Organisation, intubation skills and monitoring in the acute care of critically ill children in Dutch general hospitals

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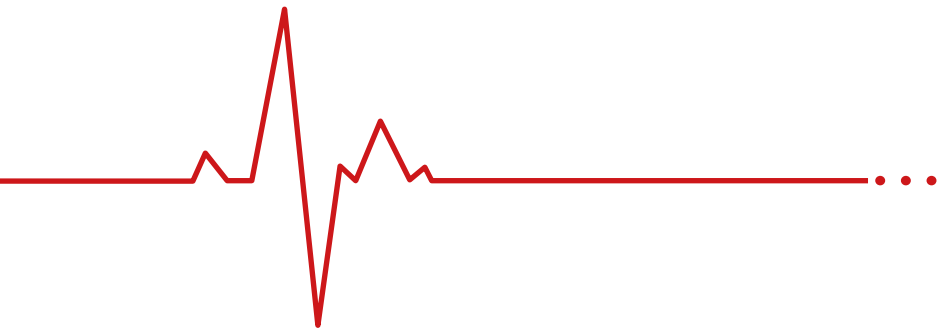
Sam Janneke van Sambeeck



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Voor Elise en Simon

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Chapter 1

Introduction and objectives

Introduction and objectives

Critically ill children are defined as children with imminent or manifest compromised vital signs with respect to respiration, circulation and neurologic and/or metabolic state. Critically ill children need immediate and appropriate care and monitoring (1,2). This thesis focuses on the current state and future perspectives of the organisation of acute care for critically ill children in Dutch general hospitals. It also addresses the early recognition of deteriorating vital signs of in-hospital paediatric patients to allow instant intervention to prevent further deterioration and life-threatening events.

In paediatrics, children of all ages may develop organ failure, indicated by reduced vital signs in a comparatively short period of time, and become acutely critically ill (1,2). The first hour of acute care of critically ill paediatric patients or paediatric trauma patients is referred to as the 'golden hour'. Survival rates, chances of recovery or the decrease of residual damage are time dependent and improve when accurate acute care is delivered within the first hour, or at least as fast as possible (1,2). To provide efficient, accurate acute care in the first hours after admission, medical and logistic protocols with standardised logistic flow-charts and agreements about responsibilities must be available (3). The article, 'Monitor healthcare related damage 2015/2016' by the Netherlands Institute for Health Services Research (NIVEL) describes organisational processes as an important factor in successful patient care (4). When healthcare-related damage occurs, in the majority of cases, there are multiple causes, which include a combination of patient, human and organisational factors (4). Damage can often be prevented by closely following the existing professional standards and improving the organisation of professional standards and processes (4). The number of organisational causes in healthcare-related damage can be underestimated in file studies because patient files contain very little information about the organisational process of the care the patients receive (4). Organisational processes influence healthcare professionals' actions and decisions, which makes solid logistic protocols for acute paediatric care of utmost importance (3,4).

Part one: The organisation of acute care of critically ill children

1.1 Organisation of paediatric acute care in the Netherlands

National and regional regulations and geographic conditions determine the organisation of the admission and treatment of critically ill children. In the Netherlands, critically ill children are primarily admitted to the nearest general hospital (5-7). In 2015, there were 83 general hospitals and eight university medical centres with paediatric departments in the Netherlands. In most hospitals critically ill children coming from outside the hospital are presented in the emergency room (ER) where the first paediatric life support is started. However, in some hospitals these patients are primarily seen and treated in the

paediatric ward (7). Besides the paediatric patients that are presented from outside the hospital, hospitalised patients in the paediatric ward can deteriorate over time and need acute medical care as well (7). The ER and the paediatric ward are both in-hospital departments where paediatric critical care settings are likely to occur.

In a paediatric critical care setting the attending paediatrician at the general hospital is responsible for the first advanced life support to stabilise the patient. This first advanced life support is performed in cooperation with the nursing staff and, if available, emergency physicians, anaesthetists, intensive care specialists or other members of the attending medical staff.

After the first advanced life support, the majority of intensive-care-dependent children are transferred to a tertiary paediatric intensive care unit (PICU) (6). Centralisation of intensive care for children is implemented, since critically ill children have better clinical outcomes in mortality and morbidity at lower costs when treated in tertiary PICUs compared to paediatric wards or (adult) intensive care units (ICU) in general hospitals (8,9). In most cases, specialised paediatric retrieval teams, including a paediatric intensive care specialist and a PICU nurse, perform referrals to the PICU (10). In the Netherlands, the mean number of operational PICU beds is around 120, spread over the eight university medical centres. PICUs admit children from the ages of four weeks (as well as neonates with surgical or cardiac diseases) to 18 years with wide variations in pathophysiology and occurrence of disease (8-11).

Annually, in the Netherlands, around 1,500 of these children are transferred from one of the 83 general hospitals to a PICU of one of the eight university medical centres. Considering the number of paediatricians in general hospitals, this results in an average of three transfers of critically ill children per paediatrician per year (11). It is not known how many critically ill children are not transferred to a PICU after first advanced life support, because these children do not require admission to an ICU after first treatment, die before transfer or are admitted to an adult ICU of a general hospital. The latter possibility might be done when length of stay in the ICU is expected to be less than 24 hours, in particular for adolescents.

The initial approach, assessment and treatment of patients who need critical care is essential for the prognosis (2). Because of limited experience with critically ill children in general hospitals, adequate organisation and training are of utmost importance to optimise the prognoses of critically ill children (3,12-14). This is best demonstrated by the reduction of mortality in children with meningococcal disease after the optimisation of acute care in general hospitals, the sharing of protocols as part of this optimisation, the centralisation of paediatric intensive care and the introduction of dedicated paediatric retrieval teams (3).

1.2 How organisational protocols can help reduce stress in acute care settings

Healthcare professionals describe the acute care or resuscitation of critically ill patients as a stressful experience (15). During critical care, this stressful experience is mostly caused by the perception of 'chaos' at the scene (15). This perceived chaos is caused by a disorganised, non-standardised resuscitation environment and by having too many or too few participants involved in a resuscitation (15). In case of paediatric critical care, healthcare professionals experience more insecurity about their actions compared to adult critical care settings. This is caused by their low level of exposure to and experience with paediatric critical care and by the diversity of unexpected situations in paediatric critical care settings (2). Professionals experience a lower level of stress during the critical care setting when they have more exposure to critical care settings combined with frequent simulation training (15).

During paediatric critical care settings, a multidisciplinary team of medical staff and nurses must work together to provide the best care. Working agreements recorded in local protocols, simulation-based team training and a fully equipped resuscitation cart at the ER and paediatric ward are necessary to give the best care possible and to prevent unnecessary, stressful situations that might lead to inadequate practice (2,7,16).

1.3 Simulation-based training

The low number of admissions of critically ill children in general hospitals results in limited experience in the acute care of these children (11). Also, paediatric residents have limited exposure to critically ill patients. This is not only caused by the low incidence of critically ill children and paediatric resuscitations, but also by the limitations of working hours and an increase in subspecialisations (fellowships), all of which lead to a low exposure and therefore more often inadequate resuscitation skills (11,17-19). This lack of exposure demands adequate, deliberate practice in advanced paediatric life support (APLS) and simulation-based training. Deliberate practice involves repetitive performance of intended cognitive or psychomotor skills in a focused domain, combined with rigorous skills assessment. This provides learners with specific feedback, resulting in increasingly better skills performance, in a simulated setting (17-19).

Simulation-based training combined with deliberate practice is offered in the national APLS course in combination with the recertification course (RCC) and in the European Paediatric Advanced Life Support (EPALS) course (20). The Dutch Foundation for the Emergency Medical Care for Children (SSHK) organises these courses. In the Netherlands, paediatricians and emergency physicians in training are obliged to gain an APLS certification, although it is not mandatory for re-registration as a medical specialist.

Studies on the educational impact of the Newborn Life Support Course (NLS), APLS and advanced trauma life support (ATLS) show that the skills and knowledge learned in these courses decline within the first six months after the course is completed (8,21,22). Attendance at nationally accredited resuscitation courses should be encouraged, but

simulation-based training and staff assessments on hospital level should be organised because of the significant decay in psychomotor skills if not frequently used or refreshed (21,22).

Simulation-based resuscitation training has proven to be a powerful learning tool to enhance medical and nursing staffs performance of psychomotor resuscitation skills (23-25). Simulation-based resuscitation training is associated with improved paediatric outcome following cardiopulmonary arrest (25) and would ideally take place regularly and allow teams that work together to train together and improve teamwork (26). Training with multidisciplinary team members with different levels of expertise acting in their usual environment (in situ simulation) on physiological variables is required to introduce cultural context and social conditions to the learning experience (26) and to test the workability of local agreements and protocols. Embedding local team training programmes on a regular basis is mandatory for a cultural change toward sustained improvements in team performance and patient safety (23). It is noteworthy that simulation-based training is not proven to be effective in developing specific procedural skills, such as endotracheal intubation (27,28). Studies show that there is no guarantee that well-learned skills on manikins lead to successful procedures in real-life situations (27-29).

1.4 Equipment, materials and medication

To optimise the acute care for critically ill children, resuscitation teams must rely on the equipment, materials and medication needed for APLS (30), which are often stored in paediatric resuscitation carts. The availability of medical materials and medication in the ER and the paediatric wards gives insight into the quality of care that can be provided on site. The presence of adequate materials and medications is a prerequisite for optimal care and reflects the quality of care for golden-hour treatment in critically ill children (7). Studies have found that these carts are frequently incomplete and that ERs in general hospitals are far better equipped to meet the needs of critically ill paediatric patients compared to the emergency facilities in paediatric wards (7,31,32).

1.5 Objectives

Dutch studies relating to the organisation and training of paediatric acute care are lacking. One could hypothesize that local guidelines concerning the organisation of acute care and simulation-based training are lacking in most general hospitals. Besides this, one could hypothesize that standardised inventory lists for paediatric resuscitation carts are lacking. This might lead to suboptimal organisation and training and incomplete resuscitation carts.

The aim of the first and second study of this thesis is to assess the hospital-level agreements and protocols concerning the organisation of paediatric critical care, including the training, materials and medication needed to provide acute paediatric care in Dutch general hospitals. This assessment is a first step towards national guidelines and national

inventory lists, with the ultimate goal to improve the organisation of paediatric critical care in Dutch general hospitals.

Part two: Endotracheal intubation

2.1 Importance of endotracheal intubation

During the acute care of critically ill children, multiple lifesaving interventions may take place. One of the most crucial interventions is securing the airway to provide adequate oxygenation and ventilation. All other therapeutic manoeuvres are futile if an open airway and adequate ventilation are not secured (33). There are multiple techniques to secure an open airway. Studies show that in paediatric out-of-hospital or in-hospital cardiac arrest, endotracheal intubation (ETI) does not improve outcomes compared to bag and mask ventilation (33,34). However, ETI remains the standard for securing the airway in situations when the provider is unable to adequately ventilate the unconscious patient with bag and mask ventilation or via a supraglottic airway device, when there is a prolonged absence of airway protective reflexes (33) or when prolonged invasive mechanical ventilation is needed. In the Netherlands, critically ill children are primarily admitted to nearby general hospitals (5-7). In these hospitals, due to the low incidence of critically ill children, paediatricians' exposure to ETI is expected to be low (11).

Delivery care is present in most Dutch general hospitals, but neonatal intensive care units (NICUs) are present in only 10 of the 91 Dutch hospitals (5). In general hospitals, neonatal resuscitation is the responsibility of the attending general paediatrician. Approximately 10% of newborns need assistance to start breathing at birth. In total, less than 1% of newborns require extensive pulmonary resuscitative measures (35,36). Since the incidence of ETI in neonates is low, the exposure of general paediatricians to neonatal ETI is also expected to be low.

Unsuccessful and/or prolonged intubation attempts by inexperienced or unskilled providers might lead to complications, such as not obtaining a safe, open airway; trauma to the oropharynx and larynx; prolonged interruption of thorax compression and ventilation during cardiopulmonary resuscitation; and hypoxemia due to prolonged ETI attempts or failure to recognise tube mis- or displacement (33,37). These complications can result in 50–70% mortality (38,39). The incidence of such complications is high when ETI is performed by inexperienced care providers (33,37-39).

2.2 Learning curve in endotracheal intubation

A classic learning curve is seen in the performance of ETI. There is a positive correlation between the number of ETIs performed and the increase of success rate. The average rates of successful ETI were 60% after performing 20 ETIs and 90% after performing 80 ETIs (40). At least 50 to 60 ETI real-life procedures need to be conducted to achieve a 90%

success rate (40-42). Furthermore, it has been shown that the success rate of an elective ETI, under the supervision of a board-certified anaesthetist does not stabilise at 95% until more than 150 ETIs are performed (42). These studies demonstrate a direct correlation between the level of experience of ETI-provider and the success rate, intubation time and number of attempts needed to perform successful ETI (40-42). Despite this, 18% of providers require some form of assistance after performing 80 ETIs (40). Nine percent of the ETIs had to be handed over to a more experienced colleague (42).

These studies include elective ETI procedures conducted in controlled (operating room) settings. In critical care settings, the complexity of the ETI increases (43,44). Difficult ETIs in routine anaesthesiology occur at a rate of 1.15–3.8%. In critical care settings, this percentage increases to 3–5% (44-46). The higher rate of difficult ETIs in emergency settings combined with the accompanying perceived stress as complicating factor, makes it plausible that more than 50 to 60 ETIs are needed to achieve a 90% success rate in critical care settings (43-46). Since the number of ETIs performed in neonatal or paediatric critical care settings is low, it is expected that paediatricians working in general hospitals have little experience in performing on-site ETI. The exposure of paediatric residents to ETI is low as well: in the Netherlands ETI is not an obligatory 'entrustable professional activity' during residency training. It is likely that anaesthetists have more experience with performing ETI in general, but also in performing ETI in neonates and children compared to paediatricians. Considering this, one might expect that in general hospitals anaesthetists perform ETI in critically ill neonates and children. However, formal and informal contact with paediatricians in Dutch general hospitals suggests the opposite, especially in neonates and very young children.

2.3 Objectives

One could hypothesize that, in Dutch general hospitals, both paediatricians and anaesthetists perform ETI in neonates and children. It is expected that anaesthetists have more experience in ETI in general and therefore have better intubation skills. This will result in higher success rates and performance scores compared to paediatricians, even if neonatal and paediatric ETI is performed infrequently. One could hypothesize that protocols concerning local agreements about who should perform neonatal and paediatric ETI in in acute care settings are lacking. The aim of the second part of this thesis is to demonstrate who —the paediatrician or the anaesthetist— is performing ETI in neonates and children in critical care settings in Dutch general hospitals. The objectives on this item are 1) to explore the exposure of paediatricians and anaesthetists to neonatal and paediatric ETI in acute care settings; 2) to compare the intubation skills of paediatricians and anaesthetists in a neonatal and child manikin; 3) to explore if the level of on-site exposure to ETI correlates with the performance on both manikins; and 4) to test if the self-perceived capability of ETI performance correlates with the performance on both manikins, in both groups.

Part three: Paediatric early warning system

3.1 Early recognition of deterioration in hospitalised children

Clinical deterioration resulting in acute lifesaving interventions in hospitalised children is not rare; up to 3% of children admitted to the hospital need some form of critical care during their stays (47,48). Cardiopulmonary arrest in hospitalised children is associated with poor outcomes with high mortality and morbidity (47,48). Children who deteriorate or die unexpectedly in the hospital often have observable signs in the 12-hour period before deterioration (48,49). The results of a paediatric mortality study in the United Kingdom estimate that one out of five (20%) in-hospital paediatric deaths result from detectable deteriorations prior to death. Treatment during the deterioration could have prevented death (49). Avoidable primary care factors include failure in recognising and managing serious infections and inadequate management of asthma and epilepsy (49).

Early recognition of children at risk for deterioration and cardiopulmonary arrest is often difficult and challenging because of the infrequent incidence of such events and the increasing patient-nurse ratio in paediatric facilities (48). Given the low incidence of cardiopulmonary arrests among in-hospital children, it is difficult to maintain adequately skilled staff (48). This complicates the prevention and management of cardiopulmonary arrest in children (48).

The early recognition and treatment of in-hospital children with evolving critical illnesses is a key element in preventing cardiopulmonary arrest and reduces mortality and morbidity (50-52). A pilot study undertaken by the Confidential Enquiry into Maternal and Child Health (CEMACH) states, 'For paediatric care in hospital we recommend a standardised and rational monitoring system with imbedded early identification systems for children developing critical illness and early warning score' (49). At that time, these early warning scores were already used in adult identification assessments to distinguish patients at risk for deterioration linked to a standardised call procedure for a step-up care. However, additional value of adult identification assessments is limited since these systems show high false-positive rates combined with low sensitivity for predicting serious adverse outcome and hospital mortality (53).

3.2 Development of paediatric early warning systems over time

Over the last decade, different kinds of paediatric early warning systems have been designed to improve early recognition of evolving critical illnesses in hospitalised children to avoid further clinical deterioration. This early warning system consists of a predefined set of parameters with age specific cut off points (the afferent limb). This score should be linked to the efferent limb of the system that ensures a standardised procedure for step-up care with accompanying rules for how to react to a decline in the score (50,54). The efferent limb includes the call for assistance from a medical intervention team with skills, competencies and experience in the acute care of critically ill children (50,54). The early

warning score combined with the manner of response to this score is known as the Paediatric Early Warning System (PEWS).

In 2006, Duncan et al described the first PEWS score. They showed that in 78% of the performed rescue calls in order to obtain immediate assistance for the treatment of impending cardiopulmonary arrest, their PEWS might have identified clinical deterioration at least one hour in advance of the adverse event (50). The PEWS score Duncan et al developed relies on 20 vital signs. The sensitivity of 78% and specificity of 90% showed great potential to improve treatment outcome by early detection of evolving critical illness in hospitalised children. However, the length of this 20-item scoring list made it inefficient for use in daily practice.

At the same time, Haines et al developed and validated a 15-item PEWS score called the Bristol PEWS, named after the Bristol Royal Hospital for Children in the southwest of England. Their observational study showed a sensitivity of 99% and a specificity of 66% (55). However, the study had several limitations, which made the 99% sensitivity questionable.

Monaghan and his team at the children's hospital in Brighton, England, designed a nine-item tool called the Brighton score (56). Quist-Therson et al adapted Monaghan's model by using colours as indicators of deterioration (57). The simplicity, efficiency and color-coded hierarchy made this version of the Brighton score more intuitive. Their PEWS showed a sensitivity of 80% to detect patients with Rapid Response Team and code events. These events are defined as an event that involves a patient in need of immediate medical assistance for treatment of impending or actual cardiopulmonary arrest. In a 2009 prospective study, Tucker et al described the sensitivity of the Brighton score at 71% at a score of ≥7 and 90% at a score of ≥3 for detecting clinical deterioration resulting in unplanned transfer to a PICU (58). Akre et al published a retrospective study of the Brighton score and described a sensitivity of 85.5% at a score of ≥4 to detect patients with Rapid Response Team and code events prior to this event (59).

Other PEWS scores have been developed and prospectively tested (see Table 1). In 2009, Edwards et al published a validation study of the Cardiff and Vale PEWS (C&V PEWS) (60). The C&V PEWS was developed by an expert group and was based on eight vital parameters based on the 2005 APLS guidelines for the recognition of sick children (2). The C&V PEWS score has a sensitivity of 70% (60). This study included data until the time of event which increases the apparent performance of these scores. Moreover, in 2009 Parshuram et al published the Bedside PEWS (61). The 7-item Bedside PEWS is the best-known and probably most-used scoring system. The Bedside PEWS was found to have a sensitivity of 82% at a PEWS score of 8 out of 26 (61). In a larger multicentre case control study in 2001, Parshuram at al found the Bedside PEWS showed a lower sensitivity of 64% at a score of ≥7 (62). This sensitivity between 64% and 82% of the Bedside PEWS (61,62) is lower than the 85.5% sensitivity described in the retrospective validation study of the Brighton score (59) and is similar to the initial validation studies reporting sensitivities of 70% for the C&V PEWS score (60) and 71% for the Brighton score (58). Despite these

similarities, the multicentre case control study of the Bedside PEWS is the best validation study. These studies used fixed data ending one hour before the event, no retrospective data was included, and more appropriate outcome measures for clinical practice were used.

Despite many PEWS have been developed and tested, it is unclear which system or system feature is the most useful for detecting deterioration in in-hospital paediatric patients (63). Even the concept of PEWS as a system is poorly developed. Lambert et al recent systematic review confirms that robust empirical evidence on which PEWS' are most effective is limited (63).

Table 1. Overview of sensitivity and specificity of the five major PEWS scores.

Author	PEWS variables	Sensitivity	Specificity	Validation setting
Duncan et al 2006 (Duncan PEWS)	20 items	78%	90%	Tertiary facility setting
Haines et al 2006 (Bristol PEWS score)	15 items	99%	66%	Tertiary facility setting
Tucker et al 2009 (Brighton score)	9 items	90% (≥3)	74%	Tertiary facility setting
Akre et al 2010 (Brighton score)	9 items	85.5%	-	Tertiary facility setting
Edwards et al 2009 (C&VPEWS)	8 items	70%	90%	Tertiary facility setting
Parshuram et al 2009 (Bedside PEWS)	7 items	82%	93%	Tertiary facility setting
Parshuram et al 2011 (Bedside PEWS)	7 items	64%	91%	Tertiary facility setting

3.3 PEWS in the Netherlands

In 2008, the Dutch Hospital Association introduced a safety management system (SMS) called 'Prevent Damage, Work Safely' in response to a national study on potentially avoidable care-related patient damage in Dutch hospitals (64). Based on this SMS, a paediatric safety management programme was developed in 2011. The aim of this programme was to reduce the number of cases of potentially avoidable harm by 50% in the following five years. One of the six themes in this programme was the 'early identification and treatment of critically ill children' (64). In this respect, the expert group recommended to implement a so-called emergency intervention system based on a PEWS score, that should be linked to the efferent component of the system which includes standardised call procedure for step-up care with accompanying rules that describe how to react to a decline in the score (50,54). A PEWS score validated according to Dutch guidelines and the national healthcare system was not available at that time. It was recommended that hospitals should use a validated PEWS score, such as that of Duncan et al (50) or Parshuram et al (61), or a non-validated PEWS score developed by the British National Health Service Institute for Innovation and Improvement (65). This recommendation was given even

though the two validated systems were tested in tertiary facility settings. These systems were not validated in general hospital settings. These PEWS scores were validated in emergency department settings of tertiary facility settings and can be useful for predicting the level of care needed, but are not suited for triage (66).

3.4 Objectives

One could hypothesize that not all hospitals complied with the recommendation to implement a PEWS score, since there was no implementation method or validated PEWS score available for the Dutch healthcare system. The general aim of the last part in this thesis is to determine the current state in Dutch general and tertiary hospitals with regard to the use of PEWS four years after the publication date of the paediatric SMS. This overview of the current situation is needed to obtain information about the changes that are needed to reach a uniform, standard PEWS in the Netherlands. A uniform, standard national PEWS is necessary to study the effects and added value of the PEWS in the Netherlands.

The objectives in this item are 1) to assess the number of hospitals in the Netherlands using a PEWS; 2) to explore which PEWS scores are introduced in the hospitals; and 3) to create an overview of all items used in the PEWS scores.

This thesis aims to identify possible approaches to improve paediatric critical care in Dutch general hospitals by studying the organisation, skills and surveillance in the care of critically ill children.

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Chapter 2

Acute care of critically ill children in general hospitals
Article in Dutch: Acute opvang van kinderen in algemene ziekenhuizen

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Samenvatting

Doel Nagaan hoe de eerste opvang van kinderen in kritieke toestand in algemene ziekenhuizen georganiseerd is, of de zorgverleners voldoende getraind zijn en of de benodigde materialen en medicatie aanwezig zijn.

Opzet Enquêteonderzoek gecombineerd met een bezoek op locatie.

Methode Wij verzonden vragenlijsten aan alle primair betrokken specialisten op de spoedeisende hulp (SEH) en de kinderafdeling, en aan alle secundair betrokken specialisten (anesthesisten en intensivisten) in de 9 algemene ziekenhuizen in Zuidoost-Nederland. 2 onderzoekers voerden op locatie een gestructureerd interview met de verantwoordelijke kinderarts, en controleerden materialen en medicatie op de SEH en de kinderafdeling.

Resultaten Van de 195 verzonden vragenlijsten waren er 97 (49,7%) bruikbaar voor analyse. De respons van de primair betrokken specialisten (77,6%) was ruim tweemaal zo hoog als die van de secundair betrokken specialisten (31,9%). In 7 ziekenhuizen waren mondelinge afspraken gemaakt over de organisatie van de acute opvang, 1 ziekenhuis beschikte over een protocol, 2 ziekenhuizen hadden een werkgroep ingesteld voor dit onderwerp. Van de respondenten wist 1 op de 5 niet dat er afspraken bestonden en veronderstelde ruim 1 op de 3 ten onrechte dat er een protocol was. Van de primair betrokken specialisten beschikten 2 op de 3 over een certificaat voor Advanced Paediatric Life Support (APLS), van de secundair betrokkenen 1 op de 13. Scenariotrainingen werden gegeven in 8 ziekenhuizen. 8 ziekenhuizen beschikten over een kinderreanimatiekar zowel op de spoedeisende hulp als op de kinderafdeling, in 3 ziekenhuizen was deze op beide afdelingen compleet. In 6 van de 9 ziekenhuizen ontbraken larynxmaskers en ventielen voor positieve eindexpiratoire drukbeademing (PEEP-knoppen). De medicatie was in alle ziekenhuizen compleet.

Conclusie In de 9 onderzochte ziekenhuizen verdienden alle onderzochte aspecten (organisatie, training en materialen) aandacht. Veel specialisten bleken niet APLS-gecertificeerd, vaak ontbraken schriftelijke protocollen voor organisatie en scholing. Maatregelen die snel tot verbetering kunnen leiden, zijn het instellen van een werkgroep die zich met de acute opvang van kinderen in kritieke toestand belast, en het invoeren van een uniforme inventarislijst voor spoedopvangmaterialen.

Introductie

Kinderen die in kritieke toestand verkeren omdat de vitale functies -respiratoir, circulatoir, metabool of neurologisch- verstoord zijn of dreigen te worden, worden in Nederland meestal opgevangen in 1 van de 84 algemene ziekenhuizen (1,2). De primaire opvang is doorgaans de taak van de kinderarts, de arts spoedeisende hulp (SEH) of een arts-assistent onder hun supervisie. In tweede instantie kunnen anesthesisten, intensivisten of andere specialisten worden ingeschakeld. De kinderen die er het ernstigst aan toe zijn, jaarlijks ongeveer 1500, worden na de eerste opvang overgeplaatst naar de pediatrische intensive care unit (PICU) van een academisch ziekenhuis. Een algemeen kinderarts zal per jaar gemiddeld 3 kinderen overplaatsen naar een PICU.

De eerste opvang van kinderen die in kritieke toestand zijn, is essentieel voor de prognose. Voor kinderen met septische shock op basis van meningokokkenziekte is bijvoorbeeld aangetoond dat suboptimale organisatie van de spoedzorg tot hogere mortaliteit leidt.[3] De lage incidentie en de grote diversiteit in leeftijden en pathologieën maken het moeilijk om voldoende praktijkervaring op te bouwen. Daarom zijn goede organisatie en adequate training van groot belang (3-9). Er zijn diverse trainingsprogramma's speciaal gericht op de spoedhulp aan kinderen, waaronder pediatric Basic Life Support (pBLS), Advanced Pediatric Life Support (APLS), de APLS-Recertification Course (RCC) en European Paediatric Life Support (EPLS) (10). In Nederland moeten kinderartsen en SEH-artsen gedurende hun opleiding verplicht de APLS-cursus volgen, maar bij herregistratie is de RCC niet verplicht. Omdat acute opvang altijd plaatsvindt in een team van medisch specialisten en verpleegkundigen is het ook belangrijk dat het hele team regelmatig deelneemt aan scenariotrainingen. En tot slot zijn voor de acute opvang bepaalde materialen en medicamenten nodig, al zijn die niet altijd allemaal aanwezig.

Doel van dit onderzoek was het in kaart brengen van de acute opvang van kinderen in kritieke toestand in algemene ziekenhuizen in Zuidoost-Nederland, als aanzet om te komen tot aanbevelingen en een nationale richtlijn. Onderzocht zijn de organisatie, de training van de zorgverleners en de aanwezigheid van materialen en medicatie.

Methode

Medio 2011 verstuurden wij 195 papieren vragenlijsten aan alle kinderartsen, SEH-artsen, anesthesisten en intensivisten werkzaam in de 9 algemene ziekenhuizen in Zuidoost-Nederland. Arts-assistenten lieten wij buiten beschouwing omdat zij geen eindverantwoordelijkheid dragen en hun bezetting relatief snel wisselt. Chirurgen zijn niet aangeschreven; zij zijn weliswaar verantwoordelijk voor de traumaopvang, maar het aantal vitaal bedreigde kinderen met ernstig trauma is veel kleiner dan het aantal met algemeen pediatrische problematiek. Ook andere specialisten zijn niet aangeschreven, want zij

spelen in eerste aanleg geen rol in de behandeling van patiënten met bedreigde vitale functies.

De kinderarts is in principe de hoofdbehandelaar van kinderen die in kritieke toestand verkeren en zorgt zo nodig ook voor de overplaatsing. Daarom hebben wij de kinderarts die verantwoordelijk is voor de organisatie van de eerste opvang op locatie geïnterviewd.

Vragenlijst

De vragenlijst bestond uit meerkeuzevragen en stellingen waarop het antwoord kon worden aangegeven op een 5-punts likertschaal. De vragenlijst omvatte een algemeen deel met vragen aangaande specialisme, ervaring en APLS-certificering, en 3 hoofdstukken over organisatie, trainingen en materialen en medicatie.

Wij verstuurden in totaal 195 vragenlijsten aan 62 kinderartsen, 14 SEH-artsen, 85 anesthesisten en 34 intensivisten. De vragenlijsten waren geanonimiseerd, maar wel gecodeerd op ziekenhuis en specialisme.

Bezoek op locatie

De interviews met de 9 verantwoordelijke kinderartsen werden afgenomen door steeds dezelfde 2 personen. De interviewers vroegen alleen naar feitelijke informatie. Zij controleerden ook de inhoud van de kinderreanimatiekar op SEH en kinderafdeling, aan de hand van een inventarislijst die in eerder onderzoek was ontwikkeld en werd aangevuld met de 'expert opinion' van de 5 kinderarts-intensivisten werkzaam in het Maastricht Universitair Medisch Centrum+ (figuur 1) (11).

Statistische analyse

Bij vragen over de aan- of afwezigheid van werkafspraken, protocollen en werkgroepen werd het mondelinge antwoord van de verantwoordelijke kinderarts als leidend beschouwd. De schriftelijke antwoorden van respondenten werden hieraan getoetst. De analyse is uitgevoerd met behulp van SPSS 18.0; voor de weergave van de resultaten is beschrijvende statistiek gebruikt.

Resultaten

Vragenlijst

Wij kregen 99 (50,8%) van de 195 vragenlijsten retour, waarvan er 97 (49,7%) geschikt waren voor verdere analyse. De respons van de primair betrokken kinderartsen en SEH-artsen, die 59 (77,6%) van de 76 vragenlijsten terugstuurden, was hoger dan die van de secundair betrokken intensivisten en anesthesisten, die 38 (31,9%) van de 119 vragenlijsten terugstuurden.

Figuur 1 Checklist voor de inhoud van de kinderreanimatiekar, zoals gebruikt in het Maastricht Universitair Medisch Centrum+.

Maastricht UMC+

INVENTARISLIJST/CHECKLIST KINDERREANIMATIEKAR

AIRWAY – BREATHING

Non-rebreathing mask (NRM)	□ Kind	□ Volwassen
Beademingsballon (met O_2-bufferzak)	□ Kind	□ Volwassen
PEEP[a]-ventiel	□ 0-10 cmH_2O	□ 0-20 cmH_2O
Beademingsmaskers	□ Maat 00 □ Maat 0/1 □ Maat 2	□ Maat 3 □ Maat 4 □ Maat 5
Mayotubes	□ Maat 3.5 □ Maat 5 □ Maat 5.5 □ Maat 7	□ Maat 8 □ Maat 9 □ Maat 10 □ Maat 12
Laryngoscoop – handvat	□ Groot	□ Klein
Laryngoscoop – onderdelen	□ Batterijen	□ Reservelampje
Laryngoscoop – blad	□ Miller 0 □ Miller 1	□ McIntosh 1 □ McIntosh 2 □ McIntosh 3 □ McIntosh 4
Magilltang	□ Klein □ Middel	□ Groot
Yankauer	□ Aanwezig	
Voerdraad tube	□ Klein	□ Medium
Airwayexchange-katheter	□ 8 French □ 11 French	□ 14 French
Siliconenspray	□ Aanwezig	
Tubes zonder cuff	□ Maat 2.0 □ Maat 2.5 □ Maat 3.0 □ Maat 3.5 □ Maat 4.0	□ Maat 4.5 □ Maat 5.0 □ Maat 5.5 □ Maat 6.0 □ Maat 6.5
Tubes met cuff	□ Maat 3.0 □ Maat 3.5 □ Maat 4.0 □ Maat 4.5	□ Maat 5.0 □ Maat 6.0 □ Maat 7.0 □ Maat 8.0
Larynxmaskers	□ Maat 1.0 □ Maat 1.5 □ Maat 2.0 □ Maat 2.5	□ Maat 3.0 □ Maat 4.0 □ Maat 5.0
Uitzuigunit	□ Aanwezig	
Uitzuigkatheters	□ 6 Charrière □ 8 Charrière □ 10 Charrière	□ 12 Charrière □ 14 Charrière
O_2-cilinder	□ ≥ 100 bar	
Thoraxdrain	□ 10 Charrière □ 12 Charrière	□ 16 Charrière □ 20 Charrière

CIRCULATION

Defibrillator	□ Aanwezig	
Gelpads (defibrillator)	□ Kind	□ Volwassen
Infuusnaald	□ 18 Gauge □ 20 Gauge	□ 22 Gauge □ 24 Gauge
PAC[b]-naald	□ 19 Gauge	□ 20 Gauge
Intraossale naalden (botboor)	□ Aanwezig	
Infuussysteem	□ Druppelkamer □ Perfusorlijn	□ Zijlijn □ Spikes
Infuuszakken	□ NaCl[c] 0.9% □ Glucose 5% □ Glucose 10%	□ Mannitol 15% □ $NaHCO_3$[d] 8.4% □ Gelofusine

OVERIG

Spuit	□ 1 mL □ 2 mL □ 5 mL	□ 12 mL □ 20 mL □ 50 mL
Naalden	□ Intramusculair □ Subcutaan	□ Opzuignaald
Naaldcontainer	□ Aanwezig	
Driewegkraan	□ Aanwezig	
Afsluitdopjes infuus	□ Aanwezig	
Ampulbrekers	□ Aanwezig	
Desinfectans	□ Aanwezig	
Gazen	□ Steriel	□ Onsteriel
Stuwband	□ Aanwezig	
Leukoplast	□ Smal	□ Breed
Scheermesje	□ Aanwezig	
Maagsonde	□ 6 Charrière □ 8 Charrière □ 10 Charrière	□ 12 Charrière □ 14 Charrière □ 16 Charrière
Spuiten voor maagsonde	□ 10 mL	□ 50 mL
Stethoscoop	□ Aanwezig	
Schaar	□ Aanwezig	
Kocher	□ Aanwezig	
Reanimatieprotocollen (per gewichtscategorie) óf PRIL[e]	□ Aanwezig	
Handschoenen (niet- steriel)	□ Small □ Medium	□ Large □ eXtra-Large
Handschoenen (steriel)	□ Maat 6.5 □ Maat 7.0	□ Maat 7.5 □ Maat 8.0
Reanimatieplank	□ Aanwezig	
Verzegeling	□ Aanwezig	

DRUGS

□ Adenosine	□ Dobutamine	□ Flumazenil	□ Lidocaïne 2%
□ Amiodarone	□ Dopamine	□ Furosemide	□ Midazolam
□ Atropine	□ Epinefrine (1:1.000)	□ Glucose 50%	□ NaCl[c] 0.9% kleine flacon
□ Calciumgluconaat 10%	□ Epinefrine (1:10.000)	□ Ketamine-S	□ Norepinephrine
□ Clemastine	□ Etomidaat	□ Kaliumchloride	□ Rocuroniumbromide
			□ Succinylchloride

MONITOR

□ ECG
□ Ademfrequentie
□ $TcSaO_2$[f]
□ ECG-electroden
□ Pulse-oxymeter
□ Capnografie

[a]PEEP: Positive End-Expiratory Pressure; [b]PAC: Port-à-Cath; [c]NaCl: Natriumchloride; [d]$NaHCO_3$: Natriumbicarbonaat; [e]PRIL: Pediatrisch Reanimatie en Interventie Lint; [f]$TcSaO_2$: Transcutane zuurstofsaturatie.

Van onze 97 respondenten meldden er 74 (76,3%) dat er in hun ziekenhuis mondelinge afspraken waren over de opvang van kinderen in kritieke toestand. Van deze 74 meldden er 44 (59,5%) dat deze afspraken ook waren vastgelegd in schriftelijke protocollen en gaven er 39 (52,7%) aan dat in hun ziekenhuis een werkgroep zich bezighield met het onderwerp.

De primair betrokken kinderartsen en SEH-artsen waren in meerderheid APLS-gecertificeerd; 38 (64,4%) van de 59, tegenover 3 (7,9%) van de 38 secundair betrokken respondenten. Op de vraag of er ook scenariotrainingen plaatsvonden, antwoordden 60 respondenten (61,9%) bevestigend, maar slechts 6 (10%) van hen vonden dat de werkafspraken voldoende aan bod kwamen in deze trainingen.

Bezoek op locatie

Van de 9 geïnterviewde kinderartsen gaven er 7 aan dat er mondelinge of schriftelijke afspraken waren. In 1 ziekenhuis waren deze afspraken vastgelegd in een protocol; 2 ziekenhuizen hadden een werkgroep ingesteld om de acute opvang van kinderen te organiseren. Tabel 1 geeft aan welke ziekenhuizen een BLS- of pBLS-training verplicht stellen voor alle artsen en verpleegkundigen, hoe vaak er scenariotrainingen werden gegeven en of ook de kinderarts aan die scenariotrainingen deelnam.

In 3 ziekenhuizen waren de kinderreanimatiekarren op zowel de SEH als de kinderafdeling compleet. Het larynxmasker ontbrak in 4 ziekenhuizen op de kinderafdeling en in 6 ziekenhuizen op de SEH. Een ventiel voor positieve eindexpiratoire drukbeademing (PEEP-knop) ontbrak in 4 ziekenhuizen op beide afdelingen. In alle ziekenhuizen controleerde de verpleging maandelijks de kinderreanimatiekar, in 2 ziekenhuizen controleerde een apotheekmedewerker de medicatie.

Gecombineerde Resultaten

In de 7 ziekenhuizen waar mondelinge werkafspraken waren, was 1 op de 5 respondenten (20,2%) niet bekend met deze afspraken. In het ziekenhuis met het schriftelijke protocol bleek 1 op de 7 (14,3%) niet op de hoogte van het bestaan hiervan, en in de 8 ziekenhuizen zonder protocol verkeerde ruim een derde (34,2%) in de veronderstelling dat dit er wel was. In de 7 ziekenhuizen zonder werkgroep dacht ruim de helft (53,7%) dat deze wel bestond.

In de 2 ziekenhuizen die een multidisciplinaire werkgroep hadden, was de overgrote meerderheid (87,9%) tevreden met de gemaakte werkafspraken, in de ziekenhuizen zonder werkgroep was dat een krappe meerderheid (56,4%). In de 2 ziekenhuizen met werkgroep wisten meer respondenten wie eindverantwoordelijk was voor de opvang (84,8% versus 66,7%) en waren er ook meer tevreden over de organisatie (63,6% versus 51,3%). In de 7 ziekenhuizen zonder werkgroep gaf een grote meerderheid van de betrokkenen (82,5%) aan dat een multidisciplinaire werkgroep de acute opvang van kinderen in kritieke toestand zou kunnen verbeteren.

Tabel 1. Opleiding en training voor de acute opvang van kinderen in kritieke toestand in 9 algemene ziekenhuizen

ziekenhuis	BLS verplicht*	scenariotraining†	
		frequentie	deelname kinderarts
1	ja	1 x per maand	ja
2	nee	1-2 x per jaar	nee
3	ja	2 x per jaar	nee
4	ja	4 x per jaar	nee
5	ja + pBLS	1 x per maand	ja
6	ja	1 x per maand	nee
7	nee	2 x per jaar	nee
8	ja	1 x per maand	ja
9	ja	nooit	n.v.t.

BLS = Basic Life Support, pBLS = pediatric Basic Life Support; n.v.t. = niet van toepassing

* Jaarlijkse BLS- en/of pBLS-training door de Raad van Bestuur verplicht gesteld voor alle artsen en verpleegkundigen.

† Teamtraining voor alle artsen en verpleegkundigen die primair en secundair betrokken zijn bij de acute opvang van kinderen in kritieke toestand.

Beschouwing

In dit onderzoek hebben we alle bij de opvang betrokken specialisten benaderd, omdat we niet alleen geïnteresseerd waren in de organisatie van de opvang en in het trainingsaanbod, maar ook in de individuele bekendheid van de betrokkenen met afspraken en protocollen, in welke trainingen zij gevolgd hadden en in hoe zij deze waardeerden. Opvallend is het grote verschil in respons tussen de kinderartsen en SEH-artsen, doorgaans de eerst betrokkenen, en de anesthesisten en intensivisten, die vaak pas in tweede instantie bij de opvang betrokken raken. Een verklaring is wellicht dat de secundair betrokken specialisten slechts zeer zelden geconfronteerd worden met een kind in kritieke toestand.

Organisatie

De specialisten die betrokken zijn bij de acute opvang van kinderen in kritieke toestand zijn onvoldoende op de hoogte van de bestaande werkafspraken en protocollen. Dit uit zich op tweeërlei wijze: onbekendheid met de werkafspraken die er zijn, en onterechte aannames omtrent de aanwezigheid van protocollen of werkgroepen. Het schaarse eerdere onderzoek bevestigt dit beeld: in 2003 bleek dat slechts 59% van de SEH-hoofden in de Verenigde Staten op de hoogte was van de richtlijnen van de 'American Association of Pediatrics' (AAP) (12,13).

Dat de meeste betrokkenen geneigd zijn de aanwezigheid van protocollen en werkgroepen te overschatten, kan voortkomen uit de aanname dat de reanimatiecommissie

zorgt voor de organisatie van de opvang van kinderen in kritieke toestand. In geen van de ziekenhuizen echter had een kinderarts zitting in de reanimatiecommissie. 'Self-serving bias', een fenomeen waarbij men geneigd is successen toe te schrijven aan zichzelf en falen af te schuiven op externe factoren, zou een andere verklaring kunnen zijn. Immers, een oordeel over de organisatie van het eigen ziekenhuis is indirect ook een oordeel over het eigen functioneren.

De specialisten werkzaam in de 2 ziekenhuizen waar een werkgroep zich bezighoudt met de opvang van kinderen in kritieke toestand zijn tevredener over de gemaakte werkafspraken en de organisatie, en vinden de eindverantwoordelijkheid duidelijker geregeld. Het overgrote deel van onze respondenten is ervan overtuigd dat een multidisciplinaire werkgroep bijdraagt aan een gestructureerde organisatie van de acute opvang van kinderen in kritieke toestand, maar toch heeft slechts een klein aantal ziekenhuizen zo'n werkgroep. Deze discrepantie kan veroorzaakt worden door 'organizational silence': de hiaten in de organisatie zijn bekend, maar worden stilzwijgend voor lief genomen.

Trainingen

De graad van APLS-certificering, evenals de respons op onze vragenlijst, was veel hoger onder de primair betrokken specialisten dan onder de secundair betrokken anesthesisten en intensivisten. Toch heeft ook van de kinderartsen en SEH-artsen nog 35,6% geen APLS-certificaat, zelfs al is de APLS-cursus verplicht in de opleiding en verhoogt zij aantoonbaar het vaardigheidsniveau en het zelfvertrouwen (6,7). Van de 7 ziekenhuizen die een jaarlijkse BLS-training verplicht stellen, vult slechts 1 ziekenhuis deze aan met een specifiek pediatrische BLS- training.

Doordat zij jaarlijks slechts weinig kinderen in kritieke toestand zien, krijgen artsen in de kliniek onvoldoende gelegenheid om hun vaardigheden toe te passen. Scenariotrainingen bieden dan gelegenheid om die vaardigheden extra te oefenen (8). In 8 van de 9 ziekenhuizen worden scenariotrainingen gegeven in wisselende frequentie, van maandelijks tot jaarlijks. Het organisatorische deel van de acute opvang komt echter onvoldoende aan bod in de trainingen. Bovendien worden de scenariotrainingen voornamelijk bijgewoond door verpleegkundigen en arts-assistenten, en slechts zelden door specialisten, terwijl juist gezamenlijke deelname vereist is om de samenwerking in acute situaties te verbeteren (9).

Materialen en medicatie

Alle ziekenhuizen beschikken over een kinderreanimatiekar op de SEH en 8 hebben er ook een op de kinderafdeling. Over het algemeen waren de materialen goed op orde. Alleen larynxmaskers en PEEP-knoppen ontbraken in sommige ziekenhuizen, mogelijk door onbekendheid met deze materialen. Wat ook kan meespelen, is dat er geen uniforme Nederlandse inventarislijsten zijn.

Een vergelijking met buitenlandse ziekenhuizen valt voor de Nederlandse ziekenhuizen zeer gunstig uit, zowel in ons onderzoek als in eerder Nederlands onderzoek (11,14). In 2006 bleek in de Verenigde Staten slechts 7,2% van de SEH-posten volledig te zijn uitgerust met de door de AAP aanbevolen materialen (14). In ons onderzoek was de medicatie compleet in alle reanimatiekarren en waren nergens houdbaarheidsdata overschreden.

Beperkingen

Ons onderzoek heeft enige beperkingen die inherent zijn aan vragenlijstonderzoek: ten eerste zijn vragenlijsten gevoelig voor self-serving bias en ten tweede kan men er niet zeker van zijn dat de respondent de vraag juist heeft geïnterpreteerd. Om dit te ondervangen, hebben wij ons onderzoek uitgebreid met een bezoek op locatie. Een andere beperking is de suboptimale respons op onze vragenlijsten, vooral van de zijde van secundair betrokken specialisten. Een laatste beperking is dat wij het verpleegkundig personeel buiten beschouwing hebben gelaten, terwijl juist deze groep altijd op de afdeling aanwezig is en vaak als eerste bij het kind is.

Aanbevelingen

Er is ruimte voor verbetering van de acute opvang van kinderen in kritieke toestand in algemene ziekenhuizen. Een eerste stap zou zijn het oprichten van een multidisciplinaire werkgroep, samengesteld uit medisch specialisten en verpleegkundigen die betrokken zijn bij deze opvang. Deze werkgroep zou als taak kunnen hebben het maken en implementeren van werkafspraken en protocollen, het opzetten van trainingen en zorg dragen voor de benodigde materialen en medicatie. Voor het draagvlak en de invloed binnen het ziekenhuis zou het goed zijn als de werkgroep zou functioneren onder auspiciën van de Raad van Bestuur.

Een tweede stap is betere training. Men zou voor de primair betrokken specialisten (kinderartsen en SEH-artsen) volledige APLS-certificering verplicht kunnen stellen bij herregistratie. Voor secundair betrokken specialisten is het aan te raden de EPLS-cursus te volgen. Verder zouden alle betrokken specialisten, arts-assistenten en verpleegkundigen regelmatig een verplichte scenariotraining moeten volgen om werkafspraken, protocollen en samenwerking te trainen. Daarnaast kan ziekenhuisbrede bekendheid met kinderreanimatie gerealiseerd worden door BLS-trainingen uit te breiden met pBLS.

Tot slot is één Nederlandse inventarislijst voor kinderreanimatiekarren sterk aan te bevelen.

Conclusie

Ons onderzoek heeft blootgelegd dat ziekenhuizen de acute opvang van kinderen in kritieke toestand in algemene ziekenhuizen aandacht verdient. De verbeterpunten die wij aantroffen, waren voornamelijk het maken van werkafspraken en protocollen, de graad van APLS-certificering, deelname aan lokale (scenario)trainingen en in mindere mate de aanwezigheid van materialen.

In de onderzochte ziekenhuizen bleek ons onderzoek een goede aanzet tot verbetering. Eén jaar na het aanbieden van de aanbevelingen bezochten de onderzoekers de ziekenhuizen nogmaals. Bij dit bezoek waren de kinderreanimatiekarren in alle ziekenhuizen compleet, en was in alle ziekenhuizen een begin gemaakt met het bespreken of vastleggen van de organisatie en het oprichten van werkgroepen.

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Chapter 3

Dutch paediatrician's opinions about acute care for critically ill children in general hospitals

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Abstract

Paediatricians in general hospitals have limited experience with critically ill children, due to the low incidence and their diversity in age, pathology and presentation. Consequently, adequate organization, training and materials and medication are of major importance. This voluntary and anonymous survey-based study was conducted to gain insight in the current status of these aspects. In June 2012, all 687 paediatricians employed at 84 general hospitals in the Netherlands received a hardcopy questionnaire with questions relating to demographics, organization, training and materials and medication concerning the acute care for critically ill children. Of the sent questionnaires, 41.3 % were eligible for analysis. According to the organization of the acute care of critically ill children, 73.9 % of the respondents indicated verbal agreements were made, of which 77.0 % stated that these were recorded in written protocols. Taskforces were present according to 64.5 % of our respondents. Of the respondents, 64.4 % were Advanced Paediatric Life Support (APLS) certified. Of the stated training scenarios, 90.8 % were available in their hospital, which were followed on a regular basis by 63.9 % of the paediatricians. Paediatric resuscitation carts were present on both emergency department and paediatric ward according to 95.1 %. Materials (37.7 %) and medication (45.3 %) were frequently lacking.

Conclusion Paediatricians from general hospitals in the Netherlands consider that acute care for critically ill children has to be improved in terms of organization, training and teamwork, and medication and materials. National guidelines concerning the organization and training may contribute to this improvement, as well as a standardized inventory list for paediatric resuscitation carts.

Keywords Health care delivery-organization of care; Critical illness; Paediatrics; Emergency care; Intensive care unit, paediatric

Introduction

The organization of the admission and treatment of critically ill children is depending on countries and areas (urban versus rural). Critically ill children are defined as children with imminent or manifest compromised vital-respiratory, circulatory, metabolic and/or neurological signs. In the Netherlands, critically ill children are usually admitted primarily to a general hospital (21), and the paediatrician is responsible for the acute care of these children in cooperation with the nursing staff and potentially with the emergency physicians, anaesthetists, intensivists or other members of the medical staff. After the first advanced life support, the most critically ill children are transferred to a paediatric intensive care unit (PICU). Annually, in the Netherlands, around 1500 of these children are transferred from one of the 84 general hospitals to the PICU of one of the 8 University Medical Centers. Considering the number of paediatricians, this leads to an average of three critically ill children per paediatrician per year. The experience with these children is further complicated by their diversity in pathology, age and presentation. The initial approach, assessment and treatment are essential for the prognosis (18). Because of the limited experience, adequate organization and training are of utmost importance to optimize the care for critically ill children (2,6,10,11,13,19,24,25). As one typical example in children with meningococcal disease, suboptimal organization of acute care leads to a higher mortality rate (13).

To optimize the care for critically ill children, the advanced paediatric life support (APLS) course in combination with the recertification course (RCC) and the European paediatric life support (EPLS) and European paediatric immediate life support (EPILS) course are available as training tools (15). The Dutch Foundation for the Emergency Medical Care for Children organizes most of these courses. After completion, APLS certification is made by the Dutch Foundation for the Emergency Medical Care for Children and remains valid for 4 years, after which the RCC or APLS course can be retaken. In the Netherlands, paediatricians and emergency physicians in training are obliged to gain APLS certification, although APLS certification is not mandatory on reregistration as a medical specialist and is not a requisite to obtain a job in the Netherlands. To optimize the performance of the medical and nursing staff involved with the care of critically ill children, local team scenario training is also necessary (7). Finally, these teams need to rely on materials and medication needed for the APLS, often localized in paediatric resuscitation carts. Studies have found these carts to be frequently incomplete (1,4,8,12,16,22).

At the moment, Dutch studies relating to the organization and training are lacking, as are national guidelines and inventory lists. We hypothesized that this might lead to suboptimal organization and training, and incomplete resuscitation carts. We conducted our study to assess the current state of the organization, training and materials and medication for the acute care for critically ill children in general hospitals in the Netherlands, as a first step toward national guidelines and inventory lists.

Materials and methods

In June 2012, hardcopy questionnaires were sent to 687 paediatricians in 84 Dutch general hospitals. The questionnaire started with a general part concerning gender, age, exposure to and interest in the acute care for critically ill children and was followed by three subchapters regarding 1) organization, 2) training and 3) materials and medication. Questions were multiple choice. If protocols, taskforces and/or training scenarios were present, statements were used to assess satisfaction in these items. These statements could be answered using a five-point Likert scale (1 strongly agree to 5 strongly disagree). In order to avoid acquiescence bias, the Likert scale items irregularly alternated between positive and negative statements (9). The questionnaires were anonymous, though coded per hospital. Four weeks after the initial email, an email reminder was sent once. We compared demographic characteristics of the respondents to the membership data of the Dutch Association of Pediatrics ('Nederlandse Vereniging voor Kindergeneeskunde', NVK).

Statistical analyses

Data were analysed using SPSS 21.0 (IBM, New York, USA). Univariate variables were analysed using means and standard deviations (SD) and also by minimum and maximum scores, if not normally distributed (SD; minimum-maximum; number (*N*)). Bivariate relationships of discrete variables were investigated by cross-tabulations and analysed by Pearson's chisquare test. To test representativeness of the results, respondents' demographics were compared to national data from the NVK using the one sample *t* test. Blocks of Likert-type items pertaining to the same subject in the questionnaire were analysed by principal components analysis. Items had to have factor loadings >+0.50 for positively and <−0.50 for negatively formulated statements. Cronbach's alpha was used to test for internal consistency. Scale construction was done by averaging valid item scores to the original five-point Likert scale. A *p*-value <0.05 was considered to be statistically significant.

Results

Out of 687 sent questionnaires, 287 (41.8 %) were returned. Three were excluded due to extensive missing data, leaving 284 (41.3 %) eligible for analysis. The comparison of our demographics with national data showed a significant ($p < 0.001$) overrepresentation of paediatricians aged 30 to 39 years (Table 1). Of the 279 paediatricians, 72.4 % had seen less than 6 critically ill children over the last 12 months (Table 2). On a scale of 1 to 10, with 1 displaying the lowest and 10 the highest possible interest in the organization of acute care for critically ill children, the respondents rated their interest with an average of 7.7 (SD 1.62; 2.00-10.00; $N = 284$).

Organization

According to 73.9 % of the paediatricians, agreements concerning the acute care for critically ill children were made. Furthermore, 77.0 % of these paediatricians declared that these agreements were recorded in a written protocol. Satisfaction with protocols was rated on a five-point Likert scale, using the average of seven items (α=0.87) shown in Table 3, with a mean score of 2.34 (SD 0.62; 1.00-3.71; *N*=150). Regarding the presence of a taskforce charged with the organization of acute care for critically ill children, 64.5 % of the respondents indicated that such a taskforce was present in their hospital. Satisfaction with taskforces was rated on a five-point Likert scale, using the average of seven items (α= 0.80) shown in Table 3, with a mean score of 2.47 (SD 0.58; 1.00-4.14; *N*=93).

Table 1. Demographics of all survey respondents (*n*=284), compared to data from the Dutch Association of Pediatrics ('Nederlandse Vereniging voor Kindergeneeskunde', NVK) of paediatricians working in general hospitals (*n*=551)

	Respondents[a] *n* (%)[c]	NVK membership[b] *n* (%)[c]	*p*-value
Gender			
Female	181 (63.7)	335 (60.8)	0.34
Male	103 (36.3)	216 (39.2)	
Age (years)			
30–39	72 (25.4)	89 (16.2)	<0.001
40–49	121 (42.6)	211 (38.3)	
50–59	72 (25.4)	190 (34.5)	
≥60	19 (6.7)	61 (11.1)	

[a] *N*=284 [b] *N*=551

[c] Due to rounding cumulative percentages, this may not be 100 %

Table 2. Exposure to and interest in acute care for critically ill children

	Respondents[a] *n* (%)[b]
Number of critically ill children seen in the last 12 months[c]	
0	10 (3.6)
1	32 (11.5)
2–5	160 (57.3)
6–10	57 (20.4)
>10	20 (7.2)
Interest in acute care for critically ill children (scale 1–10)	
<6.0	28 (9.9)
6.0–8.0	72 (25.4)
>8.0	184 (64.8)

[a] Unless otherwise specified, total respondents (*n*=284) are described

[b] Due to rounding cumulative percentages, this may not be 100 %

[c] *N*=279, due to missing data (*n*=5)

Training

Of all respondents, 90.9 % had achieved APLS certification at some point in their career. Of the respondents, 2.1 % started the APLS course without acquiring certification and 7.0 % never took the course. At the time of our survey, 64.4 % of our respondents were APLS certified. When analysing for relationships between demographics and APLS certification, we found that paediatricians aged 60 years and over (n=19) were significantly less certified (p=0.037). Concerning training scenarios, 90.8 % of our respondents indicated that these trainings took place in their hospital. Paediatricians participated on a regular basis in 63.9 % of these trainings. Training scenarios were subdivided in basic life support (BLS), paediatric BLS (pBLS), advanced life support (ALS), APLS and newborn life support (NLS). All types of training were given with an average of twice a year, varying from 'never' to 'twice or more monthly'. Satisfaction with training scenarios was rated on a five-point Likert scale, using the average of six items (α=0.78) shown in Table 3, with a mean score of 2.58 (SD 0.65; 1.00-4.50; N=210). Our respondents specifically stated these training scenarios increased their self-confidence on a five-point Likert scale, with a mean of 1.92 (SD 0.65; 1.00-4.00; N=226). In relation to training, we assessed the opinions of the performance of the nursing staff in the emergency department (ED) and paediatric ward (PW) during the acute care. Regarding this subject, 53.9 and 60.5 % of the paediatricians respectively indicated not to be satisfied with their performance.

Materials and medication

As shown in Table 4, 80.3 % of the paediatricians stated to be aware of recent guidelines regarding materials and medication for the acute care for critically ill children. According to 95.1 % of the respondents, a paediatric resuscitation cart was present at both the ED and the PW. Of our respondents, 41.2 % stated these carts were checked at least monthly. Over the past 12 months, paediatric resuscitation carts were often found to be incomplete during the acute care for a critically ill child. Materials were incomplete in 37.7 % and medication in 45.3 % of the carts. Furthermore, 29.3 % of our respondents indicated that they had difficulty finding the necessary materials due to non-uniform lay-out of the carts.

Table 3. Factor loading corresponding to statements regarding protocols, taskforces and training scenarios

Statement	Factor loading
I deem the *protocols* made in my hospital concerning the acute care…[a]	
…still too rudimentary	-0.84
…framed very clear	0.82
…executable in practice	0.77
…incomplete	-0.76
…all-embracing	0.73
…applicable in every acute care setting	0.69
…kept too vague	-0.67
I consider the *taskforce* regarding the acute care in my hospital…[b]	
…to not meet frequently enough	-0.78
…very active in formulating organizational protocols and keeping these up to date	0.75
…not effective in forming agreements concerning the acute care	-0.73
…adequate in reporting frequently and clearly enough about their activities	0.63
…accessible through their contact person	0.62
…rarely noticeable in the actual conduction of the acute care	-0.61
…not open to suggestions from the outside	-0.57
I think the *training scenarios* being conducted in my hospital…[c]	
…are all-embracing, because all possible acute care scenarios are being trained	0.80
…give a very representative image of the acute care for critically ill children	0.77
…succeed completely in training the organisational part of the acute care	0.73
…fail to train the division of tasks of the health care workers	-0.68
…do not emphasize the medical part of the protocol for the acute care	-0.61
…are performed at an adequate rate	0.55

[a] N=150 [b] N=93 [c] N=210

Discussion

The rationale of this questionnaire was to obtain insight in the organization and training of the acute care of critically ill children in the general hospitals in The Netherland and to create awareness of this subject. The ideal way to know the reality is to validate the given answer during site visits to the general hospitals, as we did in our regional pilot study (23). Unfortunately, visiting all hospitals was not a realistic option.

Table 4. Awareness of recent guidelines regarding materials and medication, availability and inspection of paediatric resuscitation carts on both emergency department (ED) and paediatric ward (PW), lacking of materials and medication and non-universally equipped paediatric resuscitation carts

	Respondents[a] *n* (%)[b]
Aware of necessary materials and medication for the acute care of critically ill children according to recent guidelines[c]	
Yes	81 (28.6)
I think so	149 (52.7)
In doubt	28 (9.9)
I do not think so	9 (3.2)
No	9 (3.2)
Not aware of recent guidelines	7 (2.5)
Paediatric resuscitation cart present	
On both ED and PW	270 (95.1)
Present on ED, not on PW	8 (2.8)
Present on PW, not on ED	6 (2.1)
Inspection of paediatric resuscitation cart on a regular basis on both the emergency department and paediatric ward[d]	
Yes, weekly	84 (31.2)
Yes, monthly	27 (10.0)
Yes, unknown frequency	148 (55.0)
Unfamiliar with inspection	10 (3.8)
No, not inspected	0 (0)
Missing materials on either ED or PW in the last 12 months[e]	
Never	332 (62.3)
Occasionally	201 (37.7)
Missing medication on either ED or PW in the last 12 months[f]	
Never	290 (54.7)
Occasionally	240 (45.3)
Inability to find materials or medication due to non-universally equipped paediatric resuscitation carts[g]	
Never	186 (70.7)
Occasionally	77 (29.3)

[a] Unless otherwise specified, total respondents (*n*=284) are described
[b] Due to rounding cumulative percentages, this may not be 100 %
[c] *N*=283, due to missing data (*n*=1)
[d] *N*=269, due to missing data (*n*=1) and lacking of a paediatric resuscitation cart on either ED (*n*=8) or PW (*n*=6)
[e] *N*=533, due to combining valid data from the ED (*n*=258) and PW (*n*=275)
[f] *N*=530, due to combining valid data from the ED (*n*=253) and PW (*n*=277)
[g] *N*=263, due to missing data (*n*=21)

Respondents reported a similar low incidence in exposure to critically ill children as we calculated from the Dutch PICU database. This supports our statement that experience with these children is low. Since real-life experience is low, clear and accessible protocols,

especially concerning organization, together with adequate training programs are of major importance to achieve the best possible care. Despite the fact that the data are limited to one European country, we presume that this does not only apply to the Netherlands but also to other countries.

Publications on the organization of acute care for critically ill children are scarce and show room for improvement (1,8). A first step to improvement is making agreements concerning the responsibilities and tasks either verbal or written during the acute care (10). However, only three quarters of our respondents indicated that these were made.

The other aspect of the organization that we surveyed was the presence of a taskforce charged with the acute care for critically ill children. According to one third of our respondents, such a taskforce was not present in their hospital. It seems contradictory that adults and children differ so much that it is necessary to have their own resuscitation protocols (3,5,14,17), but in most resuscitation committees (RC), paediatricians are not participating. Before conducting this national study, we did a regional pilot in which we also site-visited nine general hospitals. In this study, we did not only find that specialists were unaware of existing agreements, protocols and taskforces concerning the care for critically ill children but also assumed the presence of these while they did not exist (23). Therefore, we strongly recommend the institution of a taskforce for vitally compromised children in all general hospitals. Both medical and nursing staff involved in the acute care of children should take council in this taskforce, which could be subdivided in workgroups tasked with agreements and protocols, training programs and materials and medication. This would preferably be done under supervision of the Board of Directors to increase authority and create a position equal to the existing RC. However, just installing a taskforce might not be enough, which is illustrated in our study by the rather low grade of satisfaction with existing workgroups. Consequently, improvement in existing workgroups seems desirable.

As for training and APLS certification, we found that one out of ten paediatricians never acquired APLS certification and only two out of three paediatricians were APLS certified at the moment of our study. As younger paediatricians are more likely to be APLS certified due to the fairly recent obligation to take this course in their training, the overrepresentation of younger paediatricians might mask an even lower degree of certification. Although the group of paediatricians that were over 60 years of age was small, we found a significant lower degree of certification in this group. A reason could be that older paediatricians lean on their substantial experience or that they do not participate in the on calls anymore. As the interest in the acute care for critically ill children was rated with an average of 7.7, lack of interest does not seem likely to contribute to this low certification grade. This low grade is worrisome, as the APLS course has proven to be effective in increasing self-confidence and improving skills required during the acute care (2,11,19,20). Since the APLS course is one of the best tools, we recommend that APLS, EPLS or EPILS certification should be mandatory on reregistration as a paediatrician or emergency physician. Considering the limited number of critically ill children that

presents themselves at the ED or PW, one cannot depend on these real-life situations and the APLS course alone to remain adequately skilled in this specific type of care. Training scenarios, which have shown to be a valuable asset in maintaining knowledge and practice in acute situations, could be used for this purpose (6,24,25). Nine out of ten respondents reported that at least one type of training scenario was being conducted in their hospital. If present, they also indicated that these scenarios were effective in boosting self-confidence. However, one third of the paediatricians did not participate in these training scenarios on a regular basis. Taking care of a critically ill child requires teamwork for which scenario team training has proven to be an effective medium, but only if the whole team takes part in this training (7). That there is room for improvement of scenario team training is also demonstrated by the fact that more than half of the surveyed paediatricians deemed the nursing staff in the ED and PW not trained well enough in one or more aspects of the acute care for critically ill children. In a team training scenario, these disgruntlements could be made discussible in a safe learning environment instead of during the real-life care for a critically ill child.

Lastly, we focused on the necessary materials and medication. Four out of five paediatricians indicated that they considered themselves aware of recent guidelines regarding the use of materials and medication for the acute care for critically ill children. However, in general, the paediatrician is not responsible for the actual presence of these materials. Only half of the carts were checked on at least a monthly basis, usually by the nursing staff without supervision or use of a universal inventory list. That the content of the paediatric resuscitation carts can be improved is illustrated by the fact that respondents reported these carts were often incomplete. These findings are consistent with prior research (1,4,8,12,16,22). A standardized national inventory list for paediatric resuscitations carts might improve this.

Limitations

The principal limitation of this study is the respondents' familiarity with and knowledge of the addressed subjects as this is a survey-based study. Visiting all hospitals to compensate for this restriction was not a realistic option. Instead of this, we did cross match the answers of all paediatricians employed at the same hospitals and found a substantial amount of contradicting responses regarding the presence of verbal agreements, protocols and taskforces. This implies that there is a lot of obscurity about the organization of the acute care for critically ill children, which is exactly what we are trying to demonstrate with this study and our regional study (23). Other limitations of this study are the number of responses obtained, and the bias related to the paediatricians' age. The fact that we did not test actual skills to compare with opinions of skills is also one of the limitations in this study. Therefore, we are currently performing a study in which we will compare actual endotracheal intubation skill with one's individual opinion on this skill. In this study, we did not put questions on recent guidelines to test opinions about self-awareness of

recent guidelines, because this would enlarge the questionnaire with the risk of a lower response rate.

Conclusions

Paediatricians in general hospitals are seldom confronted with critically ill children. In order to optimize the acute care for these children, adequate organization, training and availability of materials and medication are of utmost importance. Paediatricians from general hospitals in the Netherlands consider that acute care for critically ill children must be improved in terms of organization, training and teamwork, and medication and materials. We think that national guidelines concerning the organization, local taskforces, tightening of the requirements for reregistration and a standardized inventory list for paediatric resuscitation carts can contribute to this improvement.

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Chapter 4

Endotracheal intubation skills of paediatricians versus anaesthetists in neonates and children

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Abstract

Background This study compares the performance of paediatricians and anaesthetists executing a neonatal and a paediatric endotracheal intubation (ETI) in simulated settings.

Methods Participants completed a questionnaire and performed an ETI scenario on a neonatal and a child manikin. The procedures were recorded with a head camera and cameras attached to standard laryngoscope blades. Three blinded experts reviewed all recordings individually. The outcomes were successful intubation, time to successful intubation, number of attempts, complications, and a total performance score. An end-assessment rating from 1 to 10 was given and an assessment whether the participant was sufficiently able to perform a safe ETI.

Results 104 participants (52 paediatricians and 52 anaesthetists), working in Dutch general hospitals and participating in on-call duties, were included. For the neonatal ETI, the rate of successful intubation was in favour of the anaesthetists although not significantly. Anaesthetists performed significantly better in all other outcomes measured. Of the paediatricians, 65% was rated sufficiently adept for a neonatal-ETI *vs* 100% of the anaesthetists. Paediatricians (29%) overestimated while anaesthetists (33%) underestimated their performance in neonatal ETI. As for the paediatric ETI, all outcome measures were significantly better for anaesthetists. Of all paediatricians, only 15% was considered sufficiently able to perform safe paediatric ETI *vs* 94% of the anaesthetists.

Conclusions In this manikin study, anaesthetists were far more adept in performing ETIs in neonates and children compared to paediatricians. Complications are expected to occur less frequently and less seriously when anaesthetists perform ETIs: clear interprofessional agreements on who will perform the ETI are recommended.

Keywords Child; Infant, Newborn; Intubation, Intratracheal; Hospitals, General.

Introduction

Endotracheal intubation (ETI) is the golden standard for securing the airway in situations where the provider is unable to ventilate the patient adequately with a bag-and-mask or by a supraglottic airway device, or if an open airway is compromised (1,2). Unsuccessful intubation-attempts lead to complications, resulting in a high mortality rate (3-6). There is a direct correlation between the experience of the ETI provider and the success rate, intubation time and number of attempts needed for each ETI (7-11).

In Dutch general hospitals the attending paediatrician is responsible for the acute care of critically ill neonates and children, in cooperation with emergency physicians, anaesthetists, intensivists and nursing staff (12). Due to the low incidence of critically ill children and newborns requiring an acute ETI (13-15), the paediatricians' exposure to ETI is expected to be low (12,13).

Our hypothesis is that, since anaesthetists have more experience and exposure in ETI, they have better intubation skills and higher success rates than paediatricians in neonatal and paediatric ETI. The study objectives are; 1) to explore the actual exposure of paediatricians and anaesthetists to ETI in neonates and children; 2) to compare the intubation skills (success rate, intubation time, number of attempts, degree of laryngeal view, complications and overall performance) of both groups in a neonatal and a child manikin setting; 3) to compare the self-perceived capability of the ETI performance with the actual performance on the manikins.

Methods

Study design

A cross-sectional study was performed among paediatricians and anaesthetists, practising in general hospitals. At their respective annual national medical conferences, specialists were asked to volunteer to perform ETI procedures on a neonate and a child manikin. Exclusion criteria for participants were: 1) working in a tertiary facility or university hospital, 2) not participating in neonatal care or acute care of critically ill children, and 3) not participating in on-call duties.

The research and scenario setup were standardised for all settings. All participants started with an electronic survey (Appendix A), after which they continued with the intubation scenarios on both manikins.

Procedures

The electronic survey consisted of a general section concerning age and time since completion of residency, a second section concerning exposure to ETI in neonates and children in the past year, and their self-perceived competence. Also, participants were asked

their opinion about which medical specialist would be the most suited to perform an ETI on neonates and children. General questions were multiple choices. Questions concerning their self-perceived competence or opinions were based on a five-point Likert scale (1= completely incompetent to 5= highly competent) and (1= not at all preferred to 5= very preferred). The questionnaires were anonymous, coded per specialty and linked to the intubation performances on both manikins.

After completing the survey, the participant was equipped with a head camera (Go Pro Hero4 Silver®, San Mateo, United States of America) and proceeded to the intubation scenario on the neonate and child manikins. The setup of both manikins was identical, apart from the manikin size. Participants received information about the manikins age and clinical condition. They were asked to perform an ETI on the neonatal and child manikins just as they would perform it in real-life situations. The intubation procedures were filmed in overview by the head camera. The view from the laryngoscope blades was filmed with 5 mm cameras with lightning (Waterproof Endoscope Camera® USB 5 mm 6LED, J&S United Technology, Taipei, Taiwan), attached to standard laryngoscope blades (Macintosh and Miller), replacing the original light source. The laryngoscope blades and corresponding handles were similar to those used in daily clinical practice. The two manikin scenarios were: 1) Neonate manikin (Newborn Anne, Laerdal Medical®, Stavanger, Norway), representing a full-term newborn female, weight 3500 grams. She was born in the delivery room after an uncomplicated pregnancy. At birth, there was no spontaneous breathing after five sustained insufflation breaths. The circulation was normal. 2) Child manikin (SimJunior, Laerdal Medical®, Stavanger, Norway), representing a six-year-old previously healthy boy admitted to the emergency department with acute respiratory insufficiency and secondary apnoea, but with normal circulation.

Outcomes

Three experts, blinded for the specialty of the participants, individually rated all the videos of the performances of the participants. These experts, further referred to as observers, consisted of a senior paediatric-intensivist, a senior neonatologist and a senior paediatric-anaesthetist, all working in a tertiary facility university medical centre and with extensive experience in airway management. All observers rated the intubation procedures of the participants independently, using the footage from the overview head camera and the laryngoscope blade cameras. A predefined 8-item scoring list (Appendix B) was used to rate the intubation performance, further referred to as the total performance score. Higher scores indicate better performance, positive and negative ratings could be given to different components, with a maximum total score of 13 points. This total performance score was based on 1) steps outlined in the Advanced Paediatric Life Support (APLS) and European Paediatric Advanced Life Support (EPALS) airway management checklists and 2) expert opinion by the observers.

The primary outcome of this study was the intubation success rate defined as an endotracheal tube placed through the vocal cords. Secondary outcomes included the time to successful intubation, the number of attempts, degree of laryngeal view, the number of complications (laryngoscope blade between the vocal cords, oesophagus intubation, transfer the laryngoscope handle from one hand to the other during intubation and incorrect cuff placement (between the vocal cords), and the total performance score (see Appendix B). In addition, an end-assessment rating from 1 to 10 (1 being the lowest and 10 being the highest score) and the impression whether the participant was sufficiently capable to perform a safe ETI in a neonate and a child were secondary outcomes.

Statistical analysis

Characteristics of the participants were reported as absolute values and percentages, stratified by specialty. Differences between paediatricians and anaesthetists were tested using Pearson's Chi-squared test.

For both manikins, the outcome measures of the total performance score and the end-assessment grade between paediatricians and anaesthetists were tested using the Mann-Whitney U test. Differences in the proportion of participants that performed successful ETI and the proportion of participants that were found sufficiently able to perform the procedures were tested using Pearson's Chi-squared statistic. In case of expected cell counts of five or less, we used Fisher's Exact test. The difference between paediatricians and anaesthetists on the number of attempts needed for successful ETI was tested using the non-parametric Mann-Whitney U test, while the difference in total time required to perform ETI was tested using the independent t-test.

In case of disagreement between observers on categorical scales, the category that was scored by the majority was used for the analysis. Otherwise, the average score was used for the analysis for continuous items. We used Cohen's Kappa to determine agreement between observers for binary items, and the intraclass correlation coefficient (ICC) for (semi-) continuous variables. In case of perfect agreement on a binary item, only the total agreement was computed. Self-reported clinical experience and the self-perceived capability of the participants are tested for differences between paediatricians and anaesthetists using Pearson's Chi-squared test. All analyses were performed using IBM (New York, USA) SPSS version 23. Figures were made in R version 3.3.3 (Vienna, Austria).

Results

Out of 132 participants, 104 were eligible for analysis. Twenty-eight (21,1%) participants were excluded because of incomplete survey, incorrect instructions, no on-call duty or video/camera error (e.g. incomplete view). Out of these 104 participants, 52 were registered paediatricians and 52 registered anaesthetists.

Electronic survey

Characteristics of the participating physicians are shown in table 1. There were no statistically significant differences in age or length of time since completion of residency between both groups. Questionnaire responses of the participants about existing agreements on who is performing ETI in neonatal and paediatric acute care settings and who preferably should perform ETI, are shown in table 1 as well.

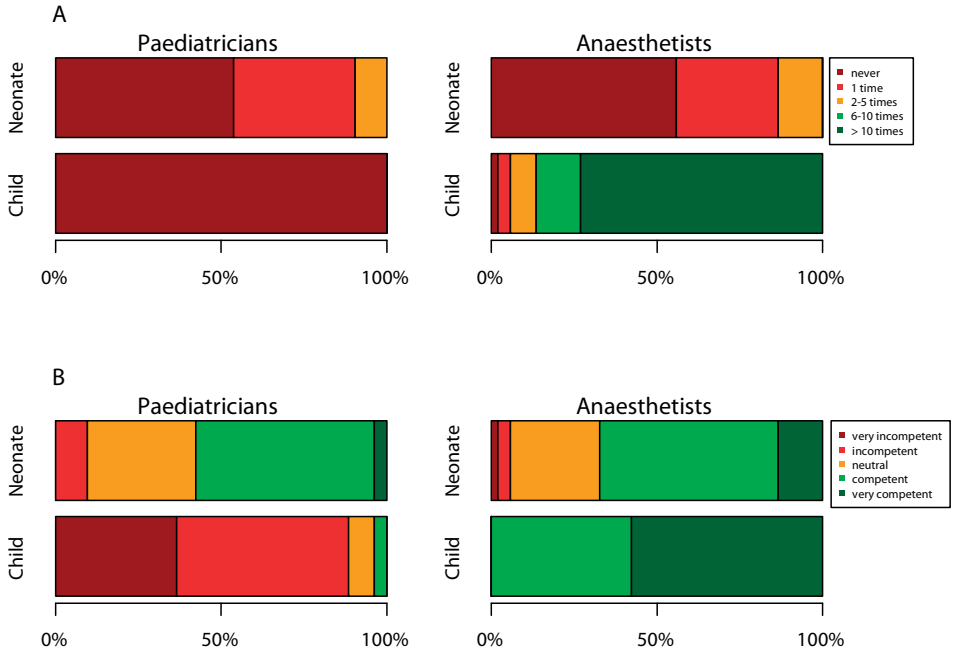
Table 1. Characteristics and questionnaire responses of all participants, stratified by specialty.

	Paediatricians (n = 52)	Anaesthetists (n = 52)	P-value for difference
Age			0.138
< 40 years	8 (15.4%)	10 (19.2%)	
40 - 50 years	32 (61.5%)	21 (40.4%)	
51 - 60 years	7 (13.5%)	15 (28.8%)	
> 60 years	5 (9.6%)	6 (11.5%)	
Time since completion of residency			0.162
< 5 years	6 (11.5%)	9 (17.3%)	
5 - 10 years	11 (21.2%)	8 (15.4%)	
11 - 20 years	27 (51.9%)	19 (36.5%)	
> 20 years	8 (15.4%)	16 (30.8%)	
Are there written agreements about who performs ETI in neonates and children?			0.066
Yes	11 (21.2%)	22 (42.3%)	
No	15 (28.8%)	10 (19.2%)	
Don't know	26 (50.0%)	20 (38.5%)	
Who is performing ETI in neonates and children?			0.047
Paediatrician	2 (3.8%)	11 (21.2%)	
Anaesthetist	29 (55.8%)	21 (40.4%)	
Paediatrician in neonates, anaesthetist in children	5 (9.6%)	2 (3.8%)	
Don't know	12 (23.1%)	16 (30.8%)	
Otherwise ('most capable person')	4 (7.7%)	2 (3.8%)	
Is it preferred that anaesthetist perform the neonatal ETI?			0.010
Not preferred	22 (42.3%)	7 (13.5%)	
Neutral	21 (40.4%)	31 (59.6%)	
Preferred	9 (17.3%)	14 (26.9%)	
Is it preferred that anaesthetist perform the paediatric ETI?			0.030
Not preferred	4 (7.7%)	5 (9.6%)	
Neutral	9 (17.3%)	23 (44.2%)	
Preferred	39 (75.0%)	24 (46.1%)	

Figure 1A shows the distribution of self-reported experiences with ETI of both groups participants over the past year. On average, anaesthetists reported to have performed ETI more often than paediatricians, not statistically significant for ETI in neonates (p =

0.738), but statistically significant for ETI in children ($p < 0.001$). Figure 1B shows the distribution of self-perceived capability of performing ETIs on neonates and children. On average, the self-perceived capability of an ETI in neonates reported by the paediatricians was higher than by the anaesthetists, although not statistically significant ($p = 0.253$). The self-perceived capability of performing an ETI in children was statistically significant higher in anaesthetists compared to paediatricians ($p < 0.001$).

Figure 1A. Self-reported experiences (on a yearly basis) with endotracheal intubation in neonates and children.
Figure 1B. Self-perceived capability of performing endotracheal intubation on neonates and children.



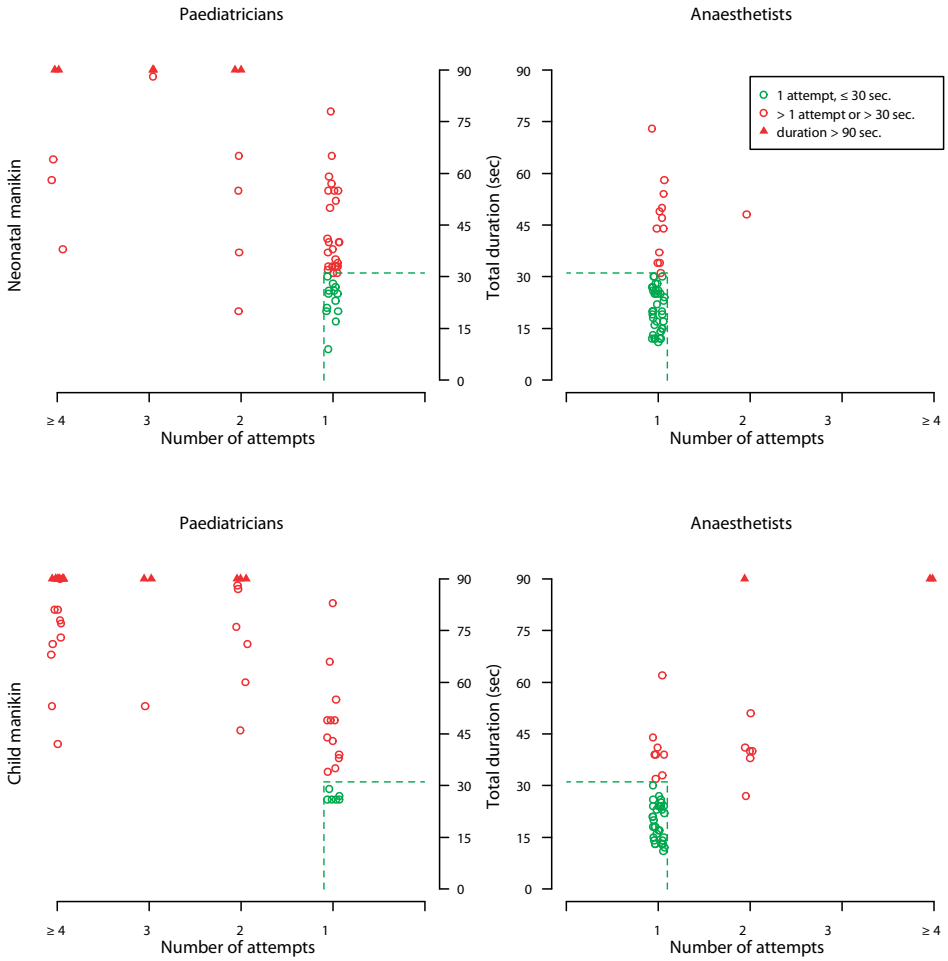
Endo-tracheal intubation performance

We observed a non-significant difference in the proportion of paediatricians *versus* anaesthetists that performed a successful neonatal ETI (i.e. tube in) (90.4% *vs* 100%, $p = 0.057$). The difference in a successful paediatric ETI was statistically significant (paediatricians 57.7% *vs* anaesthetists 96.2%, $p < 0.001$).

On the neonatal manikin 38 (73.1%) paediatricians, succeeded the ETI in one attempt, compared to 51 (98.1%) of the anaesthetists ($p = 0.001$). On the child manikin, 18 (34.6%) of the paediatricians succeeded in one attempt *versus* 43 (82.7%) of the anaesthetists ($p < 0.001$). Two paediatricians (4%) refused to perform the procedure on the child manikin, since they felt not capable of performing the procedure and they would not perform this procedure in their hospital.

Figure 2 shows the distribution of the time and number of attempts needed to perform an ETI on both manikins per specialty. On average, paediatricians needed 47.7 seconds to perform an ETI on the neonatal manikin compared to 27.1 seconds by the anaesthetists ($p < 0.001$). On the child manikin, paediatricians needed 83.4 seconds *versus* anaesthetists 33.6 seconds ($p < 0.001$).

Figure 2. Distribution of the time and number of attempts needed to perform ETI on both manikins per specialty (mirror wise).



The median total performance score using the predefined scoring list (Appendix B) on the neonatal manikin was 7.5 for the paediatricians compared to 11.5 for the anaesthetists ($p < 0.001$). The median total performance score on the child manikin was 2 for the paediatricians *versus* 12.3 for the anaesthetists ($p < 0.001$). For the median total performance

score, the observers had a very high agreement (ICC = 0.983 for the neonate, 0.989 for the child).

The median number of complications on the neonatal manikin was 1.0 for the paediatricians *versus* zero for the anaesthetists (p = <0.001), and on the child manikin 2.0 for the paediatricians *versus* zero for the anaesthetists (p < 0.001). Table 2 shows the complications per specialty. In the child manikin paediatricians produced significantly more complications than anaesthetists. There was complete agreement between the three observers for procedures on both manikins with respect to the complications (ICC = 1.00).

Table 2. ETI complications on the neonatal and child manikin stratified by specialty.

		Paediatricians (n)	Anaesthetists (n)	p-value
Blade between vocal cords	Neonate	16 (30.8%)	9 (17.3%)	0.108
	Child	25 (48.1%)	8 (15.4%)	< 0.001
Tube in oesophagus	Neonate	8 (15.4%)	0 (0.0%)	0.06
	Child	21 (42.0%)	3 (12.5%)	< 0.001
Transferring laryngoscope (form one hand to the other)	Neonate	16 (30.8%)	1 (1,9%)	< 0.001
	Child	19 (38.0%)	2 (3.8%)	< 0.001
Incorrect cuff placement (cuff between vocal cords)	Neonate	-	-	-
	Child	3 (9.7%)	0 (0.0%)	0.114

Paediatricians scored a significantly lower end-assessment grade for the procedure on the neonatal manikin compared to the anaesthetists (median 5.8 *vs* 7.6, p < 0.001). For the procedure on the child manikin, paediatricians scored a median score of 3.5 *vs* 7.3 for the anaesthetists (p < 0.001). The observers' ICC was 0.81 and 0.86 respectively for the end-assessment grades of the participants on the neonatal and child manikin.

For the neonatal manikin, 34 (65.4%) paediatricians were considered sufficiently able to perform the procedure, compared to 52 (100%) of the anaesthetists (p < 0.001). For the child manikin, this was 8 (15.4%) *versus* 49 (94.2%) (p < 0.001). The observers had 100% agreement on these ratings. Figure 3 shows the distribution of the end-assessment grade, the total performance score and the consideration "(in)sufficiently able to perform ETI" on both manikins per specialty.

Table 3 shows the distribution of self-perceived capability of performing ETI in comparison with the qualification given by the observers: in some participants there is a discrepancy between their self-perceived capability and the assessed performance.

Figure 3. Distribution of the end-assessment grade, the total performance score and the consideration (in)sufficiently able to perform ETI on both manikins per specialty.

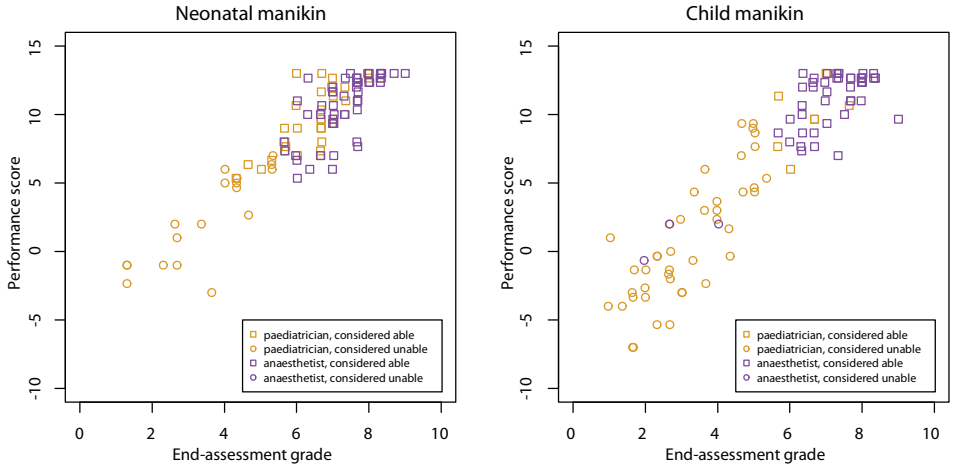


Table 3. Self-perceived capability of performing ETI on neonates and children by paediatricians *versus* anaesthetists, in comparison with their performance on a neonatal and child manikin.

	Neonate		Child	
	Paediatricians	Anaesthetists	Paediatricians	Anaesthetists
Aware of competency	42.3 %	67.3 %	0.0 %	94.5 %
Not aware of competency	23.1 %	32.7 %	15.7 %	0.0 %
Aware of lack of competency	5.8 %	0.0 %	74.5 %	0.0 %
Unaware of lack of competency	28.8 %	0.0 %	9.8 %	5.8 %

Discussion

This study shows that anaesthetists are better in performing ETI on both neonatal and child manikin and perform significantly better on most components compared to paediatricians, resulting in a higher success rate and less complications.

Neonatal ETI

As the survey reveals, the majority of paediatricians and anaesthetists still believe that paediatricians should perform the neonatal intubation, which is based on a historical basis. Yet, the anaesthetist appears to be the most qualified person to carry out this procedure in general hospitals.

Remarkably, one third of the anaesthetists underestimated their capability in performing a neonatal ETI (not aware of competence). A possible explanation is the low number of exposures after finishing their residency. On the other hand, a quarter of the

paediatricians rated themselves capable to perform the neonatal ETI, but according to the observers they were not skilled enough for this procedure (unaware of lack of competence). The difference in the performance of ETI in neonates in favour of the anaesthetists is most likely due to the general skills and experience of anaesthetists on airway management and the lack of this experience of paediatricians.

Paediatric ETI

Concerning the paediatric ETI, differences on all items were highly significant in favour of the anaesthetists, reflected by the high number of anaesthetists graded competent to perform a paediatric ETI. Conversely, in the group of paediatricians only a low number was considered sufficiently able to perform a paediatric intubation. Most paediatricians are well aware of their lack of this competence in paediatric ETI.

The lack of exposure

Studies have shown that 50-60 ETI real-life procedures need to be conducted to achieve a 90% success rate in controlled settings (7-9). However, 18% of providers still require assistance after 80 intubations (8). These numbers will not be achieved by paediatricians in Dutch general hospitals. The exposure of paediatric residents to ETI is low as well: in the Netherlands ETI is not an obligatory 'entrustable professional activity' anymore during their residency training (16-18). Studies on neonatal ETI by paediatric residents show a low success rate of 20-26% (19-22). This is caused by the declining exposure to ETI by the decrease of ETIs performed on neonates due to a shift from invasive to non-invasive respiratory support strategies and antenatal glucocorticoids (23). This lack of exposure to ETI cannot be replaced by simulation-based manikin training, since this training is not a guarantee for successful skills in the acute care setting (24,25).

Although Dutch general anaesthetists have limited experience, especially in neonatal ETIs on an annual basis, they are by far more expert in ETI procedures. They are highly skilled in airway management inclusive the avoidance of potential serious complications. This makes them the most suitable to perform ETI in neonates and children in acute care settings.

Future perspectives for the acute care setting

Actually, in many general hospitals it is often not the anaesthetist who is performing the emergency ETI in neonates or children, but in high incidences still the paediatrician (as a result of historical factors). This undesirable situation might also be the case in other countries. The present study clearly shows the need for a change when it comes to national and local protocols on who should perform an emergent neonatal and paediatric ETI. The lack of agreements on who will perform ETI in neonates and children in the acute setting is highly concerning since this will lead to unsafe situations in which both paediatricians and anaesthetists do not feel responsible and/or capable to perform the ETI.

Facilitation of change

The fact that this study shows that the anaesthetist is the most skilled person to perform the emergency ETI in neonates and children, does not make the implementation of new agreements on this subject easy. In particular, it will be difficult since anaesthetists have a low self-perceived competence in performing neonatal ETI, and in the survey only 27% of the anaesthetists thought they should be responsible for the ETI in neonates. The reticence of anaesthetists to perform an emergency neonatal ETI is maybe due to the difficulty to maintain neonatal ETI skills in general hospitals since the lack of regular on-site ETIs in neonates.

To address this problem, 1) at a national level, an advanced paediatric airway management-training course should be developed for anaesthetists and residents in anaesthesia and be mandatory both during residency and for re-registration. To maintain adequately skilled, attendance at the national courses and local skill-training programmes and assessment are needed since over time there is significant decay in skills when not frequently used or refreshed (26,27). 2) Tertiary care centres have to play a key role in facilitating regional training facilities to enable anaesthetists from general hospitals to remain skilled and confident in neonatal ETI. 3) It is of no use to train general paediatricians in performing ETI when they cannot gain the practical airway-management experience needed to adequately perform ETI. Instead there should be developed a national course for paediatricians and residents in paediatrics to obtain and maintain the skills in non-invasive manoeuvres for free airway, mask-and-bag ventilation and the introduction of a supraglottic airway device. Also, this course should be mandatory during residency and for re-registration in paediatrics.

Limitations

Literature shows that skills learned on manikins are no guarantee for the success in real-life situations (24,25). For this study we used manikins, since it was impossible to perform the meticulous study in vivo on neonates and children. This was the best study design we could conceive to compare two groups of medical specialists in a precise standardised setting. The restrictions given by the manikins were the same for both groups.

Conclusions

Anaesthetists are more successful and better qualified in intubating neonates and children compared to paediatricians. Agreements between these specialties need to be made urgently and translated in concrete national and local protocols with the main appointment that in general the anaesthetist will perform ETI on neonates and children in acute care settings.

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Appendices

Appendix A. Questionnaire

Participant number:

1. What is your specialty?
- Paediatrician
- Anaesthetist

2. What is your age?
- < 40 years
- Between 40-50 years
- Between 51-60 years
- > 60 years

3. Time since board-certification in years:
- < 5 years
- Between 5-10 years
- Between 11-20 years
- > 20 years

4. In which city do you work? (open question)

5. In what kind of hospital do you work?
- Large general hospital
- Middle-large general hospital
- Small general hospital

6. Do you have a subspecialty? If yes, which subspecialty?
- Yes, I am
- No

7. Are you a consultant paediatrician/anaesthetist with on-call responsibilities for paediatric and neonatal care?
- Yes
- No

8.a. How many times in the past year did you perform bag-mask ventilation or did you use a Neopuff (T-piece) on a newborn (<24 hours after birth)?
Never / once / 2-5 times / 6-10 times / > 10 times

8.b. How many times in the past year did you use a supraglottic airway device in a newborn (<24 hours after birth)?
Never / once / 2-5 times / 6-10 times / > 10 times

8.c. How many times in the past year did you perform endotracheal intubation on a newborn (<24 hours after birth)?
Never / once / 2-5 times / 6-10 times / > 10 times

9.a. How many times in the past year did you perform bag-mask ventilation on an infant?
Never / once / 2-5 times / 6-10 times / > 10 times

9.b. How many times in the past year did you use a supraglottic airway device in an infant?
Never / once/ 2-5 times / 6-10 times / > 10 times

9.c. How many times in the past year did you perform endotracheal intubation on an infant?
Never / once / 2-5 times / 6-10 times / > 10 times

10.a. How many times in the past year did you perform bag-mask ventilation on a child?
Never / once / 2-5 times / 6-10 times / > 10 times

10.b. How many times in the past year did you use a supraglottic airway device in a child?
Never / once / 2-5 times / 6-10 times / > 10 times

10.c. How many times in the past year did you perform endotracheal intubation on a child?
Never / once / 2-5 times / 6-10 times / > 10 times

11. Do you find yourself competent to perform an endotracheal intubation on a newborn in an acute setting?
Not at all competent / not competent / neutral / competent / very competent / don't know

12. Do you find yourself competent to perform an endotracheal intubation on an infant in an acute setting?
Not at all competent / not competent / neutral / competent / very competent / don't know

13. Do you find yourself competent to perform an endotracheal intubation on a child in an acute setting?
Not at all competent / not competent / neutral / competent / very competent / don't know

14. How many times do you train the following skills?
a. Neopuff (T-piece) ventilation
Never / once a month / every 6 months / once a year
b. Bag-mask ventilation
Never / once a month / every 6 months / once a year
c. Laryngeal airway mask insertion
Never / once a month / every 6 months / once a year

d. Endotracheal intubation
Never / once a month / every 6 months / once a year

15. How do you train your skills? (multiple answers possible)
- On a manikin
- In the operation room
- On the intensive care unit
- During EPALS / APLS or other courses
- Otherwise:

16. Are there any agreements on which person will intubate a neonate or child in an acute care setting in your hospital?
Yes / No / Don't know

16a. If yes, who will intubate the neonate or child in an acute care setting?
- Paediatrician
- Anaesthetist
- For neonates the paediatrician, for children the anaesthetist
- Intensivist
- ER-doctor
- Don't know
- Otherwise:

17. Are there any written agreements (protocol) about who will intubate a neonate or child in an acute care setting in your hospital?
Yes / No / Don't know

17a. If yes, who will intubate the neonate or child in an acute care setting?
- Paediatrician
- Anaesthetist

- For neonates the paediatrician, for children the anaesthetist
- Intensivist
- ER-doctor
- Don’t know
- Otherwise:

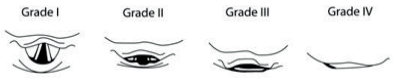
18. Is it your opinion that it is preferred that children are intubated by an anaesthetist?
    Not at all preferred / not preferred / neutral / preferred / very preferred
Explanation (optional):

19. Is it your opinion that it is preferred that neonates are intubated by an anaesthetist?
    Not at all preferred / not preferred / neutral / preferred / very preferred
Explanation (optional):

Appendix B. Total performance scoring list

Total performance scoring list endotracheal intubation of neonatal manikin

Observer:	Participant:			Date:
Choice of materials				
Laryngoscope	Miller 1	Mac 1	Mac 2	
Tube size	tube 2.5	tube 3.0	tube 3.5	tube 4

Intubation (Total performance score)	**Points**	
Pre-oxygenation technique [1]	3	neutral position, adequate CE-grip, frequency 40-60/min
	2	minus 1 item
	1	minus 2 items
	0	minus 3 items
	−2	not conducted
Duration of the successful attempt [2]	1	≤ 30 seconds
	−1	31 sec - 60 sec
	−2	> 60 sec
Duration all attempts (max 3) [3]	3	≤ 30 sec
	2	31 sec - 60 sec
	1	61 sec - 120 sec
	0	> 120 sec
	−1	No successful intubation or ≥ 4 attempts
Number of attemps [4]	3	1 attempt
	2	2 attempts
	1	3 attempts
	−1	≥ 4 attempts or no successful intubation
Bag-mask ventilation between attempts	2	ventilation between all attempts
	−2	no ventilation between one or more attempts
Cormack-Lehane Classification[5]	2	grade 1: most of the glottis can been seen
	1	grade 2: only posterior portion of glottis or only aryte-noid cartilages are visible
	0	grade 3: only epiglottis seen
	−1	grade 4: neither glottis nor epiglottis seen
Potential complicating factors [6]	−2	laryngoscope blade through vocal cords / causing defor-mation
	−1	switch laryngoscope to other hand during intubation
	−2	tube in oesophagus
	−2	incorrect cuff placement: between vocal cords
Tube position	1	correct (oral 10-11cm and nasal 11-12cm)
	−1	too shallow (oral < 10cm and nasal < 11 cm)
	−1	too deep (oral > 11cm and nasal > 12cm)

Check tube position	**points**	
Thoracic excursion	3	≥ 3 items done
Auscultation lung	2	2 items done
Auscultation stomach	1	1 item done
Laryngoscopy	−2	no control
Saturation		
Capnography / End-tidal CO_2		

End-assessment grade

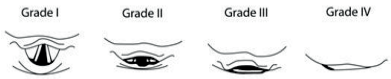
1------2------3-------4-------5-------6--------7--------8-------9-------10

☐ Not sufficiently qualified ☐ Sufficiently qualified

[1] Pre-oxygenation technique: Head in neutral position, correct holding of mask and mandibula according CE-grip, adequate ventilation frequency (40-60/minute).
[2] Duration of successful intubation attempt: Duration of successful intubation attempt was defined as the time from introduction of the laryngoscope blade into the mouth to the time it was removed during the successful intubation attempt. (Successful intubation attempt was defined as the tube passing the vocal cords.)
[3] Duration of all intubation attempts (max 3): was defined as the time from introduction of the laryngoscope blade into the mouth to the time it was removed during all intubation attempts, irrespective of whether a tube was introduced during this attempt. With a maximum of 3 attempts in total.
[4] Number of attempts: was defined as the number of attempts that is needed for successful intubation.
[5] Cormack-Lehane classification: was defined as the glottic visibility according to the Cormack-Lehane classification observed during the successful intubation attempt.
[6] Potential complicating factors: Manoeuvres that can cause traumatic injury or oedema to the vocal cords, mucosa or larynx. Manoeuvres that represent inadequate intubation technique and/or insufficient anatomic knowledge.

Total performance scoring list endotracheal intubation of child manikin

Observer:	Participant:			Date:
Choice of materials				
Laryngoscope	Mac 2	Mac 3	Mac 4	
Tube size	tube 4 tube 5.5	tube 4.5 tube 6	tube 5 tube 6.5	

Intubation (Total performance score)	**Points**	
Pre-oxygenation technique [1]	3	sniffing position, adequate CE-grip, frequency 20-40min
	2	minus 1 item
	1	minus 2 items
	0	minus 3 items
	−2	not conducted
Duration of the successful attempt [2]	1	≤ 30 seconds
	−1	31 sec - 60 sec
	−2	> 60 sec
Duration all attempts (max 3) [3]	3	≤ 30 sec
	2	31 sec - 60 sec
	1	61 sec - 120 sec
	0	> 120 sec
	−1	No successful intubation or ≥ 4 attempts
Number of attemps [4]	3	1 attempt
	2	2 attempts
	1	3 attempts
	−1	≥ 4 attempts or no successful intubation
Bag-mask ventilation between attempts	2	ventilation between all attempts
	−2	no ventilation between one or more attempts
Cormack-Lehane Classification[5]	2	grade 1: most of the glottis can been seen
	1	grade 2: only posterior portion of glottis or only aryte-noid cartilages are visible
	0	grade 3: only epiglottis seen
	−1	grade 4: neither glottis nor epiglottis seen
Potential complicating factors [6]	−2	laryngoscope blade through vocal cords / causing defor-mation
	−1	switch laryngoscope to other hand during intubation
	−2	tube in oesophagus
	−2	incorrect cuff placement: between vocal cords
Tube position	1	correct (oral 15-17cm and nasal 20-21cm)
	−1	too shallow (oral <15cm and nasal < 20 cm)
	−1	too deep (oral >17cm and nasal > 21cm)

Check tube position	**Points**	
Thoracic excursion	3	≥ 3 items done
Auscultation lung	2	2 items done
Auscultation stomach	1	1 item done
Laryngoscopy	−2	no control
Saturation		
Capnography / End-tidal CO_2		

End-assessment grade

1------2------3-------4-------5-------6--------7--------8-------9-------10

☐ Not sufficiently qualified ☐ Sufficiently qualified

[1] Pre-oxygenation technique: Head in sniffing position, correct holding of mask and mandibula according CE-grip, adequate ventilation frequency (20-40/minute).
[2] Duration of successful intubation attempt: Duration of successful intubation attempt was defined as the time from introduction of the laryngoscope blade into the mouth to the time it was removed during the successful intubation attempt. (Successful intubation attempt was defined as the tube passing the vocal cords.)
[3] Duration of all intubation attempts (max 3): was defined as the time from introduction of the laryngoscope blade into the mouth to the time it was removed during all intubation attempts, irrespective of whether a tube was introduced during this attempt. With a maximum of 3 attempts in total.
[4] Number of attempts: was defined as the number of attempts that is needed for successful intubation.
[5] Cormack-Lehane classification: was defined as the glottic visibility according to the Cormack-Lehane classification observed during the successful intubation attempt.
[6] Potential complicating factors: Manoeuvres that can cause traumatic injury or oedema to the vocal cords, mucosa or larynx. Manoeuvres that represent inadequate intubation technique and/or insufficient anatomic knowledge.

Chapter 5

Pediatric Early Warning System Scores: Lessons to be Learned

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Abstract

The objective was to evaluate the use of a pediatric early warning system (PEWS) score in Dutch general and university hospitals, 4 years after the introduction of a national safety program in which the implementation of a PEWS was advised. An electronic cross-sectional survey was used. All general and university hospitals (n=91) with a pediatric department in the Netherlands were included in the study. The response rate was 100%. Three-quarters of all Dutch hospitals were using a PEWS score in the pediatric department. A wide variation in the parameters was found leading to 45 different PEWS scores. Almost all PEWS scores were invalidated, self-designed, or modified from other PEWS scores. In one-third of the hospitals with an emergency room, a PEWS was used with a wide variation in the parameters leading to 20 different PEWS scores, the majority of which are invalidated. Three-quarters of the hospitals did implement a PEWS score. The majority implemented an invalidated PEWS score. This may lead to a false sense of security or even a potentially dangerous situation. Although these systems are intuitively experienced as useful, the scientific evidence in terms of hospital mortality reduction and patient safety improvement is lacking. It is recommended to establish a national working group to coordinate the development, validation, and implementation of a wide safety program and a PEWS usable for both general and university hospitals.

Keywords pediatric early warning system (PEWS); implementation; validation; safety management system; pediatric department.

Introduction

In 2008, the Dutch Hospital Association introduced a safety management system (SMS) called 'Prevent Damage, Work Safely' in response to a national study on potentially avoidable care-related patient damage in Dutch hospitals (1). On the basis of SMS, a pediatric safety management program was developed in 2011. The aim of this program was to reduce the number of cases of potentially avoidable harm by 50% in 5 years. One of the six themes in this program was the 'early identification and treatment of critically ill children' (1). In this respect, the expert group recommended implementing a so-called Emergency Intervention System based on a pediatric early warning score (from here on referred to as PEWS score). This PEWS score, as an afferent component of the system, should be linked to a standardized call procedure for a step-up care with accompanying rules on how to react on a decline of the score as an efferent component of the system (2,3). These scores combined with the manner of response to these scores are known as the Pediatric Early Warning System (PEWS).

A PEWS score validated according to Dutch guidelines and national health care system had not yet been available at that time. It was recommended at the time to use a PEWS score validated according to foreign guidelines, such as that by Duncan et al (2) or Parshuram et al (4), or the invalidated PEWS score developed by the British National Health Service Institute for Innovation and Improvement. This recommendation was provided although the two validated systems were tested in completely different settings. The systems of Duncan et al and Parshuram et al were validated in a tertiary care setting in which the final outcomes, 'resuscitation' and 'urgent admission to the pediatric intensive care unit (PICU)' were used to identify critically ill children. They were validated in emergency departments only for predicting the level of medical care needed but not for triage. The systems were never validated for settings in general hospitals. So, although the Dutch Hospital Association had recommended implementation of early warning systems in all hospitals, no PEWS score had been validated for use in Dutch general hospital settings.

The purpose of this study was to investigate how many hospitals complied with this recommendation and what kind of PEWS scores hospitals choose to use in the Netherlands, 4 years after the introduction of the national safety program, and to determine lessons learned and to be learned.

Materials and Methods

With the aim to establish how many Dutch hospitals did use a PEWS score at their pediatric department and emergency room (ER), and which PEWS score and parameters were used, a cross-sectional survey was conducted by means of an electronic survey (Supplementary Material, available in the online version). The respondents were asked to state their motivation for implementing a PEWS score, and the satisfaction (dichotomous yes-no

questions) with the functioning of the PEWS. All Dutch hospital locations with a pediatric department were included in this study. Hospital locations that provide only outpatient treatment were excluded. At the time of the survey, there were 83 general hospitals and 8 university hospitals in the Netherlands. In total, 91 (general and university) hospital locations with a pediatric department were included in the study. The emergency pediatric patients are primarily seen at the ER in 82 of these 91 locations. At the other nine hospitals, emergency patients are primarily seen at the pediatric ward.

An electronic survey was sent by email to one of the pediatricians of these 91 hospitals between October 2014 and November 2014, with the request to fill out the survey on behalf of their departments or to forward the survey to the person responsible for the PEWS. The pediatricians selected are responsible for the PEWS or have an affinity with acute care or are approached by the department as the representative to fill in the survey. They are consultants to the pediatric ward, the ER, and the outdoor patient clinic. They reflect the consensus of the department in satisfaction questions, for both pediatricians and nurses. Non-responders were sent reminders after 2 and 4 weeks. The missing three hospitals were contacted by a phone call in which the survey was completed. The results were analyzed using SPSS statistics 20.0 (IBM Corp., Armonk, USA); descriptive statistics were used to present the results.

Since this study included no human subjects, approval of the study by the Institutional Review Board was not necessary.

Results

Pediatric Departments

The response rate was 100%. In total, 75% (68/91) of the Dutch hospital locations with a pediatric department implemented a PEWS score at their pediatric department (Fig. 1), including four of the eight university medical centers. The SMS safety program was the most important reason for implementing a PEWS score in 75% (51/68) of the hospitals. Another reason for implementing a PEWS score was the need for better monitoring of the clinical course (22%; 15/68) or after a severe incident (3%; 2/68).

The 68 hospitals with a PEWS score used 45 different versions of PEWS scores, with 20 different parameters in various combinations (Table 1). None of the parameters was used in all systems.

Figure 1. Pediatric early warning system (PEWS) score at Pediatric Departments and Emergency Rooms in the Netherlands.

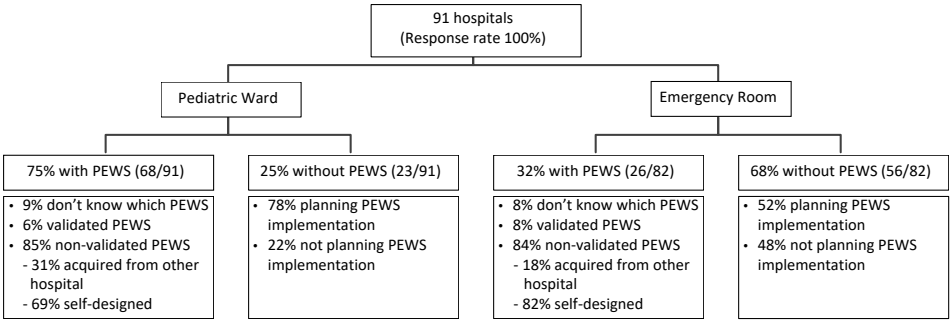

Table 1. Parameters used in pediatric early warning system scores at pediatric ward and emergency room

	Pediatric ward *n* = 68		Emergency room *n* = 26	
Parameter	No.	%	No.	%
Heart rate	66	97.1	25	96.2
Respiratory frequency	66	97.1	26	100.0
Oxygen saturation	61	89.7	24	92.3
Oxygen therapy	53	77.9	20	76.9
Blood pressure	45	66.2	18	69.2
Temperature	43	63.2	17	65.4
Nurses' worried sign	42	61.8	20	76.9
Consciousness	41	60.3	16	61.5
Capillary refill	29	42.6	9	34.6
Parents' worried sign	22	32.3	11	42.3
Respiratory effort	22	32.2	8	30.8
Diuresis / urinary production	6	8.8	3	11.5
Nebulization frequency	3	4.4	2	7.7
Behavior	3	4.4	1	3.9
Color	3	4.4	3	11.5
Convulsion	3	4.4	1	3.9
Persistent postoperative vomiting	2	2.9	1	3.9
Pain score	1	1.5	0	0.0
Chest retractions	1	1.5	1	3.9
Diarrhea	1	1.5	0	0.0

Out of the 68 hospitals using a PEWS score, 15 (22%) indicated that they implemented a validated PEWS score (Brighton PEWS (5), 4/15 or Parshuram, 10/15). One of these 15 respondents did not know what type of validated system was used and 11 did modify the PEWS score by adding parameters. Finally, 3 of the systems were identical to the Parshuram PEWS and none to the Brighton PEWS score. The other hospitals used invalidated

scoring systems (85%; 58/68) or could not indicate what their scoring system was based on (9%; 6/68). The invalidated scoring systems were acquired from other hospitals (31%) or designed by the staff of the hospitals themselves (69%).

Out of the four academic hospitals using a PEWS score, three indicated that they implemented a validated PEWS score but none of these scores were identical to Brighton or Parshuram PEWS score (Table 2). These three were all modified by removing or adding parameters. The parameters added were 'Nurses' worried sign' and/or 'Parents' worried sign'.

Of the respondents using a PEWS, 76% (51/67) indicated that they were satisfied with the functioning of the PEWS score at their department. One hospital with a PEWS was not included in this assessment because the PEWS had been implemented only a few days before the survey was conducted.

In 66 (including the four academic hospitals) of the 68 hospitals (97%) with a PEWS, the first response to an elevated PEWS score was to contact a physician (pediatrician or pediatric resident). Depending on the severity of the score and/or the physicians' opinion, a Rapid Response Team in general hospitals (if this did exist) or a Pediatric Rapid Response Team in academic hospitals was called.

Table 2. Pediatric early warning system scores used in academic and general hospitals

		Which PEWS score at pediatric ward?				
		Validated	Invalidated		Don't know	Total
			Copied (other hospital)	Self-designed / modified		
Type of hospital	General	3	18	37	6	64
	Academic	0	0	4	0	4
Total		3	18	41	6	68

Emergency Rooms

In 26 out of 82 hospital locations with an ER, a PEWS score was used (Fig. 1) including one of the eight university medical centers. The SMS safety program was available in 73% (19/26) hospitals, the most important reason for implementing a PEWS score on the ER. Another reason for implementing a PEWS score was the need for better monitoring of the clinical course (15%; 4/26) or for another reason not further defined (12%; 3/26). The 26 hospitals were using 20 different versions, with 18 different parameters in various combinations (Table 1). In 7 out of the 26 hospitals (27%), the respondents did indicate that they were using a validated PEWS score (Brighton or Parshuram). However, the parameters of these seven 'validated' scoring systems show that only two of the systems were exactly the same as the Brighton or Parshuram PEWS score. The other five systems were modified by the user by adding parameters. This means that validated scoring systems were used in only 8% (2/26) hospitals. Four out of 22 invalidated early warning scores were unpublished systems acquired from other Dutch hospitals, and 18 were scoring systems designed by the staff of the hospitals themselves. Most of these self-designed

scoring systems were designed by pediatricians in collaboration with ER nurses. Respondents of 19 hospitals using a PEWS score in their ER (76%) indicated that they were satisfied with the functioning of the PEWS without formal evaluation. One hospital could not respond in this item since the PEWS had been implemented only a few days before the survey was conducted.

Discussion

In summary, we found that three-quarters of the hospitals did implement a PEWS score. The majority implemented an invalidated PEWS score. This may lead to a false sense of security or even a potentially dangerous situation.

Motivation to Implement PEWS

The main reason for implementing a PEWS was by far the SMS safety program. This result indicates that hospitals have implemented invalidated scoring systems with the extrinsic motivation to merely "check the box" to implement some scoring system rather than out of intrinsic motivation. Implementation of a new scoring system or strategy in safety management in hospitals only based on extrinsic pressure is less likely to be successful than based on intrinsic motivation. The implementation of a new scoring system, not based on intrinsic motivation, needs some outside pressure for a successful change (6). The willingness to accept this new system depends mainly on the level of and the perceived goals behind this pressure (6). In a time that healthcare professionals are more and more occupied with documentation of all kind of data for quality indicators and certifications, the introduction of the new scoring system will only be successful if the usefulness is clear and distinguishable for them (7). Change is possible only if a well-designed intervention and implementation is used. This means that the implementation has to be well-prepared, unequivocal with a clear education of medical and nursing staff and guidance on the workplace, and evaluation on a regular basis (7,8).

The difference in PEWS rate between university (50%) and general hospitals (77%) is substantial. However, no difference in the motivation was found that can explain this discrepancy. This might indicate that there is a reduced feasibility to implement a PEWS score in large-volume hospitals.

Despite the fact that extrinsic motivation was the main reason for implementing a PEWS score, three-quarters of the respondents who used a PEWS score stated that pediatricians and nurses were satisfied with how the PEWS score was functioning at their ward. It appears that the system has an added value for healthcare professionals, even when it occasionally fails; therefore, users also have negative experiences with it.

PEWS at the Emergency Room

Despite the fact that research has shown that a PEWS score is not suitable for a triage of patients at the ER (9), our results show that in one-third of the ERs, a PEWS score could be used as the single triage system or in combination with another triage system. In the latter, it was used mostly as a monitoring system to evaluate the medical condition of the patient over time. PEWS scores at the ER have been validated only in university hospital settings and for predicting the level of medical care needed, particularly with regard to admission to a PICU, but never for triage. The predictive value of PEWS score is based on the progress over time and is not suitable as a single-scoring-triage system (9). Scoring systems like the Manchester triage system, developed and validated as triage systems for children at the ER should be used as predictive triage tools (10). After first triage with such a scoring system, the PEWS score in the ER might be useful if the patient is admitted to the ward as a first scoring point for later trends.

The professionals who are using a PEWS score at the ER should be aware of the incapability of the system as a triage instrument and the potential pitfalls (9).

PEWS at the Pediatric Ward

This study shows that the parameters used in the PEWS score did vary in a wide range and that almost all PEWS scores in use are not validated. It is remarkable that vital parameters such as heart rate, oxygen saturation, and blood pressure were not used in up to 30% of the PEWS scores, where especially heart rate and oxygen saturation are early signs of deterioration. Almost all incorporated PEWS scores were invalidated, self-designed, or modified from other PEWS scores. The Dutch situation corresponds to a large degree with the results of a study conducted in Great Britain (11).

Since the same results are found in Great Britain and the Netherlands, it is quite plausible that also in other countries PEWS scores are in use, that are not validated at all or used in a different setting (general hospital instead of university hospitals) with a different case mix of patients. The early warning scoring systems that have not been validated and currently used in Great Britain and the Netherlands have an unknown positive and negative predictive value. They might be better or worse than the validated scoring systems. In a time in which patient safety has become the main topic of governments and hospital policies, it is remarkable that hospitals develop their own early warning systems without validation. In this way, another checklist is introduced that can create false expectations and sense of safety among the users, especially when they are not aware of the pitfalls of their own PEWS score.

One of these pitfalls is demonstrated by several international studies that showed that validated PEWS scores have a relatively low sensitivity (on average not higher than 70%) and specificity for predicting resuscitation at the pediatric department or admission to a PICU (3,4,12). Another pitfall is the fact that the systems (Brighton, Duncan, and Parshuram) were validated in a tertiary care setting in which the hard final outcomes,

'resuscitation' and 'urgent admission to the PICU' were used to identify critically ill children. These systems have false-negative (underestimate the seriousness of condition resulting in a potential delay of treatment) and false-positive (overestimate the seriousness of condition resulting in a potential over-use of resources and additional costs) results. Although these PEWS scores have limited reliability, at least they have shown to be capable of identifying clinical deterioration in an early phase (3,4,12). Modifications to these scoring systems may alter the sensitivity and specificity of the existing systems, for better or for worse, which may lead to unknown pitfalls. Besides this, the PEWS is only validated in a tertiary care setting. This means that the sensitivity and specificity of PEWS scores in general hospitals and their patient populations are unknown. Remarkably, the four PEWS scores used by tertiary care settings in the Netherlands are all invalidated since they are self-designed (¼) or modified (¾). Despite the lack of evidence for using 'worried sign' as a parameter, all four academic centres added 'worried signs' to their PEWS scores. Of all general and academic hospitals that are using a PEWS score, 77% added 'nurses' worried sign' and 42% added 'parents' worried sign' as a parameter. The need to include 'worried signs' as a parameter is possibly caused by trying to minimize the possible false-negative results.

Besides the fact that the PEWS is only validated in tertiary care setting, it also has to be questioned if the end points of the validation studies of the PEWS in university hospitals are the same that should be used in general hospitals.

Validation studies on the benefits of PEWS in general hospitals and the end points to use are generally lacking (12,13), and needed.

Lessons to be Learned

The current situation with mainly invalidated, self-designed, or modified scoring systems in use can create a false sense of security, and interfere with proving that there is an added value of PEWS for healthcare in general hospitals. A lesson to be learned is that making a safety recommendation to implement the use of a PEWS score, when such a validated score does not exist for use in general hospitals, may result in an improper use of those that are available in an attempt to comply with the recommendations rather than implement a system (including an efferent component) to improve patient safety. The added value of PEWS is not only the scoring system itself (afferent component), but rather the awareness of vital signs created by the implementation of a PEWS score at the ward, and the accompanying rules on how to react on a decline of the score. The imbedding of the system and rules of escalation or de-escalation of care (efferent component) are important factors in the PEWS as a valuable instrument.

Two of the lessons learned from this study is that hospitals in the Netherlands are keen to comply with the safety recommendations to utilize an early warning score for pediatric patients and that the opportunity to implement a validated score across the

nation exist. This has to be well prepared, with a clear education of medical and nursing staff, support to the ward, and evaluation on a regular basis.

Recently, a working group has been established in the Netherlands, which is supported by the Dutch Pediatric Association. This working group will coordinate the development of a PEWS usable for both general and university hospitals, and studies to validate these PEWS. It will also give recommendations for the implementation of this system. It is our opinion that in other countries as well, such a working group appointed and supported by national pediatric associations might play a key role in the development and implementation of pediatric SMS in hospitals.

Limitations of the Study

This is a survey in which the respondents had knowledge of the research topics. The data of each department was obtained from one person. Although the respondent was asked to give the opinion of the whole department of pediatrics including doctors and nurses, there may be a respondent bias. The parameters of PEWS scores were provided by the respondents. These given parameters that will form the PEWS scores were not verified during site-visits or by a document. Moreover, the opinion of nurses was not obtained directly in this study. In a subsequent study, their opinion will also be included.

Conclusion

Four years after the introduction of a national safety program in which the implementation of a PEWS was advised, three-quarters of the hospitals did implement a PEWS score. As there was no standard validated PEWS score available according to Dutch guidelines, the majority implemented a modified or self-designed, invalidated PEWS score. This current situation may lead to a false sense of security or a potentially dangerous situation. To improve this situation, a 'PEWS Taskforce' has been established. The above-mentioned situation is also likely to exist in other countries. For each country, it is recommended to establish a national working group to stimulate and organize the development and implementation of a PEWS score usable for both general and university hospitals.

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Chapter 6

General discussion and future perspectives

Part One: The organisation of acute care of critically ill children

1.1 Organisation of paediatric acute care in the Netherlands

The paediatric intensive care unit (PICU) of the Maastricht University Medical Centre (MUMC+) is the regional tertiary care facility for the nine general hospitals in the south-eastern part of the Netherlands. Children with imminent vital organ failure are transferred to this PICU after initial acute care treatment in the general hospital. During their transfer, the PICUs paediatric retrieval team most often accompanies these children. During visits to general hospitals in the context of these transfers, the retrieval team was confronted with wide intra- and inter-hospital variations in the organisational structure of acute care for paediatric patients, individual levels of training and experience and available equipment and medication. This intra- and inter-hospital variation suggested that standardised logistic protocols and agreements on the organisation of acute care of critically ill children were lacking in the majority of these hospitals. This hypothesis is confirmed by the results of the first regional study, which shows that standardised logistic protocols concerning agreements on the organisation of acute paediatric care were made in one out of nine hospitals. In the national study, 57% of the respondents answered that their hospital had standardised logistic protocols concerning agreements on the organisation of acute paediatric care. This percentage was not verified by site visits and could be an overestimation of reality, since the regional study shows that respondents tend to overestimate the number of standardised logistic protocols that are present at their hospitals. This low number of hospitals with logistic protocols and agreements is a matter of concern, since it is shown that clear working agreements can prevent unnecessary stressful situations that can lead to inadequate acute care (1-3), in particular when real-life exposure to paediatric critical care settings is low (3,4). If logistic protocols and agreements were available, these protocols were mostly developed under the initiative of a small team of doctors and nurses who were dedicated to provide acute care or had experienced serious calamity.

Drawing attention to the lack of protocols is helpful in getting people activated to develop these protocols, as seen in site visits one year after the first study. The majority of the participating hospitals did create protocols, agreements and even task groups to coordinate the organisation of the acute care for critically ill children.

Simulation-based training

The national study 'Monitor healthcare related damage 2015/2016' to investigate avoidable causes of in-hospital mortality and describes organisational processes as an important factor in safer patient care (5). Three important factors of these organisational processes believed to prevent healthcare related damage are 1) adequate skill and multidisciplinary team training, 2) communication flows and 3) reflections on existing behavioural patterns (5). Simulation-based training can, if organised properly with skilled

instructors and dedicated time, stimulate improvement on all three. With regard to the importance of this simulation training the low number of paediatricians that are certified in Advanced Paediatric Life Support (APLS) is worrisome. This number of APLS certified paediatricians should be improved, since the APLS course has an important effect on perceived self-efficacy for resuscitation skills (6,7). Besides this, the course includes simulation scenarios, which have shown to be a valuable asset in maintaining knowledge and practice in acute care situations and promoting teamwork (8-10). There is significant decay in psychomotor skills over time when resuscitation skills are not frequently used or refreshed (11,12). Therefore, paediatricians cannot depend on their infrequent practical contact with acute paediatric care and the APLS course as a single training to remain adequately skilled in paediatric critical care. To prevent this decay of skills frequent simulation training combined with deliberate practice should be organised on hospital level. The first two studies of this thesis showed that, concerning simulation scenarios, the vast majority of respondents indicated that these trainings took place in their hospital. However, one third of the paediatricians did not participate in these training scenarios on a regular basis. Co-operating medical staff members involved in paediatric critical care settings (anaesthetists, intensive care physicians and emergency doctors) did not or rarely participate in these training scenarios. This implies that multidisciplinary teamwork was not part of the training.

One should realise that, concerning the training of acute care, the level of quality and content of these trainings (e.g. focus either on medical content and skills or teamwork, communication/crew resource management) combined with the instructors' qualifications differ in each hospital. Therefore, the fact that scenario training is provided in the vast majority of hospitals does not guarantee that these trainings contribute to the organisational process (teamwork, communication, work flow) during acute care. A standardised simulation-based paediatric resuscitation programme with standard quality, content and assessment is proven to be effective (9) and can easily be evaluated during quality visits with occupational groups. During these quality visits the content, participation numbers and quality of the standardised simulation-based training programme should be evaluated. This is only possible when occupational groups define a framework with terms and conditions of what simulation-based training should include. The board of directors of general hospitals should ensure that all healthcare professionals involved in paediatric acute care can and do participate in the simulation-based training programme on a regular basis, with a good inventory of participation.

Equipment, materials and medication

The presence of adequate material and medications is a prerequisite for optimal acute care and reflects the quality of care delivered in the first period of treatment for critically ill children (2). If the equipment is standardised, the performed procedures may be straightforward, thereby reducing the likelihood of error. Lack of standardisation of

equipment suitable for paediatric patients is a latent error waiting for a specific set of circumstances to manifest itself.

The first two studies of this thesis showed that materials and medication were frequently lacking in general hospitals. In the regional study, supraglottic airway devices and positive end-expiratory pressure (PEEP) valves were often missing. The main reason is presumably a lack of knowledge about materials and equipment and the development of new procedural techniques and materials. A standardised inventory for paediatric resuscitation carts should be developed to improve the content of the carts and reduce the likelihood of error. Paediatric emergency and intensive care specialists, preferably nationwide, should maintain and adjust the list of materials, equipment and medication necessary for APLS.

1.2 Future perspectives of Part One: The organisation of acute care of critically ill children

Recommendations for organisation, training and materials

To make multidisciplinary teamwork in acute paediatric care settings successful, clear standardised logistic protocols, simulation-based training programmes and fully equipped resuscitation carts at the ER and PD are necessary. Therefore, in the first two studies of this thesis it was strongly recommended to create a hospital committee for vitally compromised neonates and children. Both medical and nursing staff from all disciplines that are involved in the acute care of neonates and children should take part in this hospital committee. It might be helpful to make a subdivision into workgroups tasked with 1) agreements and protocols, 2) simulation-based training programme 3) materials and medication. This would preferably be done under the supervision of the board of directors to increase authority and create a position equal to the existing resuscitation committees. This committee should have a sufficient budget to implement and maintain a training programme and to finance the corresponding training equipment as well as the medical equipment needed for the acute care of critically ill neonates and children. The committee should report to the board of directors on an annual base. During their quality visits the National Societies of Paediatrics (*Nederlandse Vereniging voor Kindergeneeskunde* [NVK]), Anaesthesiology (*Nederlandse Vereniging voor Anesthesiologie* [NVA]), adult intensive care (*Nederlandse Vereniging voor Intensive Care* [NVIC]) and the Health Care and Youth Inspectorate must ensure that acute care for neonates and children is well organised.

Beside these national initiatives, regional cooperation among general hospitals and the tertiary paediatric intensive care centre is proven to be essential for adequate patient care (13-15), and a valuable asset in optimising the exchange of knowledge and initiatives to improve care in that region (13-15). Tertiary care centres should therefore contribute to optimise acute care in the referring hospitals. Having PICU teams visit the referring hospitals on a regular basis is one of the best ways to achieve this goal. Tertiary care

centres can also provide training or frameworks for a local simulation-based training programme.

Part Two: Endotracheal intubation

2.1 Endotracheal intubation in neonates and children

Questionnaire responses in the first two studies of this thesis concerning the organisation of acute paediatric care showed that in more than one-quarter of the Dutch general hospitals it was undetermined who performs paediatric endotracheal intubation (ETI) in a critical care setting (3,16). This number was confirmed in the third study of this thesis; a manikin intubation study. This study showed that during acute care settings, neonatal and paediatric ETI is performed by both anaesthetists and paediatricians. In the first, regional study, paediatricians and anaesthetists working in the nine general hospitals in the south-eastern part of the Netherlands found themselves sufficiently trained to perform difficult paediatric airway management, including intubation, in 62% and 80% respectively. This high self-perceived capability among paediatricians in performing ETI is remarkable, given their low on-site exposure to ETI. It is known from several studies that at least 50 to 60 real-life ETI procedures need to be conducted to achieve a 90% success rate in controlled settings (17-19). The manikin intubation study showed that on the neonatal manikin paediatricians tend to overestimate their performance , while anaesthetists tend to underestimate their performance.

2.2 Future perspectives of Part Two: Endotracheal intubation

Agreement on neonatal and paediatric ETI

The manikin intubation study shows that anaesthetists are far more adept in performing ETI on both neonatal and child manikin compared to paediatricians and perform significantly better on most components, resulting in a higher success rate and less complications. This makes the anaesthetist, in most cases, the most capable person to intubate a neonate and a child. This clear conclusion does not make the implementation of new agreements on this subject easy. In particular, it will be difficult since anaesthetists show a low self-perceived competence in performing neonatal ETI combined with the fact that the minority of the anaesthetists stated that they should be responsible for the ETI in neonates. The reticence of anaesthetists to perform paediatric, and in particular neonatal, ETI is maybe due to the difficulty to maintain neonatal and paediatric ETI skills in general hospitals since the lack of ETI in neonates and children. Most paediatricians felt that currently anaesthetists have too little experience with neonatal ETI. However, most paediatricians have low exposure to neonatal ETI as well and are lacking on-site ETI experience and training in general.

The fact that anaesthetists are increasingly keeping neonatal ETI away from their responsibility, combined with the low number of hospitals that have written agreements about who should perform neonatal and paediatric ETI in acute care settings, is highly concerning. This can lead to unsafe situations in which both paediatrician and anaesthetist do not feel responsible and/or capable to perform the ETI. It is remarkable that in a country where patient safety is highly valued, there is no national advice or agreement on who should perform one of the most crucial interventions during the acute care of critically ill children.

At individual hospital level, agreements should be made with regard to who should perform neonatal and paediatric ETI in acute care settings. Anaesthetists are more successful and better qualified in intubating neonates and children compared to paediatricians and therefore should state that performing ETI is part of their discipline. Paediatricians and anaesthetists, as well as the board of directors, should feel responsible to come to an agreement about this subject. These agreements should be confirmed in a local hospital protocol, as discussed in the section 'Recommendations for organisation'. During quality visitations of occupational groups, it can be verified if agreements on this subject are made. A national statement from the NVK and NVA on this subject is needed as well. Initiative to develop a national advice on this subject was recently taken by the NVK and NVA.

Facilitation of change

The maintenance of paediatric and in particular neonatal ETI skills in general hospitals is difficult due to a lack of on-site ETI. To address this problem, 1) tertiary care centres have to play a key role in facilitating regional training facilities to enable anaesthetists from general hospitals to remain skilled and confident in neonatal and paediatric ETI. Tertiary care centres can facilitate local skill-training programmes to enable anaesthetists from general hospitals to perform an established number of ETIs on neonates and children younger than one year on an annual basis. 2) At a national level, an advanced paediatric airway-training course should be developed for residents and anaesthetists. This training course should be mandatory during residency and for re-registration.

In 2015, the Difficult Airway Society (DAS) formed new guidelines for the 'management of unanticipated difficult intubation during routine induction of anaesthesia in aged 1 to 8 years' (20). This kind of guideline should be developed for the acute care setting and for neonates, as well.

The anaesthetist should be familiar with the neonatal life support (NLS) and European paediatric advanced life support (EPALS) or APLS guidelines and local protocols. This is important because all individuals participating in the acute care of neonates and children must function as a team and speak the same medical language. Paediatricians' exposure to and experience with NLS and EPALS/APLS is more extensive than that of anaesthetists. Paediatricians should remain the first responsible person to perform NLS and APLS, but

when ETI is indicated, the anaesthetist is (in most cases) the most capable person to perform ETI.

Alternative airway manoeuvres
It is of no use to train general paediatricians in performing ETIs when they cannot gain the practical airway-management experience needed to adequately perform ETIs. Instead all paediatricians should be competent in the provision of bag mask ventilation and the introduction of a supraglottic airway device. The manikin intubation study showed that only one of the 52 paediatricians used a supraglottic airway device in the past year. Since the use of supraglottic airway devices is not part of the required skills in the residency programme, it is presumed that paediatricians' basic skills and practical experience with supraglottic airway devices is low. The only national courses where there is some attention to supraglottic airway devices are the APLS and EPALS.
Paediatricians should obtain and maintain skills in alternative non-invasive airway manoeuvres to secure a free-airway, bag mask ventilation, ventilation by Neopuff and the introduction of a supraglottic airway device. This can be done by local skill training organised by the hospital committee for vitally compromised children, but should also be an important part of the national training programmes (APLS and EPALS).

Future research
Future research is required to monitor the effects of these proposed changes concerning clear agreements on who should perform ETI in neonatal and paediatric acute care settings. Since organisational factors always differ at local hospital level and because of the low incidence of neonatal and paediatric ETI in general hospitals, it will be difficult to study the effects of new agreements and training in terms of improvements in clinical outcome measures. However, it is possible to study the perceived added value and effect with regard to patient safety using qualitatively study designs. This study design to evaluate the effect of the new agreements can prove useful and relevant data about the perceived value of these agreements. The success of the advanced paediatric airway-training course can be measured by changes in skills, knowledge scores and perceived self-capability.

Part Three: Paediatric early warning system (PEWS)

3.1 Added value of PEWS

Four years after the introduction of the national safety management system three quarters of Dutch hospitals implemented a paediatric early warning system (PEWS). The vast majority of the hospitals implemented a non-validated, self-designed PEWS score since a national PEWS score was absent at that time. The use of non-validated scores with

unknown sensitivities may lead to a false sense of security or a potentially dangerous situation.

The contribution of PEWS systems to patient safety is questionable, but it seems that PEWS systems are considered useful since the majority of hospitals in western Europe, Canada and the United States use them (21,22). Qualitative studies of professionals' perceptions of the effects of PEWS on patient safety in clinical wards show positive effects of PEWS on situational awareness among professionals (21,22). For example, users of the PEWS state that having predefined values for vital signs helps users quickly detect abnormal values. Users also notice that the PEWS facilitate communication between nurses and doctors (21). Despite this, the positive effect on situational awareness only affects the perception of relevant information about the patient's actual state in the moment and does not stimulate the interpretation of relevant information or the application of this information to the future status of the patient (21). This is why a PEWS system on its own cannot predicting patient future status accurately and gives a possible explanation for the low sensitivity that all adequately validated PEWS scores of the last decade show (23). The question is how to improve this sensitivity, stimulate the interpretation of relevant information and convert this to the future status of the patient. By incorporating PEWS in a multifactorial patient safety system a more reliable safety tool for the early detection of deterioration is created. There are three important factors that can increase accuracy of a safety system in early detection of deterioration: 1) adequate implementation, 2) integration of so-called risk factors and 3) maintenance of the safety system as an inseparable set of tools.

3.2 Adequate implementation

Early warning scores need four main components that all contribute to an overall patient safety system: 1) the afferent component, which consists of a safety system including a PEWS score that detects patients at risk for clinical deterioration and initiates an adequate reaction; 2) the efferent component, which consists of the staff and resources that react to an alarming PEWS score for step-up care with accompanying rules for how to react to a decline in the score; 3) the quality and process improvement component, which includes monitoring and evaluating the functioning of the afferent and efferent components; and 4) the governance component, which covers the processes and education needed to implement and maintain the system (23).

3.3 Integration of PEWS and static risk factors in an overall patient safety system

Adequate implementation of a solitary PEWS system, according the above-mentioned items, will not largely improve the limited predictive validity of PEWS. A second important component that may improve the predictive validity for clinical deterioration is including static risk factors in the system (21,22,24). The fourth study of this thesis showed that two thirds of hospitals with a PEWS already included nurses' worries about the progress of the

physical condition ('worried signs') as an item. About one third of the hospitals with a PEWS included parents' worries as an item. This shows that the majority of healthcare professionals in the Netherlands who created a PEWS score value worried signs as a contributing factor for the early detection of clinical deterioration. A worried sign can be relevant at an early phase of detection, even when vital signs are still normal (21,24). However, incorporating worried signs into the PEWS might underestimate the relevance of these worried signs, since the PEWS will not cause alarm in most systems when other items score normal. Therefore, worried signs should not be incorporated in the PEWS but should be a separate factor that activates the safety system. When underlying causes of a complicated disease course are studied parents' or professionals' worried signs and postoperative care that might involve vital functions appear to be relevant risk factors (24).

The integration of static risk factors into a patient safety system is needed to further improve the early identification of patients at risk for deterioration. In 2014, de Vries et al. implemented such an integrated system called the Pediatric Risk Evaluation and Stratification System (PRESS) in a tertiary care setting. The PRESS is a risk evaluation system that integrates 1) a subset of static predefined risk factors, 2) dynamic vital parameters (PEWS) and 3) patient responsiveness (alert, verbal, pain, unresponsive [AVPU] score). Predefined risk factors are worried signs (including family concern), 'ICU involvement', 'high-risk treatment' (a potentially risky treatment with which professionals have limited experience) and 'transferred patients from general hospitals' (transfers made during on-call hours when staffing is limited). On admission, all hospitalised patients are classified into risk categories (standard, medium or high) according to the PEWS, their AVPU score and the coexistence of the above risk factors (21). Figure 1 shows an example of Radboudumc Amalia Children's Hospital's PRESS. A qualitatively study of professionals' perceptions of the value of the PRESS points out that the PRESS provides a greater understanding of the situation and stimulates professionals to think about risk factors, whereas PEWS only facilitates the observation that something is wrong (21). Professionals are forced to consider and anticipate possible aberrant clinical courses in patients as a result of this by assigning a PRESS risk category to a patient. Since this anticipating behaviour is especially activated in patients with normal PEWS scores, it confirms its added value independent of the PEWS at an early stage (21). In PRESS, proactively looking for risk factors helps to clarify the clinical context and directly improves the ability to predict the future status of patients. This describes the actual added value of a multifactorial safety system including static risk factors (21).

Figure 1. Example of the PRESS used in Radboudumc Amalia Children's Hospital

	Medical specialism	Diagnosis	PEWS/AVPU/PRESS	PRESS status	PEWS
Patient A	Pediatric nephrology	Kidney transplant (recipient)	1/A/Worried sign	☹	☺
Patient B	General pediatrics	Gastro-enteritis	1/A/None	☺	☺
Patient C	Pediatric pulmonology	Status asthmaticus	13/A/ICU involved	☹	☹

3.4 Maintenance of the patient safety system

The quality and process improvement component

It is a misconception to assume that after an apparently successful implementation, the patient safety system does not require any further maintenance. As in each quality intervention, the evaluation and adjustment of the patient safety system are essential to achieve and retain added value. This evaluation of quality improvements in the patient safety system may involve measuring process indicators (e.g. the percentage of patients with a PEWS score) or outcome measures (e.g. the effects on the number of resuscitations, urgent admissions to the PICU and acute interventions to prevent further deterioration). As well, measuring softer indicators such as the added value experienced by healthcare professionals may help to assess whether the system has been properly implemented. These kinds of data may be communicated to the users in order to motivate them to keep using the system. Validation studies using other endpoints more suitable for general hospitals are largely lacking (25,26).

The governance component

Organisational leadership to guide the implementation and education process is needed to make the patient safety system successful in the paediatric ward. The patient safety system can only be successful if key leaders in the hospital actively promote the importance of using it. Leadership and accountability are required to guarantee the proper long-term use of the system. It is essential to set up a well-organised training programme in which the users are informed about the advantages and disadvantages of the system. This education programme is essential since users of the system should know the potential pitfalls in view of the sensitivity limitations. It is essential for users to be aware that PEWS scores are regularly false negatives, which results in patients who urgently need acute care and admissions to the PICU, but who are not identified in a timely manner.

Knowledge of the system limitations helps users stay motivated to use it properly, even when they have seen the system produce false-negative scores on occasion.

Hospitals are dynamic environments with relatively high staff turnover. This poses a risk to the retention of knowledge about the implemented safety system. A standard training programme in which new healthcare professionals are informed about the advantages and disadvantages of the system could prevent this loss of knowledge.

3.5 Future perspectives of Part Three: Paediatric early warning system (PEWS)

To address the proliferation of unvalidated PEWS scores in the Netherlands a national 'PEWS workgroup' is established to coordinate the development, validation and implementation of a 'core set' of PEWS parameters as dynamic patient risk factors, usable for both general and academic hospitals.

Since the PEWS on its own is hardly beneficial for improving outcomes in in-hospital children, it must be introduced in daily practice as a part of a larger overall patient safety system. The PEWS has to be seen as a part of a stratification system such as the PRESS and possibly as part of a big data patient safety monitoring system.

Besides patient care, modern healthcare is directed by record keeping and regulatory requirements that deliver large amounts of data. In the healthcare industry, the term 'big data' describes the totality of data allied to patient healthcare and wellbeing (27). This big data contains clinical data and support systems (e.g. physicians' notes and prescriptions, imaging, laboratories, pharmacies, insurance and other administrative data); patient data in electronic patient records; and sensor- or machine-produced data (e.g. monitoring vital signs, social media posts, status updates etc.) (27,28). Besides this, general data like emergency care data, newsfeeds and articles in medical journals are also included (27,28). Analysing this big data reveals associations, personal patterns and trends in vital functions that give the opportunity to identify which admitted patients are at risk of deterioration and should be monitored to prevent deterioration or when to act in an early phase of deterioration (27,29-31). Big data in healthcare is overwhelming in its diversity of data types and volume, and because of the speed at which it must be managed (27) there must be a 'control centre' in the hospital were the data is synthesised and analysed using custom made software so that the emergent associations, patterns and trends can be transferred to the physician and patient, who can include this information in the decision-making process. In the future, big data patient safety monitoring systems may improve care, save lives and lower costs by extracting insights in order to make better-informed decisions (27,29-31).

It would be interesting to investigate the PEWS as multifaceted system that is part of a more extensive safety culture influenced by human and organisational factors (23). Qualitative study designs for validating PEWS and other scoring systems, such as the PRESS, can provide useful, relevant data about the perceived value of these scorings systems, underlying success factors and clues for further improvement. At this time, the Health Care and Youth Inspectorate pays too much attention to the implementation of the PEWS as a standalone system. Only checking compliance with the implementation of

the PEWS will not bring a reliable patient safety system into paediatrics. Instead of this, the Health Care and Youth Inspectorate, in collaboration with the NVK, should support further developments to the PEWS as a part of the PRESS and a more-extensive safety system. Scorings systems such as PEWS and PRESS should be subsystems in a larger, multifaceted safety framework that develops over time with strong governance and leadership, targeted training for knowledge retention and ongoing quality improvement.

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Chapter 7

Summary

Samenvatting

Valorisatie

Summary

This thesis focuses on the current state and future perspectives of the organisation of acute care for critically ill children in Dutch general hospitals. It also addresses the early recognition of deteriorating of in-hospital paediatric patients vital signs, in order to allow instant intervention to prevent further deterioration and life-threatening events. The ultimate goal is to identify possible approaches to improve the care for paediatric patients in (Dutch) general hospitals in the context of organisation, monitoring and endotracheal intubation.

Part 1. The organisation of acute care of critically ill children

Hospital-level agreements and protocols concerning the organisation of paediatric acute care, including the training, materials and medication needed to provide adequate acute care were assessed at regional (2011) and national (2012) level in the first part of this thesis.

In the regional study all 195 paediatricians, anaesthetists, intensive care- and emergency doctors employed at the 9 general hospitals in the south-eastern part of the Netherlands received a hardcopy questionnaire with questions relating to demographics, organisation, training and materials and medication concerning the acute care of critically ill children. Of all returned questionnaires, 50% were eligible for analysis. Hospital visits were conducted to verify if organisational protocols were present and to check the inventory of paediatric resuscitation carts.

Agreements and protocols on hospital-level were lacking in 8 out of 9 hospitals. The presence of logistic protocols was overestimated by medical staff members. Scenario training was given in 8 out of 9 hospitals but paediatricians do not participate in most cases. Around two-thirds of the paediatricians was certified in Advanced Paediatric Life Support (APLS). In 8 out of 9 hospitals a paediatric resuscitation cart was present at the paediatric department and emergency room (ER). In 3 out of 9 hospitals both resuscitation carts were completely equipped.

All 687 paediatricians employed at 84 general hospitals in the Netherlands received a hardcopy questionnaire with questions relating to demographics, organisation, training and materials and medication concerning the acute care of critically ill children in the national study. Of all returned questionnaires, 41% were eligible for analysis. Around 57% of the respondents stated that their hospital had a logistic protocol concerning agreements about the organisation of acute paediatric care. This percentage was not verified by site-visits. Answers of all paediatricians employed at the same hospitals were cross matched and a substantial amount of contradicting responses regarding the presence of verbal agreements, protocols and taskforces were found. This implies that there is a lack of clarity about the organisation of the acute care of critically ill children.

Scenario training was given in 91% of the hospitals. Around two-thirds of the paediatricians participated in these trainings on a regular basis. The same number of paediatricians

were certified in Advanced Paediatric Life Support (APLS). Paediatric resuscitation carts were present on both emergency department and paediatric ward in 95%, but materials (38%) and medication (45%) needed to provide acute care were frequently lacking.

In conclusion, the organisation of neonatal and paediatric acute care in Dutch general hospitals can be improved. On hospital level, a multidisciplinary committee for vitally compromised neonates and children is strongly recommended. This multidisciplinary committee can provide and oversee a standardised, adequate organisation of paediatric critical care. Both medical and nursing staff from all disciplines that are involved in the acute care of neonates and children should take part in this hospital committee. It might be helpful to make a subdivision into three workgroups tasked with the development of 1) logistics protocols and agreements, 2) a standardised high-quality simulation-based training programme with personalised participation and assessment programme, 3) a standardised inventory list with corresponding inventory control system for paediatric resuscitation carts, that include all medication, materials and equipment needed to provide optimal paediatric acute care.

This committee would preferably act under supervision of the board of directors to increase authority and create a position equal to the existing resuscitation committees. There should be a sufficient budget to implement and maintain a standardised simulation-based training programme and to finance the corresponding training equipment as well as the medical equipment needed to provide the acute care in practice. The committee should report to the board of directors on an annual basis. The organisation of the neonatal and paediatric critical care can be evaluated during quality visits by occupational groups. Beside these national initiatives, regional cooperation among general hospitals and the tertiary referral hospital is proven to be essential in adequate patient care. This cooperation is a valuable asset in optimising the exchange of knowledge to improve the acute care. Tertiary care centres should therefore contribute to optimise acute care in the referring hospitals.

Part 2. Endotracheal intubation

The second part of this thesis explored the actual exposure of paediatricians and anaesthetists to endotracheal intubation (ETI) in neonates and children in general hospitals. It described the interprofessional agreements that were made on this subject and compared the intubation skills of both groups in a neonatal and a child manikin setting. The self-perceived capability of the ETI performance was compared with the actual performance on the manikins. In a cross-sectional study 52 paediatricians and 52 anaesthetists, working in Dutch general hospitals and participating in on-call duties, were included. Participants completed a questionnaire and performed an ETI scenario on a neonatal and a child manikin. The procedures were recorded with a head camera and a camera attached to standard laryngoscope blades. Three blinded experts reviewed all recordings individually.

The results showed that agreements on who was performing neonatal and paediatric ETI were frequently lacking. Of the participating paediatricians and anaesthetists 21% and 42% respectively reported that these agreements were made. The exposure to neonatal ETI was nearly equal among paediatricians and anaesthetists. The exposure to paediatric ETI was significantly higher among anaesthetists compared to paediatricians.

Concerning the neonatal ETI procedure, except for success rate (i.e. tube through vocal cords), anaesthetists perform significantly better on all components (time to successful intubation, number of attempts, complications, total performance score, end-assessment rating and estimated sufficiently able/unable to perform a safe ETI). Of all paediatricians, 65% was considered sufficiently able to perform a safe neonatal ETI compared to 100% of the anaesthetists. Concerning the paediatric ETI procedure, differences on all items were highly significant in favour of the anaesthetists. Of all paediatricians, 15% was considered sufficiently able to perform a safe paediatric ETI compared to 94% of the anaesthetists. Around 29% of the paediatricians tended to overestimate their performance in neonatal ETI, while 33% of the anaesthetists tended to underestimate their performance in neonatal ETI.

In conclusion, anaesthetists were far more adept in performing ETI on both neonatal and child manikin compared to paediatricians. Complications were expected to occur less frequently and less seriously when anaesthetists performed ETI. This makes the anaesthetists, in most cases, the most skilled and capable person to perform neonatal and paediatric ETI in acute care settings.

Despite this clear difference in level of performance, only one quarter of all participants stated that anaesthetists should perform ETI in neonates. The situation in which both paediatricians and anaesthetists did not feel responsible and/or capable to perform (in particular neonatal) ETI in paediatric acute care settings can lead to inadequate care and unsafe situations. Interprofessional agreements need to be made and translated into concrete national and local protocols.

Implementation of new agreements on this subject will not be easy since anaesthetists showed a relatively low level of self-perceived competence in performing neonatal ETI, combined with the fact that only one quarter of the anaesthetists thought that they should be responsible for neonatal ETI. The reticence of anaesthetists to perform an emergency neonatal ETI may be due to the difficulty to maintain skilled in neonatal ETI due to the lack of regular on-site ETIs in neonates in general hospitals. To address this problem, 1) a national advanced paediatric airway management-training course should be developed for anaesthetists and residents in anaesthesia. This course should be mandatory both during residency and for re-registration. To maintain adequately skilled, attendance at the national courses, local skill-training programmes including assessments are needed, since there is significant decay in skills over time when not frequently used or refreshed. 2) Tertiary care centres have to play an important role in facilitating regional training facilities to enable anaesthetists from general hospitals to remain adequately skilled and confident in performing neonatal ETI. 3) It is of no use to train general

paediatricians in performing ETI since they cannot gain the practical airway-management experience needed to adequately perform ETI. Instead, a national course for paediatricians and paediatric residents should be developed to obtain and maintain the skills in non-invasive manoeuvres to guarantee a free airway, mask-and-bag ventilation and the introduction of a supraglottic airway device. This course should be mandatory during residency and for re-registration in paediatrics.

Part 3. Paediatric Early Warning System

The third part of this thesis provided an overview of the use of Paediatric Early Warning Systems (PEWS) in general and tertiary hospitals the Netherlands (2014).

An electronic cross-sectional survey with a 100% response rate showed that of all Dutch hospitals three-quarters implemented a PEWS. In 68 hospitals, 45 different PEWS scores were in use, including 20 different parameters. Almost all scores were unvalidated, self-designed or modified from other PEWS scores. Although these systems were intuitively experienced as useful, the scientific evidence in terms of hospital mortality reduction and patient safety improvement was lacking. Despite the fact that previous studies have shown that a PEWS score is not suitable as a triage system, PEWS scores were in use at the ER in one-third of the hospitals.

In conclusion, mainly invalidated PEWS scores with a wide variation in parameters are in use in Dutch hospitals. The use of unvalidated scores may lead to a false sense of security or to potentially dangerous situations.

An important disadvantage of PEWS is the low sensitivity of all adequately validated PEWS scores from the last ten years. PEWS affect the perception of relevant information about the patients' actual state in the moment and does not stimulate the interpretation of relevant information or the application of this information to the future status of the patient. This is why a PEWS system on its own is not adequate to predict the future status of the patient. To improve the sensitivity, stimulate the interpretation of relevant information and convert this to the future status of the patient, PEWS has to be part of a multifactorial patient safety system that include both dynamic and static patient risk factors, like 'worried signs' or 'intensive care involvement'.

To address the proliferation of unvalidated PEWS scores in the Netherlands a national 'PEWS workgroup' is established to coordinate the development, validation and implementation of a 'core set' of PEWS parameters as dynamic risk factors. The Paediatric Risk Evaluation and Stratification System (PRESS) is an example of a multifactorial safety system based on both dynamic and static patient risk factors. In the future, 'big data' patient safety monitoring systems may improve care and save lives by extracting insights from big data in order to make better-informed decisions.

Samenvatting

Dit proefschrift beschrijft de huidige situatie van de organisatie van de acute zorg voor kritiek zieke kinderen in de Nederlandse algemene ziekenhuizen. Het bestudeert werkafspraken, verantwoordelijkheden, specifieke vaardigheden en klinische observaties, die plaats vinden bij de zorg voor zieke neonaten en kinderen. Daarnaast wordt specifiek ingegaan op de situatie rondom de endotracheale intubatie van neonaten en kinderen.

In dit proefschrift wordt eveneens een visie gegeven op het bewerkstelligen van verbetering van de organisatie van de acute zorg en de detectie van vroegtijdige achteruitgang van opgenomen zuigelingen en kinderen.

Deel 1. De organisatie van de acute zorg voor kritiek zieke kinderen

In het eerste deel van dit proefschrift wordt een regionaal (2011) en landelijk (2012) overzicht beschreven over de organisatie van de acute zorg van kritiek zieke kinderen in de algemene ziekenhuizen in Nederland. Daarnaast wordt een visie gegeven op het bewerkstelligen van verbetering van de organisatie van deze acute zorg.

In een regionale studie werden middels een enquête alle 195 kinderartsen, anesthesisten, intensivisten en spoedeisende hulp artsen werkzaam in de negen algemene ziekenhuizen binnen de regio van het Maastricht UMC+ bevraagd over de mate van organisatie van de acute pediatrische zorg in het ziekenhuis waar zij werkzaam waren. Ongeveer 50% van deze vragenlijsten werd geretourneerd en geschikt bevonden voor analyse. Daarnaast werden er ziekenhuisbezoeken afgelegd om de aanwezigheid van organisatorische protocollen en de inhoud van reanimatiekarren in kaart te brengen. Uit de enquête en ziekenhuisbezoeken bleek dat organisatorische protocollen ontbraken in 8 van de 9 ziekenhuizen. Daarnaast bleek een groot deel van de medisch specialisten niet op de hoogte te zijn van de aan- of afwezigheid van deze protocollen. In 8 van de 9 ziekenhuizen werd scenariotraining gegeven om de neonatale en pediatrische acute opvang te trainen. Deze training werd met name gevolgd door verpleegkundigen. Kinderartsen en overige medisch specialisten namen zelden deel aan deze training. Twee derde van de kinderartsen was Advanced Paediatric Life Support (APLS) gecertificeerd. In 8 van de 9 ziekenhuizen was een kinderreanimatiekar aanwezig op de kinderafdeling en spoedeisende hulp. In 3 van de 9 ziekenhuizen was de inhoud van beide reanimatiekarren compleet.

In de landelijke studie werden middels een enquête alle 687 kinderartsen werkzaam in de 84 algemene ziekenhuizen in Nederland bevraagd over de mate van organisatie van de acute pediatrische zorg in het ziekenhuis waar zij werkzaam waren. Ongeveer 41% van deze vragenlijsten werd geretourneerd en geschikt bevonden voor analyse. Van de respondenten gaf 57% aan dat er organisatorische protocollen bestonden in het ziekenhuis waar zij werkzaam waren. Dit werd echter niet geverifieerd middels ziekenhuisbezoeken zoals in de regionale studie werd gedaan. De antwoorden van de kinderartsen die

werkzaam waren in dezelfde ziekenhuizen toonden echter tegenstrijdigheden ten aanzien van de aanwezigheid van organisatorische protocollen, werkafspraken en werkgroepen. Dit impliceerde dat er onduidelijkheid bestond over de organisatie van de acute zorg voor kritiek zieke kinderen.

Ongeveer 91% van de respondenten gaf aan dat de acute opvang werd getraind middels scenariotraining. Deze training werd voornamelijk door verpleegkundigen gevolgd. Twee derde van de kinderartsen nam deel aan deze training. Eenzelfde aantal kinderartsen was Advanced Paediatric Life Support (APLS) gecertificeerd. Bij 95% van de respondenten was er zowel op de kinderafdeling als op de spoedeisende hulp een kinderreanimatiekar aanwezig. Echter ontbraken benodigde materialen (38%) en medicatie (45%) regelmatig.

Naar aanleiding van de resultaten uit de regionale en landelijke studie kan worden geconcludeerd dat de organisatie van de acute zorg van kritiek zieke kinderen in een groot deel van de Nederlandse algemene ziekenhuizen verbeterd kan worden. Een ziekenhuisbrede, multidisciplinaire commissie 'vitaal bedreigde neonaat en kind' moet de uitvoering van deze verbetering waarborgen en zo de spil vormen in de coördinatie van de acute zorg voor neonaten en kinderen. Deze commissie zou onderverdeeld kunnen worden in 3 werkgroepen met als kerntaken: 1) het opstellen en vastleggen van werkafspraken in organisatorische protocollen; 2) het opstellen en faciliteren van een kwalitatief hoogstaand, gestandaardiseerd trainingsprogramma met een gepersonaliseerd participatie- en toetsingssysteem; 3) het waarborgen van de aanwezigheid van benodigde medicatie, materialen en apparatuur om adequate acute zorg te kunnen leveren met behulp van een gestandaardiseerde inventarisatielijst, inclusief controlesysteem.

Idealiter zou deze commissie hetzelfde mandaat moeten hebben als de reeds bestaande reanimatiecommissie van het ziekenhuis, met een eigen budget en begroting, onder auspiciën van de Raad van Bestuur. Om draagvlak te creëren voor deze ziekenhuisbrede commissie, is een ondersteunend advies van de betrokken beroepsvereniging wenselijk. Tijdens visitatiemomenten van de betrokken beroepsvereniging dan wel inspectie van volksgezondheid kan de mate van organisatie, training en aanwezigheid van de benodigde inventaris worden geëvalueerd. Naast deze landelijke initiatieven is regionale samenwerking tussen de lokale algemene ziekenhuizen en het tertiaire centrum waarnaar deze ziekenhuizen verwijzen van groot belang. Tertiaire centra moeten een bijdrage leveren aan het optimaliseren van de acute zorg voor neonaten en kinderen in de algemene ziekenhuizen in hun regio.

Deel 2. Endotracheale intubatie

In het tweede deel van dit proefschrift wordt een overzicht gegeven over welke medisch specialist neonatale en pediatrische endotracheale intubatie verricht in de Nederlandse algemene ziekenhuizen. Daarnaast wordt de huidige praktijkervaring van kinderartsen en

anesthesisten met neonatale en pediatrische intubatie beschreven. Er wordt eveneens weergegeven hoe de participerende kinderartsen en anesthesisten hun eigen intubatievaardigheid inschatten. Dit wordt vergeleken met de daadwerkelijke intubatievaardigheid in een gesimuleerde setting. De intubatievaardigheden van de participerende kinderartsen en anesthesisten worden eveneens met elkaar vergeleken.

In een cross-sectioneel onderzoek werden 52 kinderartsen en 52 anesthesisten geïncludeerd, welke werkzaam waren in algemene ziekenhuizen in Nederland. Nadat een enquête werd ingevuld, verrichtten de participanten een intubatiescenario op zowel het neonatale als pediatrische manikin. De intubatieprocedures werden gefilmd middels een camera bevestigd aan het hoofd van de participant en een 5 millimeter camera met lichtbron bevestigd op de standaard laryngoscoop bladen. Deze opnames werden individueel beoordeeld door drie geblindeerde experts.

Uit de enquête bleek dat werkafspraken over taakverdeling bij neonatale en pediatrische intubatie in een acute situatie vaak ontbraken. Ongeveer 21% van de kinderartsen en 42% van de anesthesisten gaf aan dat er in het ziekenhuis waar zij werkzaam waren afspraken bestonden over wie een neonaat en kind intubeert in een acute situatie. De praktijkervaring met neonatale intubatie verschilde niet significant tussen de kinderartsen en anesthesisten, echter was dit wel het geval bij pediatrische intubatie waarbij de anesthesisten significant vaker een kind intubeerden.

Bij de neonatale intubatie presteerden anesthesisten, behoudens het succespercentage (dat wil zeggen tube door stembanden), op alle overige componenten (aantal pogingen, tijdsduur, aantal complicaties, totale vaardigheidsscore, eindcijfer en bekwaamheid) significant beter dan kinderartsen. Ongeveer 65% van de kinderartsen werd bekwaam bevonden om een neonatale intubatie te verrichten versus 100% van de anesthesisten. Bij de pediatrische intubatie presteerden de anesthesisten significant beter op alle bovengenoemde componenten. Van de kinderartsen werd 16% bekwaam bevonden versus 94% van de anesthesisten. Ongeveer 33% van de anesthesisten onderschatten hun neonatale intubatievaardigheden. Daarentegen overschatten 29% van de kinderartsen hun neonatale intubatievaardigheden.

Naar aanleiding van de resultaten kan worden geconcludeerd dat anesthesisten beduidend meer vaardig zijn in het verrichten van endotracheale intubatie op zowel het neonatale als pediatrische manikin vergeleken met kinderartsen. De kans op complicaties en de ernst hiervan lijkt beduidend lager te zijn wanneer de procedure wordt uitgevoerd door anesthesisten. Dit maakt dat de anesthesist, in de meeste gevallen, de meest geschikte professional is om een neonatale en pediatrische intubatie te verrichten in een algemeen ziekenhuis.

Ondanks de grote verschillen in intubatievaardigheid ten faveure van de anesthesist, verklaarde een kwart van alle participanten dat de anesthesist de neonatale intubaties moet verrichten in een algemeen ziekenhuis. De situatie waarin zowel kinderartsen als anesthesisten zich niet verantwoordelijk en/of capabel voelen om een neonatale en/of pediatrische intubatie te verrichten in een acute situatie kan tot onveilige situaties dan

wel inadequate zorg leiden. Om dit te voorkomen moeten er intercollegiale afspraken tussen kinderartsen en anesthesisten worden gemaakt en vastgelegd in een ziekenhuisprotocol. Daarnaast is het belangrijk om op landelijk niveau, na overleg tussen de betrokken beroepsverenigingen, een gezamenlijk gedragen advies op te stellen ten aanzien van dit onderwerp.

Het maken en implementeren van nieuwe intercollegiale afspraken zal met name voor de neonatale intubatie niet eenvoudig zijn. Op dit gebied beschouwden anesthesisten zichzelf vaak als onvoldoende vaardig. De terughoudendheid in het nemen van verantwoordelijkheid voor neonatale intubatie heeft mogelijk te maken met de dalende blootstelling aan neonatale intubatie in de algemene ziekenhuizen. Dit wordt mede veroorzaakt door de centralisatie van chirurgie bij (jonge) zuigelingen.

Om deze situatie te verbeteren moet er, op zowel lokaal als landelijk niveau, meer aandacht komen voor het trainen van 'advanced paediatric airway management'. Het opzetten van een gelijknamige landelijke luchtwegcursus voor anesthesisten en arts-assistenten anesthesiologie zou een belangrijke bijdrage kunnen leveren aan het oplossen van dit probleem. Deze cursus zou een verplicht onderdeel van de opleiding moeten zijn en tevens benodigd zijn voor herregistratie. Om adequaat getraind te blijven zal deze nationale cursus ontoereikend zijn. Op lokaal niveau zal eveneens vaardigheidstraining plaats moeten vinden om verlies van vaardigheid over de tijd te voorkomen. Tertiaire centra hebben een belangrijke rol in het faciliteren van deze (real-life) trainingsmogelijkheden, zodat anesthesisten uit de omliggende algemene ziekenhuizen hun vaardigheden op peil kunnen brengen en houden.

Het is niet zinvol om kinderartsen te trainen in het uitvoeren van endotracheale intubatie wanneer er geen mogelijkheid is om de benodigde praktijkervaring op te doen om bekwaam te worden en te blijven. Voor kinderartsen en arts-assistenten kindergeneeskunde moet er eveneens een landelijke luchtwegcursus ontwikkeld worden, waarbij de nadruk ligt op non-invasieve manoeuvres om een vrije ademweg te creëren, masker en ballon beademing, en het inbrengen van een supraglottisch luchtweginstrument zoals een larynxmasker.

Deel 3. Pediatric Early Warning System

In het derde deel van dit proefschrift wordt het gebruik van Pediatric Early Warning Systems (PEWS) in de Nederlandse algemene en academische ziekenhuizen in kaart gebracht. Daarnaast wordt een visie beschreven over het gebruik van PEWS als onderdeel van een multifactorieel veiligheidssysteem.

Een digitale cross-sectionele enquête met een 100% responspercentage toonde aan dat driekwart van alle Nederlandse ziekenhuizen een PEWS gebruikte ten tijde van het onderzoek (2014). In de 68 ziekenhuizen die een PEWS hanteerden, werden 45 verschillende PEWS scores gebruikt met in totaal 20 verschillende parameters. Bijna alle PEWS

scores waren ongevalideerd, zelfontworpen of gemodificeerd naar bestaande buitenlandse PEWS scores. Hoewel deze scores intuïtief als zinvol werden ervaren, is het wetenschappelijk bewijs in termen van reductie van ziekenhuismortaliteit en verbetering van patiëntveiligheid zeer beperkt. Ondanks dat meerdere studies hebben aangetoond dat een PEWS score niet geschikt is als triagesysteem op een spoedeisende hulp, gebruikte een derde van de Nederlandse ziekenhuizen een PEWS score op de spoedeisende hulp.

Naar aanleiding van de resultaten kan worden geconcludeerd dat er in Nederland een wildgroei aan ongevalideerde PEWS scores bestaat met een grote diversiteit aan parameters. Het gebruik van ongevalideerde scores kan tot schijnveiligheid en potentieel gevaarlijke situaties leiden.

Een belangrijk nadeel van de reeds bestaande PEWS is de bij herhaling aangetoonde relatief lage sensitiviteit. Duidelijke, positieve effecten op de uitkomst van de opgenomen patiënten ontbreken. Een PEWS score geeft de klinische conditie van de patiënt weer op het moment van afname van de score. Overige patiëntfactoren die van invloed zijn op de toekomstige status van de patiënt worden hierbij niet meegenomen. Een PEWS is daardoor geen adequate voorspeller van de toekomstige klinische status van de patiënt. Om de sensitiviteit van de PEWS te verbeteren, zal het onderdeel moeten worden van een groter, multifactorieel veiligheidssysteem met niet alleen dynamische maar ook statische risicofactoren zoals ‘worried signs’ en ‘intensive care betrokkenheid’. Het includeren van meerdere patiëntfactoren verbetert de inschatting van de klinische context en het beloop van de conditie van de patiënt.

Er is een landelijke PEWS werkgroep ingesteld die de ontwikkeling, validatie en implementatie van een ‘kernset’ van PEWS parameters coördineert om de in dit proefschrift aangetoonde diversiteit in parameters en ongevalideerde scores te reduceren. De Paediatric Risk Evaluation and Stratification System (PRESS) is een voorbeeld van een multifactorieel veiligheidssysteem met zowel dynamische als statische risicofactoren. Het incorporeren van ‘big data’ in een veiligheidssysteem biedt toekomstperspectief waarbij door middel van extrapolatie van inzichten uit big data het toekomstig beloop van de vitale waarden van de patiënt kan worden weergegeven.

Dit stelt dokters en patiënten in staat om beter geïnformeerde beslissingen te nemen.

Valorisatie

Dit proefschrift is gewijd aan het verbeteren van de acute zorg voor kritiek zieke kinderen in de algemene ziekenhuizen in Nederland. Enerzijds door middel van het bestuderen van de organisatie, verantwoordelijkheden, specifieke vaardigheden en klinische observaties, die plaats vinden bij de zorg voor kritiek zieke kinderen, anderzijds door vanuit het perspectief van de betrokken specialismen te kijken naar de mogelijkheid tot verbetering.

In de studies, opgenomen in dit proefschrift, is aangetoond dat rondom de opvang van kritiek zieke kinderen en neonaten een kwaliteitsverbetering mogelijk en noodzakelijk is. Deze verbeteringen omvatten voornamelijk het opstellen en vastleggen van afspraken op het gebied van taakverdelingen en verantwoordelijkheden tussen de betrokken medische professionals. Enerzijds door afstemming binnen de algemene ziekenhuizen, anderzijds door afstemming op regionaal en landelijk niveau. Een ziekenhuisbrede, multidisciplinaire commissie 'vitaal bedreigde neonaat en kind' moet deze afstemming en de uitvoering hiervan waarborgen en zo de spil vormen in de coördinatie van de acute zorg voor neonaten en kinderen. Deze commissie zou onderverdeeld kunnen worden in 3 werkgroepen met als kerntaken:

1) het opstellen en vastleggen van werkafspraken in organisatorische protocollen;
2) het opstellen en faciliteren van een gestandaardiseerd trainings programma met kwalitatief gewaarborgde vaardigheid- en scenario teamtraining gecombineerd met 'deliberate practice';
3) het waarborgen van de aanwezigheid van benodigde medicatie, materialen en apparatuur om adequate acute zorg te kunnen leveren, met behulp van een gestandaardiseerde inventarisatie lijst, inclusief controle systeem.

Naast de organisatie van de primaire acute opvang is de klinische observatie van reeds opgenomen kinderen eveneens van groot belang. Door adequate monitoring en observatie kan klinische achteruitgang van opgenomen patiënten vroegtijdig gedetecteerd worden. Een multifactorieel veiligheidssysteem (inclusief een paediatric early warning score) geeft een overzicht van de huidige- en de te verwachten conditie van de patiënt. Vergeleken met een solitaire PEWS score vergroot een multifactorieel veiligheidssysteem de kans op vroegtijdig detectie van klinische achteruitgang door een completer overzicht te geven van de huidige- en de te verwachten conditie van de patiënt. Dit biedt de kans om vroegtijdig te anticiperen op een mogelijke achteruitgang, wat een positief effect zal hebben op het herstel van de patiënt.

Deze bovenstaande wijzigingen betreffende de organisatie van acute opvang en het monitoren van reeds opgenomen kinderen vereisen geen grote veranderingen binnen de organisatie. Deze wijzigingen vereisen eveneens geen grote financiële investeringen. Het vereist wel de wil vanuit de betrokken medisch specialisten, verpleegkundigen en raden van bestuur om concrete werkafspraken te maken en hierbij vast te stellen wie het meest kundig is in welke taak. Om een daadwerkelijke verandering op de werkvloer te

bewerkstelligen is het belangrijk om 'sleutelfiguren' te hebben die initiatief en leiderschap tonen om veranderingen door te voeren. Deze sleutelfiguren moeten in de gelegenheid worden gebracht om een tijdsinvestering te kunnen doen om de genoemde veranderingen te coördineren en te waarborgen.

Vanuit meerdere perspectieven bekeken (kind, ouders, artsen, verpleegkundigen en de maatschappij) kunnen bovengenoemde veranderingen van grote waarde zijn.

Perspectief vanuit kind

Organisatie: De structuur van de acute opvang zal verbeteren wanneer er duidelijke werkafspraken zijn gemaakt over wie deelneemt aan de opvang en hoe de verschillende taken en verantwoordelijkheden verdeeld zijn. Deze afspraken zorgen ervoor dat de concentratie van de betrokken zorgprofessionals gericht is op de medische zorg en niet op onderlinge onenigheid of onduidelijkheid.

Belangrijke medische handelingen, zoals endotracheale intubatie, dienen door de meest capabele professional te worden verricht. Dit verhoogt de kans op een succesvolle procedure en verlaagt de kans op, en de ernst van complicaties en restschade.

Een duidelijke taakverdeling zal er voor zorgen dat een belangrijke medische handeling, zoals endotracheale intubatie, minder lang wordt uitgesteld. Een concreet voorbeeld is dat het tijdig verrichten van endotracheale intubatie door een lokale medisch professional beter zal zijn voor de conditie van de respiratoir insufficiënte neonaat / kind dan dat er wordt gewacht tot het NICU/PICU team uit een tertiair centrum arriveert om deze handeling te verrichten. Door het uitstellen van de intubatie procedure bestaat de kans op uitputting, waarbij de patiënt in een slechtere vitale situatie verkeert met afgenomen reserves, waardoor de kans op complicaties met levensbedreigende gevolgen voor het kind toeneemt. Tijdige intubatie van een respiratoir insufficiënte neonaat / kind leidt tot minder complicaties zoals desaturatie, hypoxie, bradycardie of circulatiestilstand tijdens de intubatieprocedure. Daarnaast zal tijdige intubatie de duur van de gepercipieerde benauwdheid verkorten, wat de kans op posttraumatische stress reduceert.

Bovenstaande punten zullen de kwaliteit van de acute zorg voor het kritiek zieke kind en neonaat ten goede komen en zal mogelijk leiden tot minder mortaliteit en morbiditeit.

Multifactorieel veiligheidssysteem: Het invoeren van een multifactorieel veiligheidssysteem zal de kans op vroegtijdige detectie van klinische achteruitgang van reeds opgenomen kinderen vergroten, wat vroegtijdige interventie mogelijk maakt. Het voorkomen van verdere klinische achteruitgang door vroegtijdige interventie zal de morbiditeit en mortaliteit mogelijk verlagen. De kans op langdurige ziekenhuis- dan wel PICU opname zal eveneens afnemen. Door tijdig herkennen van klinische achteruitgang kan vroegtijdige consultatie plaats vinden van de expertise van NICU/PICU teams uit tertiaire centra. Hierdoor bestaat de kans dat neonaten en kinderen in een vroegtijdig stadium in het ziekteproces, en daardoor in minder slechte conditie worden overgeplaatst en behandeld. Het

aantal opnamedagen op een NICU/PICU en de hiermee gepaardgaande indrukwekkende, negatieve dan wel traumatische ervaringen zullen hierdoor mogelijk afnemen.

Perspectief vanuit ouder/verzorger

Organisatie: De ouders/verzorgers van de betreffende kritiek zieke neonaat / kind zullen vertrouwen hebben in het behandelteam wanneer er sprake is van een zichtbaar adequate structuur, organisatie en samenwerking tijdens de acute opvang. Wanneer ouders zien dat de zorg goed is georganiseerd en medische professionals adequaat samenwerken, zullen zij zich beter kunnen richten op het ondersteunen van hun kind. Dit zal ouders een beter gevoel geven over hun eigen rol gedurende de opvang van hun kind, wat ook later het verwerken van deze gebeurtenis mogelijk positief zal beïnvloeden.

Multifactorieel veiligheidssysteem: De duur van de ziekenhuisopname kan worden verkort door tijdig te anticiperen bij klinische achteruitgang van opgenomen patiënten. Hierdoor zal het negatieve, ontwrichtende (psychologische) effect van een ziekenhuisopname op het functioneren van het gezin hoogstwaarschijnlijk afnemen.

Perspectief vanuit medisch specialisten in algemene ziekenhuizen

Organisatie: Werkafspraken met duidelijk taakverdeling zorgen ervoor dat de concentratie van de betrokken zorgprofessionals gericht is op de medische zorg en niet op onderlinge onenigheid of onduidelijkheid. Discussie tussen betrokken medisch specialisten aan het bed van de patiënt over taakverdeling en verantwoordelijkheden neemt 1) onnodig kostbare tijd in beslag en 2) zorgt voor de perceptie van extra stress en spanning, wat afleidt van de hoofdtaak. Onduidelijkheid over taakverdeling en verantwoordelijkheden zijn latente fouten die manifest kunnen worden tijdens een acute opvang. Het Zwitsersekaasmodel, in 1990 bedacht door de Engelse psycholoog James T. Reason, is een model dat tracht te verklaren hoe fouten kunnen ontstaan in een organisatie en hoe meerdere fouten gezamenlijk kunnen leiden tot een calamiteit. Het betreft een cumulatief-effectmodel met 4 niveaus van falen: invloeden vanuit de fundamentele organisatie, ontoereikend toezicht, voorwaarden voor onveilig handelen en de onveilige handelingen van individuen zelf. Het ontbreken van een gestructureerde organisatie is een latente fout die manifest wordt wanneer er in een acute situatie in meerdere lagen van Reasons model gaten vallen door bijvoorbeeld individueel handelen. Een duidelijke organisatie reduceert de kans op (individuele) fouten en zal het teamwork tijdens de acute zorg ten goede komen. Een gestandaardiseerd trainingsprogramma met kwalitatief gewaarborgde vaardigheid- en scenario teamtraining is nodig om dit multidisciplinaire teamwork te optimaliseren. Medisch specialisten kunnen met adequaat multidisciplinair teamwork een grote bijdrage leveren aan het optimaliseren van de omstandigheden om goede acute zorg te kunnen waarborgen op elk moment van de dag.

Perspectief vanuit verpleegkundigen

Organisatie: Duidelijke organisatorische afspraken, adequate training en aanwezigheid van alle benodigde materialen en medicatie zorgt eveneens bij het verpleegkundig personeel voor stressreductie tijdens een acute opvang. Zoals reeds beschreven vermindert deze stressreductie de kans op individuele fouten en biedt dit meer ruimte om actief mee te denken tijdens de opvang. Een gestandaardiseerd scenario- en team trainingsprogramma zal de verpleegkundigen duidelijkheid geven over hun eigen rol en de taakverdeling van alle overige deelnemers. Gestandaardiseerde nationale inventarisatielijsten voor kinderreanimatiekarren alsmede een vastgelegd controlesysteem, voorkomt dat medicatie of materialen niet aanwezig zijn tijdens een acute opvang.

Multifactorieel veiligheidssysteem: Een multifactorieel veiligheidssysteem biedt de verpleegkundigen meer structurele en tastbare controle over de conditie van hun patiënt. De leeftijdspecifieke data set met vitale waarden, die worden gebruikt om afwijkende waarden snel te kunnen herkennen, zorgt voor een betere kennis van normaalwaarden van vitale parameters. Een scoringssysteem geeft verpleegkundigen meer onderbouwing en zelfvertrouwen om bij een 'niet-pluis' gevoel een arts te contacteren en actie te eisen. Een scoringssysteem biedt voor verpleegkundigen concrete handvaten om met de arts op een effectieve, duidelijke manier te communiceren.

Perspectief vanuit NICU/PICU team

Organisatie: Een adequate acute opvang van een vitaal bedreigde neonaat of kind heeft directe gevolgen voor de prognose, zowel in morbiditeit als mortaliteit. Een goede eerste opvang biedt de beste kans op reductie van complicaties en opnameduur op een intensive care. De tijdsduur van het transport dat NICU/PICU teams verrichten om vitaal bedreigde neonaten / kinderen op te halen in algemene ziekenhuizen neemt af wanneer er minder tijd nodig is om het kind te stabiliseren voor transport. Deze afname van transporttijd is niet alleen gunstig voor het kind maar vermindert ook de afwezigheidsduur van medische en verpleegkundige stafleden op de eigen NICU of PICU.

Multifactorieel veiligheidssysteem: Door tijdige detectie van en anticipatie op klinische achteruitgang zullen opgenomen kinderen eerder en in minder slechte conditie overgeplaatst worden naar de NICU/PICU. Hierdoor verkort het aantal opnamedagen op een intensive care. Overplaatsing in een eerder stadium van het ziektebeloop zorgt ervoor dat neonaten en kinderen die op een NICU/PICU alsnog in een kritieke danwel reanimatie setting terecht komen een grotere overlevingskans hebben met een lagere morbiditeit ten opzichte van een algemeen ziekenhuis. De overlevingskans en uitkomst van de patient verbetert wanneer gespecialiseerd personeel de acute zorg verleent.

Perspectief vanuit maatschappij

Organisatie: De reeds besproken reductie van de kans op fouten, complicaties en restschade zorgt voor minder (lange) ziekenhuisopnames en minder poliklinische bezoeken, wat leidt tot minder zorgkosten. De tijdsduur van het transport dat NICU/PICU teams verrichten om vitaal bedreigde neonaten of kinderen op te halen neemt af wanneer er minder tijd nodig is om het kind te stabiliseren of te intuberen voor transport. Het ambulance personeel is daardoor sneller inzetbaar voor overige ritten. Dit komt de zorg voor andere (spoed)patiënten ten goede, verhoogt de effectiviteit en vermindert de zorgkosten.

Multifactorieel veiligheidssysteem: Door tijdige detectie van en anticipatie op klinische achteruitgang kunnen niet alleen de kosten die gepaard gaan met een verlengde ziekenhuis- dan wel NICU/PICU opname worden voorkomen, maar ook de kosten die gepaard gaan met langdurig ziekteverzuim van ouders. Bij een kortere opnameduur zal de psychosociale- en logistieke belasting van ouders en daardoor het aantal werkgerelateerde verzuimdagen afnemen, met minder kosten voor de werkgever en overheid tot gevolg.

Addendum

List of abbreviations

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List of abbreviations

APLS	Advanced Paediatric Life Support
BLS	Basic Life Support
ED	Emergency Department
ER	Emergency Room
EPLS	European Paediatric Life Support
EPALS	European Advanced Paediatric Life Support
ETI	Endo-Tracheal Intubation
MUMC+	Maastricht University Medical Centre+
N	Number
NVA	Nederlandse Vereniging voor Anesthesiologie (Dutch Association of Anaesthesiology)
NVIC	Nederlandse Vereniging voor Intensive Care (Dutch Association of Intensive Care)
NLS	Neonatal Life Support
NVK	Nederlandse Vereniging voor Kindergeneeskunde (Dutch Association of Paediatrics)
pBLS	Paediatric Basic Life Support
PD	Paediatric Department
PEEP	Positive End-Expiratory Pressure
PEWS	Paediatric Early Warning System
PICU	Paediatric Intensive Care Unit
PW	Paediatric Ward
RCC	Recertification Course
SEH	Spoedeisende Hulp
SMS	Safety Management System
SSHK	Stichting Spoedeisende Hulp bij Kinderen (The Dutch Foundation for the Emergency Medical Care for Children)

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Curriculum Vitae

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2006 – 2007	Master courses Clinical Neuropsychology, Maastricht University. 'Brain damage' and 'behavioural disorders'.
2004 – 2011	Medical training, Maastricht University. Elective internship, West Gonja Hospital, Damongo, Ghana. Elective internship paediatrics, St Anna Hospital, Geldrop. Final internship, Paediatric Intensive Care Unit, Maastricht University Medical Centre.

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2011 – 2012	Paediatric resident, Maxima Medical Centre, Veldhoven.
2013 – 2017	Paediatric resident, Maastricht University Medical Centre. (prof. dr. Mulder, prof. dr. Zimmermann)
2017 – 2018	Paediatric resident, Catharina Hospital Eindhoven. (dr. Brackel, drs. Lavrijsen)
2018 –(2019)	Paediatric resident, neonatal intensive care, Maxima Medical Centre, Veldhoven. (dr. Niers, dr. Halbertsma)

Certification

2017 -	European Paediatric Advanced Life Support (EPALS) instructor.
2017 -	Basic Life Support instructor, European Resuscitation Council (ERC).

List of publications

Publications belonging to this thesis

2013 Sam J. van Sambeeck, Etienne J.M. Janssen, Tim Hundscheid. Sanne J.L. Martens en Gijs D. Vos. Acute opvang van kinderen in algemene ziekenhuizen, organisatie en training. Ned Tijdschr Geneeskd. 2013;157:A6510.

2014 Van Sambeeck SJ, Martens SJ, Hundscheid T, Janssen EJ, Vos GD. Dutch paediatrician's opinions about acute care for critically ill children in general hospitals. Eur J Pediatr. 2015;174(5):607-13. doi:10.1007/s00431-014-2439-7 pmid:25339423.

2018 Sam J. van Sambeeck, Joris Fuijkschot, Boris W. Kramer, Gijs D. Vos. Pediatric Early Warning System Scores: Lessons to be Learned. J Pediatr Intensive Care. 2018;7:27-32.;2017. doi 10.1055/s-0037-1602802.

2018 *Submitted:* Sam J. van Sambeeck, Sander M.J. van Kuijk, Boris W. Kramer, Petronella M. Vermeulen, Gijs D. Vos. Endotracheal intubation skills of paediatricians versus anaesthetists in neonates and children.

Publications

2012 Sambeeck van SJ, Martens S, Vos G. 'Organization and training of the acute care of critically ill children in general hospitals in the southeast Netherlands; we can do better'. Intensive Care Med. 2012;38(1):1-327. (ESICM abstract supplement issue)

2013 Sambeeck van SJ, Gent van R, Schroer C, Halbertsma FJJ. Value of an automatic external defibrillator printout as a diagnostic tool after successful AED use on a child. BMJ Case Reports. 2013 Apr 22;2013. pii: bcr2012007532. doi: 10.1136/bcr-2012-007532.

2013 Tang CY, Wijnen M, Van Sambeeck SJ, Halbertsma FJJ. Acute neonatal presentation of a lymphatic malformation. BMJ Case Reports. 2013 Aug 1;2013. pii: bcr2012006784. doi: 10.1136/bcr-2012-006784.

2014 Sam J van Sambeeck, Mavinkurve-Groothuis A, Flucke U, Dors N. Sarcoma botryoides in an infant. BMJ Case Rep. 2014 Dec 17;2014. pii: bcr2013202080. doi: 10.1136/bcr-2013-202080.

2016 Van Sambeeck SJ, Vos GD, Theeuwes BAM, van der Starre C, Fuijkschot J. De Pediatric Early Warning Score (PEWS) en veilige(re) zorg in Nederland. Praktische Pediatrie 2016;1:10-14.

Oral presentations

2011 Local conference: Local Intensive Care Conference, Helmond.
Organisation and training of the acute care of critically ill children in general hospitals in the southeast Netherlands.

Oct 2012 International conference: The Annual Congress of the European Society of Intensive Care Medicine, Lisbon. Organisation and training of the acute care of critically ill children in general hospitals in the southeast Netherlands; we can do better.

Apr 2013 Local conference: Conference LVIZ, Focus on the patient, Rolduc Kerkrade.
Organisation and training of the acute care of critically ill children in general hospitals in our region.

Oct 2014 National conference: Annual refresher course for paediatricians. Chateau Sint Gerlach, Valkenburg. Workshop: how to organize the acute care of critical ill children in general hospitals.

Oct 2016 Local conference: Pelerin symposium, Maastricht University Medical Centre.
Pediatric Early Warning Score (PEWS) and safer care in the Netherlands.

Nov 2017 National conference: Praktische Pediatrie annual conference 2017, Veenendaal. Workshop: intraosseous access, venous access and laryngeal masks.

May 2018 National conference: Dutch Association of Anaesthesiology (NVA), annual conference 2018. Endotracheal intubation skills of pediatricians and anesthetists in neonates and children.

June 2018 National conference: Dutch Association of Paediatrics (NVK), annual conference 2018. Symposium 'Severe paediatric dyspnea': Who is performing endotracheal intubation on neonates and children in general hospitals?