The deployment of a Helicopter Emergency Medical Service for vitally compromised children in the Netherlands
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Citation

Abstract
Objective: To evaluate the deployment of a Helicopter Medical Service (HEMS) for vitally compromised children in an HEMS region. A comparison is made between HEMS deployment for children and adults, with a subsequent evaluation of the current HEMS deployment criteria for vitally compromised children. Methods: Prospective descriptive cohort analysis of all HEMS calls for paediatric emergencies (age 0-18 years) in the period 2001-2008. Data regarding type and location of incident, physiological parameters, Munich-modified NACA scores, treatment and 24-hour survival were collected and subsequently analysed. Results: The HEMS had 891 calls for paediatric emergencies in the period from 2001-2008. Twenty-seven percent of these calls were cancelled before the arrival of the HEMS, while 48% of the calls for adults were cancelled. The cancel percentage of all HEMS calls increased significantly over the years; the cancel percentage of HEMS calls for children remained at a steady state. The HEMS coordinating dispatch region had a significant higher percentage of low NACA scores in comparison to the other dispatch regions. The non-trauma incidents had the lowest 24-hour survival rate, the highest 24-hour survival rate was in the incident group of HEMS calls based on mechanism of injury. Conclusion: Dispatch criteria used for HEMS in the Netherlands appear not to be well suited to children and should be adjusted to contain a score of the neurological status. Dispatch criteria based on mechanism of injury are a poor triage tool, several types of severe illness should be explicitly included. Cancel criteria for HEMS calls in children are not applied in a consistent manner, and should be revised. Key words: emergency medical services, dispatching, child, trauma

INTRODUCTION
A Helicopter Emergency Medical Service (HEMS), introduced in the Netherlands in 1996 to provide optimal pre-hospital care, consist of a physician (anaesthesiologist or trauma surgeon), a flight nurse and a pilot. HEMS physicians have received special training in adult and paediatric emergency care, pain management and extrication techniques. The HEMS leads to concentration of medical expertise with a high degree of diagnostic and therapeutic knowledge and skills. A similar system has been present and operational in many European countries for a long time.[1,2,3,4,5] The benefits of the HEMS have been substantiated by several studies.[6,7,8] The medical care provided by the HEMS has achieved a well accepted position in the full range of pre-clinical care in the Netherlands as described in a policy note on trauma by the Dutch Government in 2005.[9]

The Emergency Medical Service (EMS) is coordinated and supervised by 24 emergency dispatch regions in the Netherlands. The number of inhabitants per dispatch region ranges from 240,000 up to 1.2 million inhabitants. The dispatch regions receive the primary emergency call and decide if an EMS ambulance is sent, or an ambulance and an HEMS. The decision to activate an HEMS by the dispatcher is made in line with a strict list of criteria. The HEMS described in this study is funded by the Trauma Region Netherlands-East, which consists of a HEMS dispatch coordinating region and six adjacent dispatch regions. (Figure 1).
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Figure 1
Figure 1. Trauma Region Netherlands-East (TRNE) consists of a HEMS coordinating dispatch region and six other dispatch regions

The only specific paediatric HEMS deployment criterion in the Netherlands is paediatric cardiopulmonary resuscitation, most of the triage criteria for HEMS in the Netherlands are based on trauma mechanism. As the EMS is generally less experienced in providing medical care for vitally compromised children, support from the HEMS is requested not only for trauma cases and paediatric CPR but also for vitally compromised children in general. The objective of this study was to evaluate the deployment of the HEMS Trauma Region Netherlands-East (TRNE) for vitally compromised children. A comparison is made between HEMS deployment for children and adults, with a subsequent evaluation of the current HEMS deployment criteria for vitally compromised children. The cancel percentages of HEMS deployments for adults and children were compared, in an effort to evaluate HEMS cancel percentages in call-outs for children.

METHODS
This study is a prospective descriptive cohort analysis of 891 HEMS calls for paediatric emergencies (age 0-18 years) for which the HEMS Trauma Region Netherlands-East was activated in the period 2001-2008. The primary dispatch area of the HEMS Trauma Region Netherlands-East comprises 7 emergency dispatch regions, but assistance can be requested by the other 17 emergency dispatch regions in the Netherlands. Registered data includes age, sex, type of emergency, physiological parameters (respiratory rate, heart rate, blood pressure, capnography), Glasgow Coma Scale (GCS), pre-clinical treatment given, diagnosis in the emergency ward and survival until 24 hours after hospital admission. All patients examined by the HEMS were assessed according to the NACA (National Advisory Committee on Aeronautics) score.[10] (Table 1).

Figure 2
Table 1. The National Committee on Aeronautics (NACA) developed a simple scoring system for patients receiving air transport during the Vietnam War.[10,11] The worst clinical condition of the patient during pre-clinical management was the determining factor for classification, as described in the Munich modification of the NACA score.[11] A HEMS deployment was cancelled if the EMS-paramedic arrived on the scene first and diagnosed that either the child had no serious injury or illness, or the patient had succumbed. All data was recovered from the electronic patient data management system, custom made for the HEMS. The results were transferred into a data sheet (Excel TM, Microsoft Seattle, USA) and underwent statistical analysis and graphical depiction with SPSS Statistics 16.1 TM (SPSS Inc., Chicago, IL, USA).

Pearson chi square was used for statistical comparisons, significance was defined as p < 0.05.

RESULTS
The HEMS had 891 calls involving children in the period 2001-2008. Of these child-related calls 245 (27%) were
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cancelled before the arrival of the HEMS, while 45% of all 6749 HEMS calls in this period (48% of the calls for adults) were cancelled. Table 2 demonstrates that while the cancel percentage of HEMS calls for adults increased significantly over the years, the cancel percentage of HEMS calls for children remained at a steady percentage. Reasons for the cancel of the 245 paediatric calls were: 199 calls normal physiological parameters, 27 calls patient died, 19 calls other reasons.

**Figure 3**
Table 2. Calls and Cancels Adults and Children

<table>
<thead>
<tr>
<th>Year</th>
<th>All calls</th>
<th>Adults</th>
<th>Adult cancels*</th>
<th>Children</th>
<th>Child cancels</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>379</td>
<td>347</td>
<td>36</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td>2002</td>
<td>549</td>
<td>469</td>
<td>35</td>
<td>80</td>
<td>36</td>
</tr>
<tr>
<td>2003</td>
<td>644</td>
<td>552</td>
<td>41</td>
<td>92</td>
<td>35</td>
</tr>
<tr>
<td>2004</td>
<td>584</td>
<td>491</td>
<td>45</td>
<td>93</td>
<td>35</td>
</tr>
<tr>
<td>2005</td>
<td>601</td>
<td>503</td>
<td>43</td>
<td>98</td>
<td>31</td>
</tr>
<tr>
<td>2006</td>
<td>1100</td>
<td>934</td>
<td>53</td>
<td>166</td>
<td>39</td>
</tr>
<tr>
<td>2007</td>
<td>1431</td>
<td>1277</td>
<td>53</td>
<td>154</td>
<td>22</td>
</tr>
<tr>
<td>2008</td>
<td>1461</td>
<td>1285</td>
<td>54</td>
<td>176</td>
<td>22</td>
</tr>
</tbody>
</table>

* Chi-square p<0.05

The HEMS was called by 19 of the 24 dispatch regions in the Netherlands, with the most distant incident location situated 124 km from the helicopter base. There was no difference between the cancel percentages of the HEMS coordinating dispatch region and the other dispatchers, ninety percent (801/891) of the HEMS calls were in the primary region. However, the patients in the HEMS coordinating dispatch regions had the highest percentage of NACA I-III patients (35%); the calls for NACA I-III patients from the other dispatch regions were significantly lower (8-19%). The number of calls, cancel percentage and NACA scores of the children examined on scene per dispatch region are shown in table 3.

**Figure 4**
Table 3. Trauma Region Netherlands-East (TRNE) HEMS calls for children

<table>
<thead>
<tr>
<th>Dispatch Region</th>
<th>HEMS calls</th>
<th>Average Distance</th>
<th>Cancel Percentage</th>
<th>NACA I-III</th>
<th>NACA IV-VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRNE</td>
<td>237</td>
<td>31.2</td>
<td>21</td>
<td>81</td>
<td>131</td>
</tr>
<tr>
<td>Other regions</td>
<td>564</td>
<td>29.1</td>
<td>27</td>
<td>29</td>
<td>59</td>
</tr>
<tr>
<td>Total</td>
<td>801</td>
<td>27</td>
<td>27</td>
<td>81</td>
<td>131</td>
</tr>
</tbody>
</table>

*Chi square p<0.05

The HEMS examined and treated 646 children on scene, mean age 8.4 years (sd 5.9); 475 (74%) emergencies were trauma-related, 171 (26%) were non-trauma. Of the 646 children examined on scene 145 (22.5%) had NACA scores of I-III, and 501 (77.5%) had NACA scores of IV-VII (medical cases 11% versus 89%, trauma cases 26% versus 74% respectively). (Figure 2)

**Figure 5**
Figure 2. Patients examined on scene according to NACA score*

* Chi square p<0.05

The emergency with an above-average mortality were all the non-trauma incidents, and near-drownings or burns. ‘Passenger in motor vehicle’ was the largest emergency type, with a relatively low 24-hour mortality, ‘congenital defect’ is the emergency type with the highest 24-hour mortality. Further details of the type of emergency are described in table 4. One hundred and five children died in the first 24 hours after the incident, of which 67 children died at the incident location.
DISCUSSION

Effective dispatch criteria define which vitally compromised children will benefit from HEMS deployment. The normal physiological range of the respiratory rate and blood pressure in children is wide, and the hemodynamic parameters differ significantly from adults. Meaningful triage criteria based on patient parameters are difficult to establish in children.[12] Rhodes et al found level of consciousness to be the best single indicator for HEMS deployment in a predominantly adult population.[13] The Glasgow Coma Scale, however, also has a high sensitivity and specificity for appropriate HEMS dispatch criteria in children as demonstrated by Moront in a study of 3861 children.[12] HEMS deployment in the Netherlands is activated by a list of dispatch criteria approved by the Dutch Ministry of Health, this list is based almost entirely on mechanism of injury. The largest group of children examined by the HEMS were children who were a passenger in a motor vehicle collision. In these incidents adults were also involved as either the driver or passenger: they were the main victims for which the HEMS was called. Because the HEMS was present at the incident location the slightly injured children involved were also examined; these children had a relatively high 24-hour survival rate of 93%. This demonstrates that dispatch criteria based on mechanism of injury do not apply very well in children. (Table 4)

Furthermore, there are differences between the interpretations of the HEMS criteria in the different dispatch regions as demonstrated by the respective percentage of NACA I-III patients. Dispatch regions called for HEMS in paediatric emergencies that could lead to paediatric CPR; pre-clinical childbirth, congenital heart disease, sepsis, convulsions and drowning. The deployment of HEMS is justified in hindsight by the remarkably low survival rate in these cases, although these types of emergencies were not specifically listed. In a comparable study, Mayer described 636 paediatric patients in Germany with an overall mortality of 7%, consisting of a 9% mortality in patients with trauma versus 6.3% in non-traumatic diseases.[14] As the mortality rate in this study is 16 percent, and considering this is only the 24-hour mortality, the children in our study consist of a severely vitally compromised patient population. In another comparable study in Germany, Eich described 2271 paediatric emergencies.[15] In this study, 72.7% of the children had an NACA score of I-III and 27.3% had a NACA score of IV-VII (versus 22.5% and 77.5% respectively in our study). (Chi square p<0.05). This difference may be caused by profound differences between the Netherlands and Germany in the pre-clinical emergency care for vitally compromised children, due to infrastructure, dispatching protocols, geography, training of EMS, etc. The actual deployment criteria for HEMS in the Netherlands are not suited for children, based on the results of the aforementioned studies, the GCS should be applied in the future adjustment of the HEMS deployment criteria. It would seem worthwhile to include more potentially life-threatening events of medical origin in the future update of the dispatch criteria.

Did the dispatch of HEMS for adults and children follow the same profile since the introduction of this HEMS operation in 2001? A study by Lemson assessed whether a greater distance from the HEMS base to the incident entailed a greater cancel ratio of the HEMS deployment.[16] There was a strong correlation between the number of inhabitants per region and the number of deaths caused by trauma, the number of traffic accidents with injury, and emergency call-outs from ambulance services. Lemson et al also demonstrated that distance of the HEMS base to the emergency location was not correlated with the quantity of calls; several dispatch regions in the vicinity of an HEMS station had a lower number of HEMS calls than one would expect. Apparently, there are differences in the interpretation of HEMS criteria per dispatch region, caused by personal or
institutional interpretation. In a study by Ringburg of a similar HEMS in the Netherlands was demonstrated that adherence to HEMS dispatch rates and dispatch criteria is low.[17] Better protocol adherence by emergency dispatchers could lead to a sevenfold increase of HEMS dispatching; the reasons for suboptimal protocol adherence were unclear. When extrapolating these results against the data in this article, it would seem probable that there are numerous emergencies in the field involving vitally compromised children for which an HEMS is not called.

Do the same cancel criteria apply for children and adults? A HEMS call could only be cancelled by the EMS paramedic if no serious illness of serious injury was present, or if the child had died on arrival of the EMS. As demonstrated in table 2, there is a sharp increase in all HEMS calls over the years (by the dispatcher) with a subsequent proportional increase of the cancel percentage (by the EMS paramedic on location). In the paediatric HEMS calls, the cancel percentage has not increased over the course of the years. The cause of this discrepancy cannot be specified by this study, but could be caused by the reluctance of the EMS-paramedic to cancel if children are involved.

There are several limitations to this study. Due to the nature of the health care provided, a blind prospective study was not possible. Follow-up after 24 hours of admission through the transportation of patients to hospitals out of the primary HEMS region was not feasible; therefore the survival until hospital discharge was unknown.

CONCLUSION
HEMS dispatches for children constitute a significant part of all dispatches. A substantial proportion of these dispatches involve vitally compromised children, as demonstrated by the 24-hour mortality of 16% of all children involved, and by the fact that 77.5% of all children had a NACA score of IV-VII. Dispatch criteria based on mechanism of injury are a poor triage tool. The present triage of vitally compromised children in the field is not sufficient, and needs to be addressed at the system or political level. Dispatch criteria used for HEMS in the Netherlands appear not to be well suited to children and should be adjusted to incorporate the GCS and specific types of severe illness.

HEMS calls for children have not followed the same trends as HEMS calls for adults through the years. Contrary to HEMS calls for adults in the period 2001 until 2008, the cancel percentage of HEMS calls for children has not increased. This can be caused by an increase of the need for medical expertise in-the-field or by a growing reluctance of the EMS-paramedics to cancel the HEMS in when children are involved. The data in this study cannot determine which cause, or combinations of causes is the dominant factor. Further research into HEMS deployment for children is necessary.

References
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