instances where NDEMC students did not perform these skills even when they did have contact with paediatric patients could be due to other qualified practitioners performing them, although reasons for this are not discernable from the available data.

It is unfortunate that the youngest patients (in the neonatal age category), who present the greatest challenge in both history taking and vital signs assessment, are associated with the lowest student exposure to these skills. Even in the older patient age categories, median exposure is below 50% for all age categories in all years except the child age category in first year. Most of the time the small proportion of students exposed only get one opportunity to practise these important clinical assessment skills.

3.4.2. Airway Management and Ventilation Skills

Airway management and ventilation skills are considered the cornerstone of emergency care. In the most critically ill or injured patients, these skills are life-saving and take precedence over all others. Although apparently straightforward in theory, some of the airway management-related skills can be challenging to learn and perform at an acceptable level, particularly in the uncontrolled pre-hospital environment. For these reasons it is desirable for all students to have at least some opportunity to practice these skills under supervision on real patients, in an authentic setting.

Bag-valve-mask Ventilation

Bag-valve-mask (BVM) ventilation is considered a basic skill and is virtually always the first form of ventilation carried out in the case of an apnoeic or hypoventilating patient. This skill also plays an important part in preparation for more advanced forms of airway management, such as endotracheal intubation (ETI), by allowing pre-oxygenation of the patient for the period of apnoea associated with intubation. It is a crucial and life-saving fallback skill in cases where an endotracheal tube cannot be placed on a first or subsequent attempt. Table 9 (below) shows exposure of students in all academic years to BVM ventilation in all paediatric age categories.

As the data in Table 9 indicate, few students ever had an opportunity to perform this important clinical skill on a real patient. Median exposure is again greatest for first year students, however this is not by a very large margin compared to the median exposure of second year students. Those students fortunate enough to perform this skill generally only have an opportunity to do so once.

Table 9: Exposure and Frequency: Bag-valve-mask Ventilation

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	First	8.0	5.5; 12.0	1.0	1.0; 1.0
	Second	5.0	0.0; 9.3	1.0	1.0; 1.8
	Third	1*	-	-	-
Infant	First	4.0	0.0; 9.0	1.0	1.0; 2.0
	Second	2.3	0.0; 16.5	1.0†	-
	Third	1*	-	-	-
Neonate	First	4.0	0.8; 8.3	1.0†	-
	Second	5.5	0.0; 12.3	1.0	1.0; 2.0
	Third	-	-	-	-

IQR = interquartile range; * Not a median, only one case recorded for the 2001-2008 review period; † No interquartile range given because all frequency values were the same; [1] Median over the eight-year review period

The above data show that BVM ventilation has only been performed by a third year student on two occasions in the entire eight year study period. This is extremely low exposure (although the other academic years are not much better in this age category) and may be influenced by the fact that third year students typically take the lead in patient care at ALS level. This means that they are usually expected to delegate more basic skills to other less-qualified practitioners who may be present and focus on ALS skills such as endotracheal intubation or drug administration. Nevertheless, a student who has progressed through first and second year with the low median exposure statistics shown above may only rarely have had any experience with a clinical skill that he or she is delegating to someone else assumed to be “less experienced”.

Endotracheal Intubation

Endotracheal intubation (ETI) is still regarded as the gold standard of airway management. For this reason it is an important clinical skill for students to be exposed to, and one that requires repeated practice for the attainment of competence. Although first taught in the second year of the NDEMC, practice of ETI involving paediatric patients is only introduced in third year. Table 10 shows median ETI exposure amongst third year students in all paediatric age categories.

Table 10: Exposure and Frequency: Endotracheal Intubation

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	Third	14.5	12.3; 22.0	1.0	1.0; 1.0
Infant	Third	14.0	2.3; 19.8	1.0	1.0; 1.8
Neonate	Third	5.0	0.0; 18.8	1.0	1.0; 1.0

IQR = interquartile range; [1] Median over the eight-year review period

In comparing Table 9 and Table 10 above, perhaps the most noticeable difference is the lower exposure of third year students to the more basic clinical skill of BVM ventilation. Although it is possible that students having progressed through first and second year may have had an opportunity to practise BVM ventilation, the probability of this is small given the very low exposures. Although median exposure to cases requiring ETI was relatively higher than for BVM ventilation, this is still generally low and typically involves a single opportunity to intubate amongst those students who were exposed.

Drug-assisted Endotracheal Intubation

In cases where paediatric patients require ETI but will not tolerate laryngoscopy and placement of an endotracheal tube, sedation is required in order to facilitate this procedure. Advanced life support protocols published by the HPCSA currently advocate the use of intravenous midazolam for this purpose, although in practice midazolam is frequently used together with morphine for sedation in order to facilitate ETI. Table 11 shows median drug-assisted ETI exposure amongst third year students in all paediatric age categories. Paediatric ETI cases where either midazolam alone, or midazolam and morphine were used for sedation prior to ETI were included.

Table 11: Exposure and Frequency: Drug-assisted Endotracheal Intubation

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	Third	8.0	1.3; 11.8	1.0†	-
Infant	Third	0.0	0.0; 10.5	1.0†	-
Neonate	Third	-	-	-	-

IQR = interquartle range; † No interquartile range given because all frequency values were the same; [1] Median over the eight-year review period

The absence of neonatal drug-assisted ETI over the eight year study period is in keeping with the expectation that this form of treatment would hardly ever be needed in this age category, particularly in the pre-hospital environment. Although median exposure in the infant age category was 0%, six students each had one opportunity to perform this clinical skill during the study period (accounting for an interquartile range of 10.5%). Median exposure of 8% in the child age category, when compared to data in Table 9, suggests that roughly half (8% exposure) of all ETI attempts in children represented in this study (15% exposure, Table 10) were drug-assisted.

3.4.3. Venous Access

Second to the primacy of airway management and ventilation-related clinical skills in emergency care, comes venous access. Having access to the circulation in emergencies may be important for both administration of fluid in volume and for administration of intravenous medication.

In some cases, such as in drug-assisted ETI, the need for venous access precedes and is a requirement for definitive airway management. In other cases, such as haemorrhagic shock or dehydration, venous access may occur after management of the airway, but is often the greater focus of attention.

Students in the NDEMC programme are taught a variety of paediatric venous access techniques including peripheral venous access, femoral venous access and external jugular venous access (strictly speaking, a peripheral vein but categorised separately for the purposes of this study). In addition, intraosseous line placement is also taught as a method of gaining access to the venous circulation. Teaching and supervised practice of venous access techniques in paediatric patients is restricted to third year students.

No instances of femoral venous access or external jugular access performed by NDEMC students under supervision during clinical learning were identified over the eight year study period. Table 12 shows exposure of third year students to the clinical skill of peripheral venous access in all paediatric age categories.

Table 12: Exposure and Frequency: Peripheral Venous Access

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	Third	16.0	8.3; 25.0	1.0	1.0; 1.8
Infant	Third	0.0	0.0; 5.8	1.0†	-
Neonate	Third	0.0	0.0; 5.0	1.0†	-

IQR = interquartile range; † No interquartile range given because all frequency values were the same; [1] Median over the eight-year review period

Three students had opportunities to practise peripheral venous access on infants, and four students has similar opportunities in the neonatal age category during the eight year study period. Exposure of students to venous access in children was better, although still generally low and limited to one opportunity in the majority of cases. The lack of exposure of third year students to this clinical skill in younger patients, particularly those in the neonatal age category, can perhaps be better understood when considered in conjunction with the data contained in Table 13, (below) which summarises exposure of the same group of students to the clinical skill of intraosseous access.

Table 13: Exposure and Frequency: Intraosseous Access

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	Third	*	*	*	*
Infant	Third	0.0	0.0; 12.5	1.0	1.0; 2.0
Neonate	Third	6.0	1.3; 8.5	1.0†	-

IQR = interquartile range; * A single student performed this skill twice in this age group in 2006. † No interquartile range given because all frequency values were the same; [1] Median over the eight-year review period

As would be expected, this clinical skill was performed predominantly on the youngest category of patients, explaining the very small number of peripheral venous access attempts in this age category shown in Table 12. Although the median exposure for intraosseous access in the infant age category was 0%, eight students did perform the skill in this age category over the eight year study period, with three of them performing it twice. In the neonatal age category, performance of the skill was more dispersed, occurring in six of the eight years of the study period, but no student had more than one opportunity to perform the skill.

3.4.4. Administration of Medications

Related to intravenous access as a clinical skill is the administration of medications. Advanced life support protocols published by the HPCSA (Professional Board for Emergency Care, 2006) endorse the use, for specific indications, of 31 medications in pre-hospital emergency care, many of which are applicable to a wide range of paediatric emergency conditions. Many of the medications used in this context carry potentially serious adverse effects and require careful patient assessment and clinical decision-making for safe and effective use. Added to this is the complexity of dosage determination for paediatric patients.

Although the psychomotor skill of physically administering medication is straight-forward, the ability to make the correct decision regarding administration and dosage of a potentially dangerous medication, in an authentic environment with many distractions, is not.
Table 14 shows exposure of third year students to the clinical skill of medication administration in all paediatric age categories. Only data related to third year students has been summarised because, with the exception of medical oxygen which is also classified as a medication, only these students are allowed to administer medications to paediatric patients under supervision during clinical learning.

Table 14: Exposure and Frequency: Administration of Medications

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	Third	47.0	26.8; 55.0	4.5	1.3; 7.5
Infant	Third	26.0	19.3; 31.3	2.5	2.0; 4.0
Neonate	Third	22.5	16.0; 31.3	1.5	1.0; 2.0

IQR = interquartile range; [1] Median over the eight-year review period

Counts and proportions of the medications administered in Table 14 are shown in Table 15 (below) . When assessing these data it is obvious that the majority of exposure is accounted for by the administration of oxygen. Although playing an important part in the acute care of any patient, oxygen is also the easiest and safest medication to administer. Although a more detailed analysis is not given here, it is important to note that the medications listed in Table 15 are not mutually exclusive. Virtually all of the patients receiving one of the intravenous medications also received supplemental oxygen.

With the exception of oxygen, the top five medications in Table 15 reflect the prevalence of injury, respiratory disorders and seizures as emergencies encountered by students (in this case third year students specifically), in keeping with the data presented in Table 4.

Table 15: Counts and Proportions: Medications Administered to Paediatric Patients

Medication [1]	**Count**	**%** [2]
Oxygen (all modes of administration)	138	43.9%
Morphine	55	17.5%
Adrenaline	53	16.9%
Midazolam	41	13.1%
Beta-2 Stimulants	9	2.9%
Diazepam	7	2.2%
Atropine	5	1.6%
Ipratropium	2	0.6%
Sodium Bicarbonate	1	0.3%
Oral Glucose	1	0.3%
50% Dextrose	1	0.3%
Adenosine	1	0.3%
	314	100%

[1] All medications given intravenously, except oxygen, beta-2 stimulants and oral glucose; [2] Proportion of total medications listed

3.4.5. Cardiac Arrest-related Clinical Skills

Paediatric cardiac arrest, as defined on p. XII, accounted for 55 of the 20,745 cases (0.3%) in EMDATA over the eight-year study period. Given the rarity of these cases, it follows that student exposure to the cases themselves and clinical skills associated with them will be infrequent. Although paediatric cardiac arrest cases occur relatively infrequently in the pre-hospital environment and are generally associated with a poor outcome, resuscitation under such circumstances is complex. A very specific sequence of clinical procedures must occur in response to varying clinical and electrocardiographic cues, requiring rapid clinical decision making and application of treatment algorithms.

Although extensive use is made of simulation in teaching NDEMC students to manage cardiac arrest resuscitation, many of the most challenging aspects of this are not fully appreciated without exposure to real cases. Consequently, it is desirable for all students to have as many opportunities as possible to manage a cardiac arrest resuscitation and perform clinical procedures in this context.

Cardiac Arrest Exposure

Table 16 summarises the exposure of NDEMC students in all three academic years to paediatric cardiac arrest cases. These data are merely an indication of contact with paediatric cardiac arrest cases without consideration of specifically what the exposed students did during this time.

Table 16: Exposure and Frequency: Paediatric Cardiac Arrest Cases

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	First	3.0	0.0; 4.5	1.0†	-
	Second	0.0	0.0; 4.8	1.0†	-
	Third	0.0	0.0; 0.0	1.0†	-
Infant	First	3.0	0.0; 4.8	1.0†	-
	Second	5.5	0.0; 11.3	1.0	1.0; 1.0
	Third	8.0	6.0; 18.3	1.0	1.0; 1.5
Neonate	First	0.0	0.0; 3.8	1.0*	-
	Second	2.5	0.0; 12.0	1.0†	-
	Third	0.0	0.0; 5.8	1.0†	-

IQR = interquartile range; † No interquartile range given because all frequency values were the same; * Not a median, only one case recorded for the 2001-2008 review period; [1] Median over the eight-year review period

Despite the importance of clinical exposure to paediatric cardiac arrest resuscitation, the data in Table 16 show that this is a very uncommon occurrence. Median exposures of 0% in the second and third year group in the child age category were associated with two cardiac arrest cases in the eight year study period each. Median exposures in the first and third year groups in the neonatal age category were associated with one and five cardiac arrest cases respectively in the eight year study period. With the exception of five students, all those fortunate enough to experience a real paediatric resuscitation did this only once.

Clinical Skills

The most obvious clinical skill of importance in cardiac arrest resuscitation is cardiopulmonary resuscitation (CPR). Although easy enough to be taught to members of the lay public in a few hours, CPR is one clinical skill without which no resuscitation effort would ever stand a prospect of success and is therefore a critical skill in this context. Table 17 shows student exposure to the clinical skill of CPR in all paediatric age categories.

Table 17: Exposure and Frequency: Cardiopulmonary Resuscitation

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	First	0.0	0.0; 2.25	1.0†	-
	Second	0.0	0.0; 0.0	1.0*	-
	Third	-	-	-	-
Infant	First	0.0	0.0; 3.8	1.0†	-
	Second	6.0	1.3; 10.0	1.0	1.0; 1.3
	Third	-	-	-	-
Neonate	First	0.0	0.0; 0.0	1.0*	-
	Second	0.0	0.0; 3.8	1.0*	-
	Third	-		-	-

IQR = interquartile range; † No interquartile range given because all frequency values were the same; * Not a median, only one case recorded for the 2001-2008 review period; [1] Median over the eight-year review period

As in the case of BVM ventilation (Table 9), third year students did not perform CPR once in any of the paediatric age categories. This is most likely due to the focus on ALS procedures at this level, with more basic procedures delegated to other practitioners. While this is not incorrect, it leaves only exposure in first and second year as a possible source of experience for this important clinical skill, exposure that in the median seldom exceeds a handful of students each year.

Several other clinical skills are important within the context of cardiac arrest resuscitation. These include ETI, venous access (both previously described in a more general sense) and defibrillation. Isolation of ETI in cardiac arrest cases, as a subset of the data discussed above, revealed the data shown in Table 18 below.

Table 18: Exposure and Frequency: Cardiac Arrest-related Endotracheal Intubation

		Exposure (%)		Frequency	
Age Category	Academic Year	Median[1]	IQR	Median[1]	IQR
Child	Third	-	-	-	-
Infant	Third	5.0	0.0; 12.5	1.0	1.0; 2.0
Neonate	Third	0.0	0.0; 3.8	1.0†	-

IQR = interquartile range; † No interquartile range given because all frequency values were the same; [1] Median over the eight-year review period

Only one instance of venous access in a cardiac arrest case could be found and only one patient in the eight year study period was defibrillated.

The low exposure of all students to cardiac arrest resuscitation-related clinical skills is undoubtedly related to the low overall prevalence of these cases in the eight year study period (0.3%). However, this effect may be worsened by consideration of the fact that not all cardiac arrest cases encountered during clinical learning will be resuscitated. Although non-resuscitated cardiac arrest cases still represent a learning experience for the student (e.g. the correct procedure to be followed in declaring a patient dead), they will obviously not be associated with opportunities to practise the clinical skills referred to above.

3.5. Relationship Between Academic Year of Study and Exposure to Paediatric Emergency Cases

The preceding results have painted a picture of what is generally a low exposure amongst NDEMC students to paediatric emergency cases over a study period of eight consecutive years. Although there is no objective standard against which to judge the adequacy of such exposure, the ideal educational view would be for every student to have at least some exposure to these cases. The available data show that this is not the case and that median exposure in most academic years and paediatric age categories is below 50%. The same can be said for most of the clinical skills analysed above, particularly the more invasive ones.

One pattern emerging from the descriptive data dealt with thus far is the difference in exposure to paediatric emergency cases, and clinical skills, that occurs over different academic year groupings. Although there are consistently more first year than second and third year students over the eight year study period, exposure is determined as a proportion of each grouping, cancelling out the effect of larger groups on this statistic. Thus the first question of interest is whether there is a significant difference in mean exposure to paediatric emergency cases between the academic years, when the paediatric age categories are considered both together and in isolation.

Exposure data from all eight years of the study period were pooled and found to be normally distributed (Kolmogorov-Smirnov $Z = 0.763$, $p = 0.605$). Thus in order to investigate the question stated above and compare mean exposure between the three academic years, One-way Analysis of Variance (ANOVA) was used with exposure to paediatric emergencies as the dependent variable and year of study as the independent variable. Initially, exposure data from all paediatric age groups were pooled and ANOVA performed on this entire data set, then ANOVA was performed separately on exposure data from each paediatric age category. Descriptive exposure data and results of ANOVA are shown in Tables 19 and 20 (below).

Table 19: Mean Paediatric Emergency Case Exposure by Age Category

		Exposure (%)	
Paediatric Age Category	Academic Year	Mean	95% CI for Mean
All	First	55.25	44.08; 66.42
	Second	39.17	27.55; 50.78
	Third	45.46	36.33; 54.58
Child	First	83.63	75.39; 91.86
	Second	56.63	33.08; 80.17
	Third	62.13	42.92; 81.33
Infant	First	52.00	37.21; 66.79
	Second	35.25	13.68; 56.82
	Third	40.13	26.11; 54.14
Neonate	First	30.13	17.34; 42.91
	Second	25.63	7.89; 43.36
	Third	34.13	21.47; 46.78

95% CI = 95% confidence interval

Results in Table 20 (below) show that exposure did not differ significantly between academic years in any of the groupings.

Table 20: One-way Analysis of Variance Results

Paediatric Age Category	df	F	p-value
All	2	2.460	0.093
Child	2	3.445	0.051
Infant	2	1.414	0.265
Neonate	2	0.475	0.628

df = degrees of freedom

A second question of interest related to the differing distribution of exposure over academic years observed in the descriptive analysis is whether there is any dependence between academic year of students and exposure to paediatric emergency cases. In other words, does exposure to these cases depend in some way on being in a specific academic year? In order to assess these relationships the Chi-square test of independence was used, together with a symmetric measure of association (Cramer's V statistic) in order to determine the strength of any significant relationships. Counts of nominal exposure and academic year data are shown in the contingency table below (Table 21), grouped by paediatric age category. Chi-square test results and symmetric measures are shown in Table 22.

Table 21: Contingency Table: Academic Year x Paediatric Emergency Case Exposure

		Academic Year		
Paediatric Age Category	Exposure	First	Second	Third
All	Yes	366 (24.5%)	159 (10.7%)	177 (11.9%)
	No	334 (21.7%)	234 (15.7%)	231 (15.5%)
			Total	1491
Child	Yes	189 (38.0%)	76 (15.3%)	83 (16.7%)
	No	41 (8.2%)	55 (11.1%)	53 (10.7%)
			Total	497
Infant	Yes	113 (22.7%)	49 (9.9%)	49 (9.9%)
	No	117 (23.5%)	82 (16.5%)	87 (17.5%)
			Total	497
Neonate	Yes	64 (12.9%)	34 (6.8%)	45 (9.1%)
	No	166 (33.4%)	97 (19.5%)	91 (18.3%)
			Total	497

Table 22: Chi-square Test Results

Paediatric Age Category	Chi-square Statistic	df	p-value	Cramer's V
All	19.005	2	0.001	0.113
Child	30.415	2	< 0.001	0.247
Infant	7.861	2	0.020	0.126
Neonate	1.844	2	0.398	-

df = degrees of freedom

The results contained in Tables 21 and 22 show a significant dependence between academic year and exposure to paediatric emergency cases when all paediatric age categories are considered together, and in the child and infant age categories when these are considered separately. Specifically, proportions contained in Table 21 clearly show that the exposure of first year students is roughly twice that of second or third year students. Despite the significance of this result, Cramer's V statistic suggests only a weak degree of dependence.

In order to assess the nature of this relationship and convey the magnitude of this in a different way, the relative risk of being exposed to one or more paediatric emergency cases was calculated for first year and non-first year groups. These results are shown in Table 23.

Table 23: Odds Ratios: Paediatric Emergency Case Exposure

Category	Odds Ratio	95% CI for Odds Ratio
Odds Ratio for Exposed (Yes/No)	1.563	1.273; 1.919
For First Year Group	1.270	1.138; 1.417
For Other Academic Years	0.812	0.737; 0.895

95% CI = 95% confidence interval

Although the concept of relative risk is considered here, the design of this study is retrospective and under these circumstances the odds ratio provides a good estimate for the relative risk. (Agresti, 1996:25). Results in Table 23 demonstrate that differences in occurrence of exposure between first year and non-first year students are significant (the 95% confidence intervals do not contain one), and that the odds of first year students being exposed to paediatric emergency cases were 1.3 times greater than for non-first year students.

Earlier in this chapter the observation was made that although first year students had greater general exposure to paediatric emergency cases, the subset of patients to which they were exposed tended to be older and less severely ill or injured. In order to examine this pattern, the data analysis methods used for all paediatric emergency cases above were repeated for the P1 subset of emergency cases. The aim was to determine whether a significant relationship existed between exposure and academic year when only the most seriously ill or injured patients were considered, and if so, what the nature and magnitude of that relationship was. These results are shown in Tables 24 and 25 below.

Proportions displayed in the contingency table (Table 24) indicate that when exposure is limited to the P1 subset of patients, third year students generally have the greatest exposure, first years slightly less and second years the lowest exposure. This relationship was significant when data from all paediatric age categories were pooled, and in each separate age category.

Table 24: Contingency Table: Priority 1 Academic Year x Paediatric Emergency Case Exposure

		Academic Year		
Paediatric Age Category	Exposure	First	Second	Third
All	Yes	78 (5.2%)	56 (3.8%)	99 (6.6%)
	No	612 (41.0%)	337 (22.6%)	309 (20.7%)
			Total	1491
Child	Yes	45 (9.1%)	27 (5.4%)	46 (9.3%)
	No	185 (37.2%)	104 (20.9%)	90 (18.1%)
			Total	497
Infant	Yes	17 (3.4%)	15 (3.0%)	23 (4.6%)
	No	213 (42.9%)	116 (23.3%)	113 (22.7%)
			Total	497
Neonate	Yes	16 (3.2%)	14 (2.8%)	30 (6.0%)
	No	214 (43.1%)	117 (23.5%)	106 (21.3%)
			Total	497

Once again, although significant, Cramer's V statistic in all age categories suggests a weak association (Table 25). Relative risk, again conveyed in the form of odds ratios, shows that students in other academic years (principally third year) are roughly twice as likely as first year students to be exposed to P1 paediatric emergency cases (Table 26).

In summary, the results of data analysis presented above show that, although there is no significant difference between mean exposure in the three academic years of study, there is a significant dependence between these variables. This dependence is weak however, with first year students being slightly more likely to experience exposure to paediatric emergency cases.

Table 25: Chi-square Test Results: Priority 1 Cases

Paediatric Age Category	Chi-square Statistic	df	p-value	Cramer's V
All	33.432	2	< 0.001	0.150
Child	10.560	2	0.005	0.146
Infant	7.898	2	0.019	0.126
Neonate	18.685	2	< 0.001	0.194

Table 26: Odds Ratios: Priority 1 Paediatric Emergency Case Exposure

Category	Odds Ratio	95% CI for Odds Ratio
Odds Ratio for Exposed (Yes/No)	0.531	0.396; 0.713
For First Year Group	0.688	0.569; 0.832
For Other Academic Years	1.295	1.165; 1.440

95% CI = 95% confidence interval

When the priority of these cases is taken into consideration, and data representing the highest priority alone are analysed, the results show a change with non-first year (predominantly third year) students being almost twice as likely to be exposed to these cases. This increased likelihood of exposure to more serious cases in latter years of the NDEMC programme is desirable because it is during this time that the associated in-depth learning of paediatric emergency care theory and practice occurs. Exposure of first years to paediatric emergency cases is also appropriate because most of them are older children and less seriously ill or injured, providing a more staid introduction to paediatric emergency care with less invasive procedures during this period.

3.6. Conclusion

This chapter has given a detailed account of the study results. General characteristics of the paediatric patient population included in the sample have been presented in order to provide an overview of the context in which clinical learning took place. Exposure of students to paediatric emergency cases was summarised in the form of median exposure for each academic year of study and each paediatric age category. Frequency of exposure, for those students exposed to these cases, was also presented. Exposure generally appeared low, particularly with regard to younger patients, for students in all academic years. Although first year students generally had the greatest exposure, this involved predominantly older and less seriously ill or injured patients.

Exposure to various clinical skills was also presented in this chapter. With the exception of assessment-related clinical skills (history taking and vital signs assessment), exposure to most other clinical skills also appeared low with the majority of students in a given year having no exposure and those with exposure mostly having one or two opportunities to perform the majority of clinical skills. No difference was identified between mean exposure in the three academic years of study, but a significant relationship between some academic years of study and exposure to emergencies in some patient age categories was identified. The odds of exposure to paediatric emergency cases were greater for first year students overall, but greater for second and third year students when analysis was limited to the most seriously ill or injured patients. Discussion of these results is presented in the following chapter.

CHAPTER 4: DISCUSSION

4.1. Introduction

In accordance with the aim of and objectives this study, UJ NDEMC student exposure to paediatric emergency cases and related clinical skills has been described. The relationship between academic year of study and exposure to paediatric emergency cases has been investigated and quantified. These results were presented in the previous chapter.

In this chapter, a discussion is presented in which comments on the results are given. These findings are contextualised by comparison to published data of a similar nature, where this is available and relevant. Limitations of the study will be stated before recommendations derived from the results and discussion are given, followed by concluding remarks.

4.2. Exposure of Students to Paediatric Emergency Cases

Results conveyed in Chapter 3 show that median exposure over the eight year review period was only above 50% in all three academic years of study in the case of the child age category. It was below 50% in all three academic years in younger patients, and dropped as low as 18% in the second year neonate age category. First year students proportionally had the greatest median exposure in all age groups except that of the youngest patients (neonates), where third years had the greatest exposure.

The preponderance of first year student exposure to older patients (those in the child age category) was reinforced by the comparatively high number of individual patient contacts, compared to other age categories and other years of study. Some first year students saw up to nine children in one year, compared to no more than four neonates. Most second and third year students saw no more than one patient in each of the younger age categories (infant and neonate) per year.

Naturally, from an experiential point of view, it is not just numbers of patient contacts that matter, but the acuity of those patients and the opportunities related to this in terms of clinical skills, reasoning and decision-making. As the results in Chapter 3 show, the vast majority of patients seen by first year students were of a lower acuity (P2 and P3). This proportion of lower acuity patients decreased through second and into third year, where roughly one third of patients seen by students were P1s (Fig. 7).

The tendency for first year students to see more patients, but of lower acuity, and third year students to see fewer patients, but of higher acuity (with second year student lying between these two extremes) is a function of the way these students' clinical learning is organised. First year students tend to be placed with BLS personnel at the EMSs where they complete their clinical learning time. These personnel (and students) are typically despatched to a larger volume of lower priority incidents (typically P2 and P3). Third year students work exclusively with ALS personnel during clinical learning, who are normally only despatched to incidents involving P1 patients.

The arrangement of clinical learning described above is in line with the focus on paediatric emergency care in the third year of the NDEMC. First and second year students have some exposure to these patients and have the opportunity to interact with them in what is most often the more relaxed environment of a non-life-threatening condition. The focus of these interactions is not complex clinical reasoning or invasive clinical skills, but rather becoming comfortable with paediatric interaction and clinical assessment.

Third year students are required to practise paediatric emergency care at ALS level and in addition to being able to perform accurate and rapid clinical assessment of these patients, they are expected to perform invasive clinical skills (such as intravenous and intraosseous access, or endotracheal intubation), demonstrate higher-level clinical reasoning abilities and problem-solve effectively. The larger proportion of P1 patients seen by third year students facilitates these processes.

The only problem with what appears to be a logically structured, progressive clinical learning approach to paediatric emergency care is that not all students in each academic year actually have an opportunity to learn what is intended. The results discussed above, and displayed most concisely in Fig. 3, show that in the case of younger patients (infants and neonates) less than half, on average, of second and third year students ever have clinical contact in a given year. Although no standards exist against which to compare this exposure in terms of adequacy, it would seem to be far below the ideal of every student having at least some interaction with these cases in each year of clinical learning. The question of adequacy in clinical paediatric emergency care exposure will be elaborated on in 4.5 below.

4.3. Exposure of Students to Clinical Skills

In the preceding discussion, only student exposure to paediatric emergency cases has been considered. This has provided some insight into how often students have any form of contact with these cases, how frequently this contact is repeated for those students who are exposed and how seriously ill or injured the involved patients are, across the three paediatric age categories.

Although there is no detailed record available in terms of learning outcomes such as clinical reasoning, problem-solving or integration of theoretical knowledge into practical patient care, individual clinical skills are documented by each student during these interactions. The following discussion sub-sections (4.3.1 - 4.3.5) focus on these clinical skills.

4.3.1. Patient Assessment Skills

Results of Chapter 3, with regard to NDEMC student’s exposure to patient assessment clinical skills showed that, on average, more than half of first year students had at least one opportunity to take a history and assess vital signs in older patients (i.e. in the child age category). In other academic years, and in other age categories, exposure was generally low, dropping to between 6% and 10% for both clinical skills in infants and neonates assessed by third year students. Students in all academic years performed both clinical skills on average twice in a year on children, and infants in the case of first and second year students. In the case of other age categories these skills were performed on average once in a year. (Tables 7 and 8)

Comparison of general patient exposure data and exposure for the two skills considered here shows that, in general, first year patient exposure and skills exposure are similar, but skills exposure for second and third year students is much lower than patient exposure across all age categories (Table 27). Given the appropriateness of these two clinical skills in virtually any patient interaction, this suggests that a low skills exposure amongst second and third year students was caused by students electing to perform the skills less frequently, rather than not having opportunities to perform them.

Table 27: Difference Between Patient and Skills Exposure for Clinical Assessment Skills

		History Taking	Vital Signs
Age Category	Academic Year	Difference in Exposure Patient vs. Skill	Difference in Exposure Patient vs. Skill
Child	First	2%	0%
	Second	27%	23%
	Third	35%	32%
Infant	First	7%	7%
	Second	22%	45%
	Third	27%	28%
Neonate	First	11%	10%
	Second	11%	11%
	Third	24%	20%

The pattern of decreasing performance of these two clinical assessment skills amongst second and third year students may reflect a greater emphasis on performance of other clinical skills during the transition to ALS level of care in clinical learning. In such cases, these two forms of patient assessment may have been performed either by a supervising or other practitioner. This trend is of some concern because maximal exposure to these skills, and repeated practice, is necessary for adequate learning. Although it is common practice to delegate the recording of vital signs to another (often less qualified or experienced) practitioner, history taking should be performed by the most experienced practitioner who takes overall responsibility for patient care.

There is a paucity of published comparative data dealing with pre-hospital emergency care personnel and their exposure to clinical assessment opportunities. No studies could be found dealing specifically with students, however two studies were found that investigated clinical assessment and vital signs skills amongst practicing EMTs in North America. The focus of these studies was competence of assessment, rather than exposure to patients or skills-related opportunities, however the results do raise some important questions with regard to possible areas that require emphasis in the clinical learning environment.

In a study conducted to assess the clinical assessment skills of EMTs working in an urban EMS in the USA, Foltin et al. (2002) compared field assessment data to emergency department diagnosis in 2,430 paediatric emergency cases, stratified by age category and seven diagnostic categories. Results showed that accuracy of patient assessment was greatest (87%) in children aged between six and 11 years of age, and lowest (70%) in the infant age category. In terms of diagnostic category, accuracy of assessment was greatest (92%) for patients with major injury and lowest (58%) for patients with non-wheezing-associated respiratory illness.

The above study involved EMT-Bs, who have the most basic pre-hospital emergency care training available in the North American setting. The entire EMT-B course spans 110 hours of contact, with only one of eight modules devoted to paediatric emergency care. (Zaveri & Agrawal, 2006). Although the results of this study were undoubtedly biased by including cases involving injury- (usually easy to assess clinically) and non-injury-related emergencies, the age-related pattern of decreasing clinical assessment accuracy with decreasing age is an important finding. This suggests that students should ideally have more opportunities to practise clinical assessment skills in younger patients, but the results discussed above show the opposite trend occurring during NDEMC student's clinical learning.

In relation to the assessment of vital signs in paediatric patients, Gausche, Henderson, & Seidel (1990) conducted a study in Los Angeles, USA, assessing the frequency of pre-hospital vital signs assessment across a range of different paediatric age groups by EMTs. This was followed by a questionnaire assessing perceptions of the same cohort of practitioners about the value and difficulty of vital signs assessment in paediatric patients. Results showed that vital signs were, in general, assessed significantly more frequently in adult patients (here defined as those older than 19 years) than in paediatric patients. Frequency of vital signs assessment decreased significantly with decreasing patient age, and most patients under the age of two years did not have any vital signs assessed despite having obvious indicators of serious illness or injury. Questionnaire data showed that EMTs were less confident in assessing vital signs in younger patients. The only demographic factor associated with increased confidence in paediatric vital signs assessment was experience (measured as average callouts per 24-hour shift).

In summary, results from the current study suggest that NDEMC students in their second and third academic years did not make use of all the opportunities available to them to practise the clinical assessment-related skills of history taking and vital signs assessment in the paediatric patients they were exposed to. Reasons for this are not clear from the available data, but may be related to delegation of these clinical skills as the students tend to focus on more invasive ALS-level skills in second and third year. Students in all academic years should be using every possible opportunity to practise these clinical assessment skills. There is some published evidence to show that quality of clinical assessment and confidence in assessing vital signs in younger patients (particularly those younger than two years of age) is dependent on repeated exposure and practice.

4.3.2. *Airway and Ventilation Skills*

Because of the pivotal role played by adequacy of tissue oxygenation in the preservation of basic homeostatic function, airway and ventilation interventions are considered to be the most important in any form of emergency care. Although these interventions range from basic clinical skills, such as manual airway management techniques and BVM ventilation, to more complex skills such as ETI, proficiency is based on repeated exposure and practice.

Results of the current study show that relatively few students, on average, had opportunities to practise either the more basic clinical skill of BVM ventilation, or the more advanced skill of ETI on paediatric patients, with or without the assistance of medication. Only between 6% and 8% of first and second year students had any exposure to BVM ventilation and only two third year students performed this skill over the eight year review period (Table 9). Exposure to ETI was limited to third year students, because the skill is only included in clinical learning in that academic year. This exposure ranged between 5% and 15% on average, with the lower exposure relevant to the youngest patient age category, and the highest to the oldest patient age category. Exposure rates for drug-assisted ETI were lower still on average, at a maximum of 8% in the oldest age category (Table 11).

The results referred to above also indicate that, of the small proportion of students exposed to BVM ventilation and ETI, the norm was for both of these skills to be performed only once in a year, with a very small minority of students being able to perform either skill two or three times in one year (Tables 9 and 10). Although, as pointed out earlier in this discussion, there are no acceptable benchmarks with regard to adequate exposure for these or any other paediatric emergency care clinical skills, the proportions of exposed students identified in the current study seem very low. This is particularly so when considering the life-saving potential of these airway- and ventilation-related clinical skills, and the potential complications that can arise when ETI in particular is attempted by inexperienced practitioners.

This latter problem of inexperience, and the effects that it may have on success of airway management in paediatric patients, has received some attention in the literature. Few studies have concentrated on paediatric pre-hospital airway management, and of those that have, fewer still have described the experiences of students. In the operational context, with qualified paramedics, success rates for paediatric pre-hospital ETI are often lower than those for adults in the same EMS system and range between 45% and 82% in data from North America. (Babl et al., 2001; Boswell, McElveen, Sharp, Boyd, & Frantz, 1995; Ehrlich, Seidman, Atallah, Haque, & Helmkamp, 2004; Gausche et al., 2000; Lavery et al., 1992; Tam et al., 2009).

These mostly low success rates contradict the assertion that paediatric ETI should not be significantly more difficult than adult ETI and, in fact, may arguably be considered easier from a technical perspective. (Kovacs & Law, 2008:87). When considering the possibility that poor success rates may be associated with performance stress in paediatric ETI, and that this type of stress may well arise because the procedure is performed rarely, the link between exposure, experience and proficiency becomes apparent. Although research documenting poor success rates has studied operational paramedics and not students, the same principles would apply to students who ideally need sufficient exposure to this clinical skill to enhance their confidence before qualification and independent practice.

Although the focus of this discussion is on clinical learning exposure, and the important relationship between opportunities to practice ETI in the pre-hospital environment and success of the procedure, the literature does contain some evidence of other skill-related interventions that may improve proficiency. Two studies have documented significant improvements in paediatric pre-hospital ETI success rates after initiation of short course training specifically addressing this clinical skill. In one case, the training involved supervised operating room practice of paediatric ETI, (Losek, Szewczuga, & Glaeser, 1994) and in the second case the skills training simply involved additional manikin practice during a Paediatric Advanced Life Support course. (Baker et al., 2009). In both of these cases, previously inexperienced paramedics with a minimum of exposure to paediatric ETI were provided with additional opportunities to practice the skill of paediatric ETI, and in both cases this appears to have increased their ability. Even these less authentic forms of skill practice appear to have a measurable beneficial effect on ETI success rates.

In contrast, and not surprisingly, inadequate exposure to clinical learning opportunities during initial training appears to negate the purported benefits of complex clinical skills such as paediatric ETI. In a large, randomised study comparing the effect of paediatric pre-hospital BVM ventilation and ETI on patient outcomes, Gausche et al. (2000) showed the two forms of treatment to be equivalent with regard to both survival and neurological outcome. Closer analysis of the results show that only 57% of patients in whom ETI was attempted were successfully intubated.

Training provided for the paramedics taking part in the study by Gausche et al. (2000) included two three-hour didactic sessions and skills training on manikins. There was no operating room exposure, and no chance to practice paediatric ETI on real patients during clinical learning prior to the initiation of data collection. Considering this, it is not surprising that the ETI success rate was so low and that no outcome benefit was seen for patients in whom ETI was attempted. The authors conclude that their results support the removal of paediatric ETI as a pre-hospital skill. (Gausche et al., 2000:789-790). However what the results really show is that poor training, without any clinical exposure, produces poorly skilled practitioners.

In summary of the above discussion on airway management and ventilation skills, a small proportion of NDEMC students had opportunities to practice the important clinical skills of BVM ventilation and ETI in an average year. This is concerning because evidence exists in the literature, both positive and negative, to suggest a strong association between clinical exposure of this nature and paediatric ETI proficiency. Although considered a simpler skill to master, it is logical to think that a similar relationship exists between practice and proficiency with regard to BVM ventilation. Whether or not practitioners with inadequate clinical exposure to a skill like ETI, who are highly likely to lack confidence and technical proficiency, should be practising it remains an open question. The trade-off between potential of this skill to improve patient outcomes, and quality of performance which is difficult to obtain in many clinical learning programmes, will be discussed further in 4.5 below.

4.3.3. Venous Access Skills

As outlined in Chapter 3 (3.4.3), the collective term venous access skills includes a number of distinct skills carried out in order to obtain some form of venous access to administer fluids (i.e. replace fluid loss) or administer medications, either immediately or at some time during future patient care. Only two of the four venous access skills were represented in the clinical learning data set from the current study (peripheral venous access and intraosseous access). There were no recorded instances of femoral or external jugular venous access. This may not necessarily mean that these forms of venous access were never performed on the cohort of paediatric patients represented in this study, or that they were not needed, as supervising practitioners may have elected to perform them instead of allowing students to. Nevertheless, no student was able to obtain any practice in either of these invasive skills during the eight year review period.

Results of the current study show that student exposure to the skill of peripheral venous access was only 16% in an average year (results are once again limited to third year students because the skill is only taught to this group). As patient age category diminishes, the exposure decreases to very low levels with only a handful of students having any opportunities to practise placing intravenous lines in infants or neonates (Table 12). The results for intraosseous placement are the opposite (the greatest exposure occurs in the cases involving the youngest patients), a pattern which makes good sense when considering recommended approaches to venous access in very young patients. In such cases, where placement of an intravenous cannula by routine methods may be very difficult or impossible, there is generally a lower threshold for reverting to intraosseous access (this is recommended after two failed venous cannulation attempts). (LaRocco & Wang, 2003). Even so, in an average year only 6% of third year students had a single opportunity to practice this skill (Table 13).

Published literature on pre-hospital paediatric venous access as a clinical skill focuses mostly on success rates amongst operational paramedics in North American EMS systems. These studies show that venous cannulation was attempted in between 10% and 80% of paediatric patients. (Babl et al., 2001; Joyce et al., 1996; Lavery et al., 1992; Lillis & Jaffe, 1992; Richard et al., 2006; Scribano et al., 2000; Su et al., 1997). Success rates are not reported uniformly in all studies referring to attempted venous cannulation, but where described these ranged between 68% and 97%. (Babl et al., 2001; Lavery et al., 1992; Lillis & Jaffe, 1992; Richard et al., 2006). Most of these studies identified a lower rate of venous access attempts and success amongst younger patients, particularly those younger than six years of age.

The only studies addressing any aspect of venous cannulation skills learning are those referred to above (4.3.2) in the discussion on ETI, and the effect of additional PALS training or operating room experience. In addition to ETI proficiency, in both studies the authors examined paediatric venous access (defined as venous cannulation or intraosseous access) success rates in paramedics before and after the additional PALS or operating room exposure. In terms of significance, results were the same, indicating better performance and success rates after the additional exposure. (Baker et al., 2009; Losek et al., 1994). This again highlights the link between practice and proficiency, even if the practice is not in an authentic environment.

Similar to the discussion of venous access above, literature dealing with the clinical skill of intraosseous access is also mostly descriptive, focusing on success rates and including qualified North American paramedics. These studies show success rates of between 50% (in older children) and 87% after training programmes that are typically very short and focused, without any clinical learning component. (Anderson et al., 1994; Glaeser, Hellmich, Szewczuga, Losek, & Smith, 1993; Smith, Keseg, Manley, & Standeford, 1988). One study including Swiss physicians and paramedics showed that intraosseous success rates in children, the majority of whom were younger than six years of age, did not significantly improve after a standardised intraosseous training programme. Qualification and prior clinical experience were also found to have no significant effect on success rates. (Pfister, Egger, Wirthmuller, & Greif, 2008). These results, together with the success rates observed in North American EMS systems where training typically occurs without any clinical exposure (i.e. on manikins only), suggest that proficiency at the skill of intraosseous access is not heavily dependent on clinical exposure.

In summary, NDEMC students in the current study did not have many opportunities to practise venous access skills on paediatric patients. For standard venous cannulation, these opportunities diminished rapidly in younger patients. Opportunities to practice the skill of intraosseous access were also rare, but better represented in younger patients, as would be expected if the skill is being correctly applied. Some evidence suggests that clinical exposure is more important in developing proficiency with standard venous cannulation, than with intraosseous access.

4.3.4. Administration of Medication

Results in Chapter 3 (3.4.4) show that a relatively large proportion of third year NDEMC students (between approximately a half and a quarter) had opportunities to administer medication to paediatric patients during clinical learning. Most students had more than one opportunity to do this although the administration of supplemental oxygen, which does not involve the calculation of a dosage and is very easy to deliver, accounted for almost half of these encounters (Tables 14 and 15).

No literature are available for the comparison of this skill in a population of pre-hospital emergency care students, however several of the studies reviewed in Chapter 1 describe the administration of medications by qualified paramedics. The range of patient proportions receiving medications varies between 3% (Lavery et al., 1992) and 50% (Babl et al., 2001) in these studies, with many of the frequently administered medications similar to those described in the current study (supplemental oxygen, benzodiazepines, bronchodilators and analgesics). This is in keeping with the most commonly reported emergency types in the current study and the reported literature.

4.3.5. Cardiac Arrest-related Skills

Results presented in Chapter 3 (3.4.5) summarised both NDEMC student exposure to paediatric cardiac arrest cases in general, and also exposure to specific clinical skills practised only in the setting of resuscitation from cardiac arrest. General exposure to cardiac arrest cases was never greater than 8% in any age category in an average year of clinical learning. First year students tended to have contact with most of the cardiac arrest cases in older patients (i.e. the child age category), while second and third year students had the most contact with patients in the infant age category. Exposure to neonatal resuscitation was extremely limited (Table 16). As alluded to in Chapter 3, the low overall prevalence of paediatric cardiac arrest cases reported (0.3% of all patient care records) is the most obvious cause of this low student exposure.

Logically, if general exposure to paediatric cardiac arrest cases was poor, then exposure to clinical skills practised during resuscitation would be expected to be as poor. This was undeniably the case, however exposure to clinical skills was even lower than that for cardiac arrest cases, probably because some of the cases were not resuscitated. Analysis of both a basic skill (cardiopulmonary resuscitation) and a more advanced one (ETI) showed extremely low exposure for all students. Indeed, from these results it becomes apparent that any student having an opportunity to practise any clinical skill during paediatric resuscitation from cardiac arrest could consider themselves extremely fortunate.

Although no data from South Africa are available, paediatric pre-hospital cardiac arrest cases are a fairly rare phenomenon globally, with an incidence of between 3 and 20 annual cases per 100,000 paediatric population, in countries where this has been studied (mostly North America and Europe). (Donoghue et al., 2005; Gerein et al., 2006). Consequently, ongoing exposure of qualified paramedics to these cases is also quite rare. Outcomes from pre-hospital paediatric cardiac arrest are generally poor, with survival to hospital discharge occurring in 12% and intact neurological survival occurring in only 4%. (Donoghue et al., 2005). Factors clearly responsible for these poor outcomes are not known with any certainty, and are the focus of ongoing research.

It is possible, with paediatric cardiac arrest being a relatively rare event, that paramedics may not be particularly confident in the management of these cases or the clinical skills involved. Knowledge and skill decay tend to be consistent problems in the effective management of rare conditions because of lack of practice and experience over time. One study in the USA has documented the rapid decay of paediatric resuscitation knowledge amongst paramedics, despite various interventions to retain that knowledge. (Su et al., 2000). Studies on paediatric resuscitation skills amongst other professionals have also identified the extent and rapidity of their decay. (Duran, Aladag, Vatansever, Kucukugurluoglu, & Acunas, 2008; Kaczorowski et al., 1998).

Clearly, with the prevalence of paediatric cardiac arrest as low as observed in the current study, and the extremely limited exposure of students to these cases and related clinical skills, one could expect a rapid decay in both resuscitation knowledge and skills (the vast majority of which have been attained through simulation) after qualification of these NDEMC students. This highlights the need for ongoing, frequent updates allowing practice of these important modalities after qualification.

4.4. The Influence of Academic Year on Exposure to Paediatric Emergency Cases and Clinical Skills

In assessing the influence of student academic year on exposure to paediatric emergency cases in general, two questions were asked. Firstly, is there a significant difference in mean exposure over the three academic years as observed during the eight year review period? Secondly, is there a dependence between being in a specific academic year, and exposure to these cases? Results indicated that there was no significant difference in exposure, but that a significant (albeit weak) dependence does exist between the academic year of a student and their paediatric emergency exposure, with first year students having significantly more exposure than students in either of the other academic years. Quantification of this dependence in the form of odds ratios showed odds of exposure to paediatric emergency cases 1.3 times greater for first year students than for others.

On the face of it, this appears to be a counterproductive pattern, because the vast majority of paediatric emergency care learning outcomes are dealt with in the third year of study, including all of the ALS-level (more invasive) clinical skills. Analysis conducted on the P1 subset of paediatric emergency cases shows however that, amongst these more seriously ill and injured patients, the odds of exposure for third and second year students are almost twice those for first year students. This pattern has been commented on previously (4.3), but the calculation of odds ratios allows for a more accurate description.

The current practice of placing first year students with predominantly BLS supervising practitioners and second and third years with ALS supervising practitioners appears to result in a favourable mix of patients, in line with these students' requirements and capabilities. The only shortcoming currently is that insufficient high acuity patients are seen by second and third year students, as evidenced by their generally poor exposure (mostly below 50%) to a wide range of important clinical skills.

4.5. The Problem of Defining Adequate Clinical Exposure

In using terms such as 'inadequate' or 'poor' to describe exposure of students to paediatric emergency cases and clinical skills in the above discussion, it is logical to imagine that 'adequate' or 'good' exposure has been established. Unfortunately, this is not the case - as alluded to at several points in this chapter's discussion, there exists no valid, evidence-based benchmark to define adequacy of clinical exposure for pre-hospital emergency care students within the context of paediatric emergency care. Despite this, some research has addressed the description of learning curves, and this provides at least some idea of the relationship between exposure and competence.

The question of adequacy of exposure relates directly to how often a given student needs to practise a particular skill in order to achieve a pre-defined level of success or competence. On the one hand, this question can be applied to clinical psychomotor skills such as ETI or venous access procedures. Some research has been done in this area, in relation to a small subset of clinical skills, and the results show that the numbers tend to be fairly large (compared to the opportunities available, as described in the current study). A more difficult, and largely unstudied question, is how much exposure students require in order to achieve other important clinical skills such as clinical reasoning, problem-solving or improvisation.

Within the field of pre-hospital emergency care, two clinical skills have been studied with respect to accumulated proficiency over time. Wilson (1991) developed a graphical method allowing pre-hospital emergency care students' progress during repeated practice at both venous cannulation and ETI (in this case, adult ETI) to be assessed. This allowed students to demonstrate a given rate of cumulative success (80% in this study) before being judged to be proficient.

Several other studies investigating cumulative success and the generation of learning curves have focused solely on ETI as a clinical skill. These studies first appeared in the anaesthesia literature, focusing either entirely on anaesthesia residents (Konrad, Schupfer, Wietlisbach, & Gerber, 1998) or a mix of students from different backgrounds, including pre-hospital emergency care. (Mulcaster et al., 2003). More recent studies have concentrated on paramedic students alone, and have assessed the repeated practice of ETI in the hospital (e.g. operating room and emergency department) and pre-hospital environments. (Wang, Seitz, Hostler, & Yealy, 2005; Warner et al., 2010).

Results in the anaesthesia setting have suggested that in order to achieve a 90% success rate, students had to attempt between 47 and 57 ETIs (once again, only adult ETIs are considered in these studies). (Konrad et al., 1998; Mulcaster et al., 2003). A similarly constructed investigation concentrating on paramedic students suggested a pooled, mixed environment (i.e. both hospital and pre-hospital) attempt frequency of 25 to achieve 90%

probability of successful ETI. This number of attempts increased to over 30 for ETIs attempted in the more uncontrolled pre-hospital environment. (Wang et al., 2005). In contrast, students from a different and better resourced training programme required seven ETI attempts in order to achieve an overall success rate of 90%. This number increased to more than 20 in order to achieve a first-pass success rate of 90% (i.e. success on the first ETI attempt). (Warner et al., 2010).

The numbers cited above to achieve 90% cumulative success in adult ETI are concerning when contrasted to comparative exposure data from the current study. It could even be argued that the learning curve for paediatric intubation may have a shallower gradient, requiring more attempts to reach the 90% success threshold (although this has not yet been determined). When only between 5% and 15% of third year students in an average year have any exposure to paediatric ETI, and when this exposure entails no more than two attempts (for a very small number of students, and one attempt for the remainder), one cannot even begin to consider a ‘learning curve’, let alone try to assess any threshold of cumulative success. Although the example used here is adult ETI, because there is available literature dealing with this, the same problem relates to all of the paediatric emergency care clinical skills to which NDEMC students have had very limited exposure.

Considering the above discussion, two distinct but related aspects of the term ‘exposure’ become apparent. These two notions are linked to the questions asked in section 3.3 of Chapter 3. The first aspect is a concept of proportion - simply the subset of students in a particular grouping (in the current study academic year was the grouping) who had some form of patient contact. The ideal situation for this kind of exposure would be 100% - for all students to have at least some experience of patient care in general, or a specific clinical skill. The second aspect is a concept of frequency - amongst the subset of students who had some patient contact, how often did this occur - how repeatable was the experience? The literature on cumulative success rates and learning curves speaks to this form of exposure.

Naturally, proportional exposure in part determines repeatable exposure. Those students having no contact with a particular type of patient or clinical skill will never be able to gain any cumulative experience. But even if patient contact occurs, this must happen often enough to allow the building of proficiency through repeated practice. How often this must occur will vary depending on the clinical skill under consideration and the individual students practising the skill. With the exception of adult ETI which has been subjected to several studies of this nature (with wide variation in the number of repetitions to attain the same threshold of cumulative success), we simply do not know how often students must practise clinical skills in order to attain a predetermined cumulative success rate.

In reality, with clinical learning structured the way it has been in the NDEMC programme, most paediatric emergency clinical skills and paediatric emergency case contact in a more general sense have been associated with proportional exposures which are seldom greater than 50%, and frequently much lower than this. With the exception of a very small number of clinical skills, those students able to gain some exposure typically are able to perform a skill once or perhaps twice in an average year of clinical learning. Consequently, a given student's clinical experience in paediatric pre-hospital emergency care really is based on a "luck of the draw" basis which affords very few if any students adequate opportunities to practise important, perhaps life-saving, clinical skills before qualification and independent practice. Although the nature and frequency of paediatric emergencies in a given population are static entities, there may be aspects of clinical learning structure that could possibly be altered to ameliorate this problem.

4.6. Recommendations and Future Research

When considering the rarity of pre-hospital paediatric emergencies described in the literature, and in the current study, it seems highly unlikely that a state will ever be reached where all emergency care students will have unrestricted access to the number of emergency cases required for optimal clinical skill proficiency (a number largely undefined at present, but likely to be substantial when summed over all students in a particular grouping). However it may be possible to employ some alternative strategies to improve the quality of clinical learning, allowing all students repeated exposure to clinical skills practice even if this is not in an entirely authentic environment. Recommendations thus fall into three major groupings:

4.6.1. Internships for Newly-Qualified Paramedics

Currently, newly-qualified ALS paramedics in South Africa are registered with the HPCSA as independent practitioners. Contrary to the typical framework of early practice in other health professions, there is little support for paramedics practising in the pre-hospital environment. The newly-qualified paramedic typically works alone, or with less qualified personnel, from the first day of independent practice immediately after qualification. There is currently no supervisory or supportive framework in place for ALS paramedics early in their career who, as we have seen in the current study, may have very little or even no real clinical experience in paediatric emergency care.

In addressing this same problem in the USA, Pointer (2001) recommended a system of between six and nine months of supervised practice for newly-qualified paramedics during and after which benchmarked standards were to be assessed in order to determine fitness for unsupervised practice. Interestingly, no indication is given of the source for benchmark criteria suggested in this study, which seem very modest. Research aimed at describing clinical skills learning curves could contribute significantly to the validity of such performance benchmarks.

A descriptive account of a paramedic internship programme in Ireland is given by Bury, Janes, & Bourke (2007). Although spanning just six weeks, newly-qualified paramedics had exposure to a range of clinical situations, 46% of which involved supervised practice of ALS-level clinical skills (the Irish definition of ALS is slightly different to the local one, however many of the clinical skills involved were at an advanced level). In contrast to the suggested US model mentioned above, this approach used no pre-specified performance benchmarks.

Although clearly an approach that is believed necessary, the idea of an internship is not without potential problems. Foremost of these is the criticism that introducing an internship to address the deficiency of student exposure to a rare entity (pre-hospital paediatric emergencies) may not be very helpful because the opportunities to practise clinical skills will still be rare. An internship would have to continue for an extended period to guarantee exposure allowing completion of a predetermined, evidence-based (learning-curve determined) number of skills for all interns.

The second criticism of an internship is a more practical one and relates to EMS resources available in South Africa. In 2008 there were 1,243 registered ALS paramedics and Emergency Care Practitioners (ECPs) in South Africa – a very small number for the population served (the number available for supervision of interns would be smaller, because not all 1,243 registered paramedics and ECPs work in the field). (Health Professions Council of South Africa, 2010:8). Internships, involving the placement of a newly-qualified paramedic with one of the same qualification in operational practice, would delay the entry of new practitioners into operational practice - an effect that would probably not be considered very positively by both state and private employers.

Despite these problems, an internship would undeniably improve the level of proficiency and associated levels of confidence in at least a subset of paediatric emergency clinical skills. Both proportional and frequency-related exposure would be expected to be better than that seen in the current study because an internship would involve many more hours spent in the field than typically occurs during the student phase of clinical learning. Although it is difficult to determine the optimal duration of an internship without objective data, a time period shorter than six months to a year would probably not be adequate, particularly in the case of paediatric emergency care.

4.6.2. Hospital Clinical Skills Exposure

Intuitively, if the natural occurrence of emergencies in the paediatric population outside of hospitals is rare, then more opportunities may well be available to practise paediatric emergency care-related clinical skills in hospitals or departments devoted to this subset of patients. Experiences with the practice of ETI in the operating room environment by paramedic students in the USA have been positive, both from the perspective of a lack of complications (Brownstein, Quan, Orr, Wentz, & Copass, 1992) and the apparent benefits derived from this exposure. (Brownstein et al., 1992; Losek et al., 1994). A similar effect has been seen with venous cannulation practised in the paediatric emergency department. (Losek et al., 1994).

Operating room practice of paediatric ETI and other airway management skills has not previously been a part of the NDEMC clinical learning structure. Although the NDEMC programme has been discontinued at the UJ, clinical learning in the BTEMC programme is very similar and would benefit, during the fourth year of study when paediatric and neonatal emergency care is covered, from this kind of exposure.

To a certain extent, the suggested use of paediatric hospital exposure for clinical skills practice has already been addressed in the BTEMC programme (with the exception of operating room experience, as referred to above). Current structure of this paediatrics clinical learning component, first implemented in 2009, includes 120 hours of clinical exposure in a range of specialist paediatric units.

4.6.3. Learning Curves for Paediatric Emergency Care Clinical Skills

Although the recommendations above of an internship and increased use of hospital-based clinical learning opportunities may improve the situation with regard to adequacy of clinical learning in paediatric emergency care, no clear picture will emerge of exactly how much clinical skills practice is required until this important area of research receives more attention.

Traditionally, clinical learning in the NDEMC programme (and even currently, in the BTEMC programme) has been structured in terms of both time and numbers of clinical skills. The time requirement, for example that students spend 500 hours doing clinical learning in a particular setting, is largely an organisational framework and does not bear any relationship to quantity or quality of clinical learning. Although specific numbers of clinical skills are prescribed, there is currently no evidence on which to base the choice of these numbers. This is clearly an unsatisfactory position, as it leaves students, supervising practitioners and academic staff uncertain of the true extent of clinical skills proficiency even when the required number of skills has been completed or even surpassed.

Methods for the creation of learning curves have been described previously and are relatively uncomplicated. (Konrad et al., 1998; Mulcaster et al., 2003; Wang et al., 2005; Warner et al., 2010). They require some objective assessment tool defining criteria for success and failure of a clinical skill, and then repeated application of this tool to a group of students assessed every time they perform it. For the purposes of external validity, the students used in construction of the learning curve should come from the same background and educational context as those to whom the results will be applied in the future. Studies conducted in the construction of learning curves should be open-ended in terms of the number of skill repetitions in order to describe the full extent of each curve. Studying a predetermined number of skill repetitions may result in a situation where a learning curve is incomplete and does not ever reach the predetermined threshold for proficiency, as occurred in the study on pre-hospital adult ETI by Wang et al. (2005).

There is a dire need, in all aspects of pre-hospital emergency care clinical practice – not just paediatric emergency care, for this type of research. Without it, educators responsible for certifying the competence of practitioners simply cannot do this effectively.

4.7. Limitations of this Study

Several limitations of the current study should be taken into consideration when evaluating the results. These limitations relate to inferences made about data describing the paediatric patients, the possibility of missing patient care records (PCRs) and the effect of repeat exposure in consecutive academic years on students’ total accumulated exposure to paediatric emergency cases and clinical skills.

The set of PCRs analysed in this study represent paediatric patient care encounters of students completing clinical learning in a variety of provincial and private EMS systems throughout the Greater Johannesburg Metropolitan area. Because these cases were not consecutively or exhaustively collected, they may not be representative of the demographic or disease patterns occurring in this area.

It is possible that some patient encounters over the eight year review period were not captured by students in the form of PCRs. Section 2.2.3 of Chapter 2 addresses this problem and gives a detailed description of the procedures in place to prevent this. Such omissions, if they did occur, were most likely minimal and would not be expected to significantly alter any of the results reported in Chapter 3.

In analysing the raw data on student exposure to paediatric emergency cases and clinical skills, an approach was taken that involved consideration of each year of the review period in isolation. Extracted data from each year were then considered together, to arrive at median values for exposure over the eight year period between 2001 and 2008. In reality, students may be exposed to some clinical skills and to patient interactions repeatedly as they progress from their first to third academic years of study. This effect can only be quantified by tracking the exposure of individual students over their entire academic career and then summarising and comparing these longitudinal, personal experiences.

Although such an approach to the analysis of clinical learning data would be interesting, it would also be significantly more complex than the form of analysis used, and beyond the scope of a study of this nature. Thus it is important to recognise that the form of data analysis used in the current study may underestimate the true exposure of a given student, or group of students, to paediatric emergency cases and clinical skills because it ignores any possible repeated exposure by the same student in consecutive academic years.

4.8. Conclusion

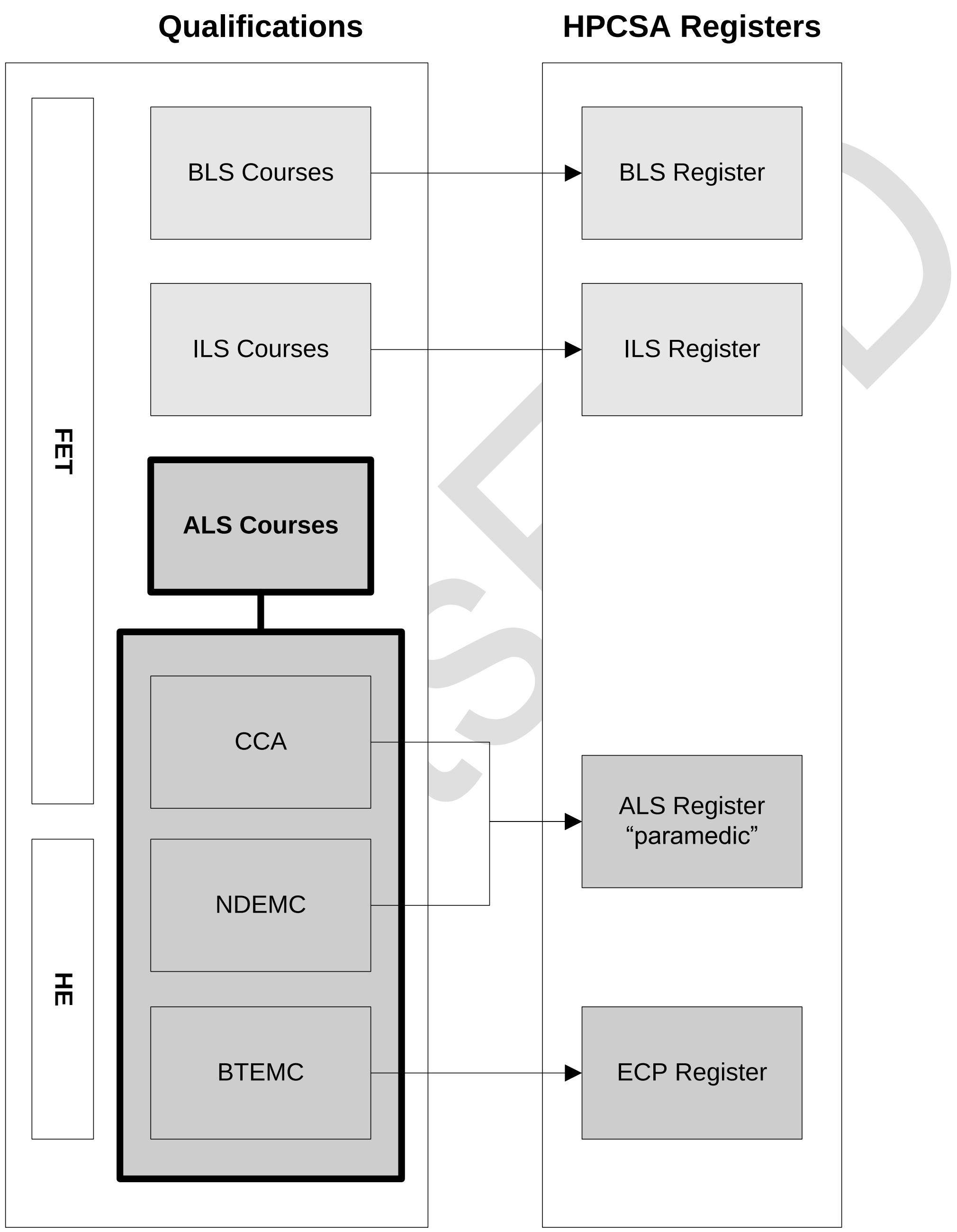
The discussion presented in this Chapter has highlighted the most significant and meaningful aspects of the results presented in Chapter 3. In many cases these results have been contextualised by referring to available literature dealing with related aspects of paediatric injury and disease or pre-hospital emergency care.

Although an objective standard is lacking, an argument has been given to support the notion that the paediatric emergency and clinical skills exposure of NDEMC students detailed in this study is generally not adequate. The reason for this appears to be related to the scarcity of opportunities for students to have contact with this subset of patients, particularly those representing the most valuable learning experiences. Where some exposure to paediatric patients and clinical skills does occur, repeatability is low thus generally precluding attainment of clinical skills proficiency which requires recurring exposure and practice.

Although the prevalence of paediatric pre-hospital emergencies cannot be altered, some other recommendations have been given to improve the exposure of NDEMC students, and newly-qualified paramedics, to paediatric emergency cases. Practice in less authentic environments may also contribute to providing a better clinical learning experience than currently exists. Finally, the need for evidence-based targets to guide clinical learning proficiency has been stated as an essential component in the improvement of paediatric emergency care clinical skills acquisition, and a better standard of care for acutely ill and injured children outside of the hospital environment.

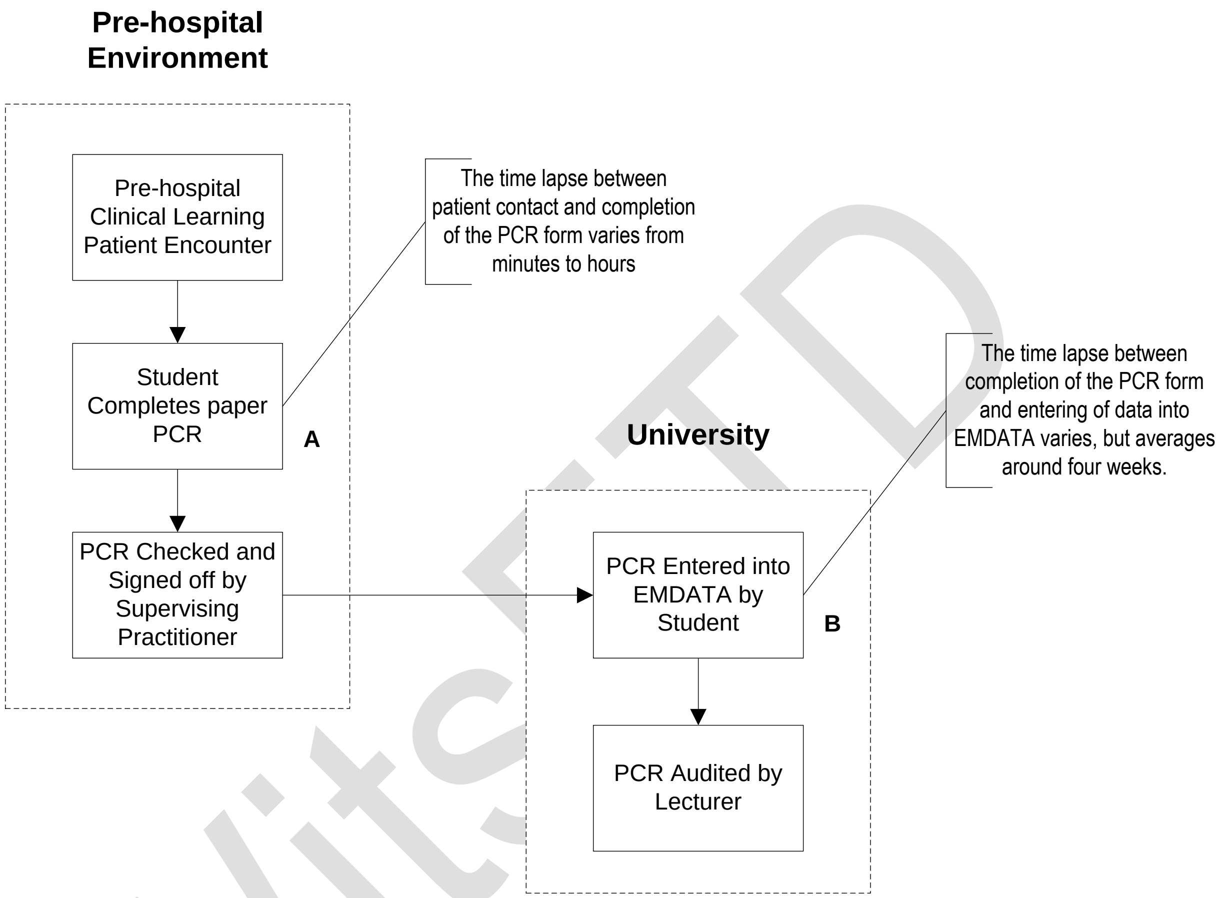
APPENDIX A

Schematic Representation of Relationship Between Pre-hospital Emergency Care Qualifications and HPCSA Registers



APPENDIX B

Process Followed by NDEMC Students in Generating Clinical Learning Data



APPENDIX C

Letter of Permission from the Department of Emergency Medical Care, UJ

UNIVERSITY OF JOHANNESBURG

12 August 2009

TO WHOM IT MAY CONCERN

Permission is hereby given to Mr C. Stein (student number 324567) to access data contained in the Department of Emergency Medical Care's Emergency Medical Database and Administration System in order to complete his research project entitled "PRE-HOSPITAL EMERGENCY CARE STUDENT EXPERIENCE WITH PAEDIATRIC EMERGENCY CASES IN JOHANNESBURG, GAUTENG". Mr. Stein may access the relevant patient care records ranging between 2001 and 2008, inclusive.

If you have any further queries, please contact me on 082 653-2125 or clambert@uj.ac.za.

Mr C. Lambert
Head of Department: Emergency Medical Care
FACULTY OF HEALTH SCIENCES

Doornfontein Campus Cnr Siemert and Beit Streets Doornfontein
PO Box 17011 Doornfontein 2028 Johannesburg Republic of South Africa Tel +27 11 406 2911 www.uj.ac.za

APPENDIX D

UJ Patient Care Record Form

UNIVERSITY OF JOHANNESBURG

UJ EMERGENCY MEDICAL CARE
PATIENT CARE RECORD

UNIVERSITY OF JOHANNESBURG

Date : dd_______mm_______yy_______

Name :

Address :

Tel No:

Gender

Race

Age

If exact age unknown:

Adult ☐ Child ☐

Infant ☐ Neonate ☐

Incident Location

Student 1 :

Student 2 :

Crew :

EMS:

INC No:

Transported By:

Transported To:

	HRS	MINS
Call Received :		
On Scene :		
Left Scene :		
At Hospital :		

Vehicle Reg. No:

Priority:

1	**2**
3	**4**

HISTORY / CLINICAL FINDINGS:

DO NOT LEAVE BLANK

MECHANISM:

MVA: ☐

☐ Front Impact
☐ Rear Impact
☐ Right Side Impact
☐ Left Side Impact
☐ Rollover
☐ Pt. Ejected
☐ Entrapment

Entrapment Duration:_________min.

Approx. Speed:________ km/h

Pedestrian: ☐

☐ Front Impact
☐ Rear Impact
☐ Left Side Impact
☐ Right Side Impact

Approx. Speed:________ km/h

Fall: ☐

Approx. Height: ________m

Shooting: ☐

Approx. Range: _____ m

Calibre: ___________

Stabbing: ☐

Other Assault: ☐

Crush Injury: ☐

Crush Duration:_____min.

Burns: ☐

☐ Thermal ☐ Chemical
☐ Electrical

PRIMARY SURVEY:

Neuro Status

☐ Alert
☐ Responding -verbal
☐ Responding - painful
☐ Unresponsive

Airway

☐ Patent
☐ Threatened - LOC
☐ Threatened – Foreign Body
☐ Threatened – Blood/Vomitus
☐ Threatened – Inflammation
☐ Threatened – Facial Trauma

Breathing

☐ Normal
☐ Tachypnea
☐ Bradypnea
☐ Respiratory Distress
☐ Central Cyanosis
☐ Apnea

Circulation

☐ Peripheral Pulses Present
☐ Peripheral Pulses Absent
☐ Central Pulses Present
☐ Central Pulses Absent
☐ Exsanguinating Haemorrhage

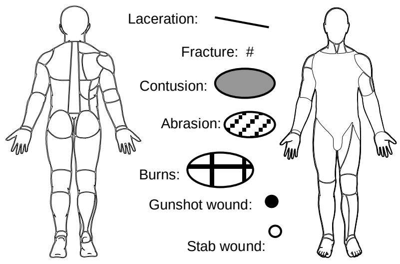
TIME										
Blood Pressure										
Pulse/min										
Resps/min										
Skin										
Pupil Reaction	L	R	L	R	L	R	L	R	L	R
Pupil Size										
GCS										
$Sa0_2$										
HGT mmol/l										
ECG Rhythm										
APGAR Score										

DO NOT LEAVE BLANK

O_2 Delivery Device________________________________ @ _______ **l/min**

TIME	DRUG/FLUID	DOSE	ROUTE

DO NOT LEAVE BLANK



PROCEDURES:

ET Intubation: ☐

☐ Oral ☐ Nasal

No. Attempts: ____

☐ Successful ☐ Failed

Sedation Required ☐

Cricothyroidotomy: ☐

Technique/Ventilation:

☐ Needle

☐ Surgical

☐ Jet Insufflation

☐ BVM Ventilation

Reason for Cric.:

☐ Failed Intubation-no Facial Trauma

☐ Facial Trauma

☐ Upper Airway Obst.-Foreign Body

☐ Upper Airway Obst.-Inflammation

Intravenous Access: ☐

No. Attempts: ____

No. Successful: ____

IV Started: ☐ On Scene

☐ In Vehicle ☐ At Destination

Full Spinal Immobilisation: ☐

OTHER TREATMENT / PROCEDURES:

DO NOT LEAVE BLANK

SKILLS PERFORMED:

______________________ ______________________

______________________ ______________________

______________________ ______________________

____

____

Crew Signature

CREW COMMENTS:

____

Signature

I hereby release ________________________, the emergency care provider and UNIVERSITY OF JOHANNESBURG from any liability of medical claims resulting from my refusal of emergency care and/or transportation to the nearest recommended medical facility. I further understand that I have been directed to contact my personal doctor with regard to my present condition as soon as possible. I have received an explanation of the potential consequences of my refusal of emergency care and/or transportation which I understand.

______________________ ______________________

Patient Signature Emergency Care Provider Signature

Date: dd________**mm**________**yy**________ **Time:**______**:**______

I hereby declare that the following valuables, belonging to the patient whose name appears on this data form, were handed over to me by _______________, the emergency care provider.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Signature: ________________________

Name: ________________________

Patient handed over to: ________________________________

____

Signature

____

Student Signature

SURVIVAL

(PRIORITY ONE PATIENTS)

Hospital: ______________________

Hospital Number: ______________________

Hospital Stay: ________ Days.

Survival:

☐ Died Pre-hospital

☐ Died in Casualty

☐ Died in ICU/Ward

☐ Discharged with Disability

☐ Discharged without Disability

EMDATA
Emergency Medical Database and Analysis System
Revised January 2007

Date Captured: dd_____**mm**_____**yy**_____

PCRID:____

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