

Out-of-hospital paediatric emergencies: a prospective, population-based study

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Background: We wanted to study the incidence, distribution and characteristics of paediatric out-of-hospital emergency care on a population level. This knowledge could ameliorate the design and education of emergency medical services and their personnel.

Methods: We studied all ($n = 1863$) emergency medical services responses and the patient records for paediatric patients (age 0–16 years) in Helsinki, Finland (population 603,968, paediatric population 92,742) during a 12-month period (2012). Patient characteristics, diagnoses, time intervals, medical treatments, procedures, vital measurements and outcome of out-of-hospital treatment were available for analysis.

Results: The incidence of emergency medical services -treated paediatric out-of-hospital emergencies was 3.8/1000 inhabitants and 20/1000 1–16-year-old inhabitants. This formed 4.5% of all emergency calls, while children have a threefold share of the population (15%). Falls, dyspnoea, seizures and poisonings account for half of all emergencies. Few patients suffered from a life-threatening condition or trauma. Cardiac arrest or need for advanced life support measures (e.g. intubation) was rare. After evaluation by the emergency medical services, only half of the patients (56%) needed ambulance transportation to hospital. Only 30 (3.7%) of the non-transported patients made an unpremeditated visit to the emergency department after the original contact with the emergency medical services. All of them were well upon arrival to the emergency department.

Conclusion: Paediatric out-of-hospital emergencies are infrequent and have specific characteristics differing from the adult population. The design and training of emergency medical services and their personnel should focus on evaluation and management of the most frequent situations.

Editorial comment: what this article tells us

Paediatric emergencies occurring in the out-of-hospital setting are rare. This prospective cohort covering 11% of the Finnish population found that falls, breathing difficulties, seizures and poisonings constitutes half of all the emergencies, and suggests that training of pre-hospital personnel should focus on these situations in addition to the basic paediatric emergency skills

The epidemiology and characteristics of paediatric out-of-hospital (OOH) emergencies have seldom been studied on the population level.^{1,2} The lack of accurate epidemiologic knowledge on paediatric OOH emergencies may lead to inadequate training and responses among emergency medical (EM) personnel. Several studies^{3–5} have reported that EM personnel consider paediatric OOH emergencies challenging and are uncertain about their own performance. Routine for paediatric procedures is difficult to achieve and maintain, even in units specialized in OOH advanced life support measures.⁶

Better understanding of paediatric OOH emergencies may help focus the education of EM personnel to most frequently needed medications and manoeuvres. In addition, epidemiologic and qualitative knowledge on OOH emergencies in children can improve the design of paediatric emergency medical services (EMS).

Approximately 10% of OOH emergencies involve children.^{1,4,7–9} Pre-existing studies have shown interesting characteristics in paediatric OOH emergencies. For instance, EM procedures are performed surprisingly seldom,^{6,7,9,10} and it seems that a large proportion of emergency calls for children are for nonemergency situations.^{7,11}

The aim of this study was to examine the incidence of EMS-treated paediatric OOH medical and traumatic emergency situations on the population level. The study was a population based, prospective one-year cohort study on all EMS responses concerning the paediatric (0 to 16 y) population of Helsinki, Finland.

Methods

Study area

Helsinki is the capital of Finland, with 603,968 inhabitants and a geographical area of 214 km² at the end of the study period, corresponding to 11% of the population and 6% of the geographical area of Finland. The area comprises both urban and suburban environments. The number of children born in 1996 or later was 92,742, which formed 15% of the population of Helsinki in 2012.

Organization of emergency medical services

Finland has a publicly financed universal health-care system run by municipalities, which provide primary and secondary health care, and jointly fund tertiary care in five university hospitals. Private care providers offer some primary and secondary care. The public health care system exclusively provides all of the OOH emergency care, including emergency call dispatching and emergency transportation.

All emergency calls from the Helsinki area are dispatched through the same number, 112, and one of the governmental Emergency Response Centres (ERC). All the dispatchers have passed a 1.5-year ERC operator education. All the emergency calls are dispatched according to a formal, national protocol. According to the protocol, the dispatcher evaluates the leading symptom, such as dyspnoea or unconsciousness, and the triage class (A–D). The combination of symptom code and triage class then determines which units are dispatched. If the emergency call does not concern a real emergency, the dispatch protocol may suggest not to call an ambulance but to advise the patient or the parents instead.

In Helsinki, all urgent medical and traumatic emergencies are responded to by a single EMS provider, the Helsinki EMS. The EMS is three-tiered. The first tier consists of 7–9 basic life support (BLS) units, the second tier of 4 advanced life support (ALS) units. The BLS units are staffed by EM technicians (EMT) and the ALS units by paramedics. One of the ALS units is a medical supervisor unit, staffed by an experienced paramedic. The mobile intensive care unit (MICU) composes the third tier and is staffed by an emergency medical physician and 2–3 EMTs or paramedics. The medicines used by the different units are described in Table 1.

An emergency medical physician is on duty 24/7. The EM personnel have the possibility for consultation with the physician by phone, or they may call the physician-staffed MICU to the scene.

After adequate examination and treatment, the EM personnel evaluate the triage class (A–D) and the leading cause for transportation. The EM personnel may also decide, usually after consultation with the physician, that the patient does not need transportation by ambulance. In

Table 1 All medicines administered to paediatric patients by different types of EMS units during the study period.

EMS unit	Medicine	Administration route	Indication	N
BLS, ALS	Paracetamol	Per rectum	Presumed febrile seizures	70
BLS, ALS, MICU	Activated charcoal	Per oral	Poisoning	18
BLS, ALS	Glucose solution	Intravenous	Hypoglycaemia	3
ALS, MICU	Midazolam	Intravenous, intramuscular, sublingual	Seizures	31
ALS, MICU	Rasemic adrenaline (epinephrine)	Inhaled	Dyspnoea due to presumed laryngitis	30
ALS, MICU	Fentanyl	Intravenous	Short-time pain, combined anaesthesia	30
ALS, MICU	Ipratropium bromide cum salbutamol	Inhaled	Dyspnoea due to presumed asthma bronchiale	28
ALS, MICU	Morphine	Intravenous	Pain	13
ALS, MICU	Methylprednisolone	Intravenous	Presumed allergic reactions, serious asthma bronchiale	7
ALS, MICU	Adrenaline	Intraosseous	Resuscitation (infant)	1
ALS, MICU	Noradrenaline (norepinephrine)	Intravenous	Hypotension	1
MICU*	Propofol	Intravenous	Combined anaesthesia, status epilepticus	4
MICU*	S-ketamine	Intravenous	Pain (trauma)	2
MICU	Suxamethonium	Intravenous	Induction of combined anaesthesia	1

*Also ALS (the medical supervisor unit), only after the consultation with a physician by phone.

BLS, basic life support, staffed by two emergency medical technicians, no intravenous medications except glucose solution for the treatment of hypoglycaemia; ALS, advanced life support, staffed by at least one paramedic; intravenous and inhaled medications may be used after a consultation with a physician; MICU, Mobile intensive care unit, staffed by an emergency medical physician and 2–3 emergency medical technicians or paramedics; a large repertory of medications and equipment used in emergency care.

that case, the EM personnel are obliged to inform the patient or the caregivers how to monitor and treat the symptoms, and to give instructions on whether they should visit health care services on their own.

The EMS system and the education of EM personnel are regulated by governmental legislation and are thus equal in all of Finland, although geographical distances do have some influence on local protocols.

Data collection

Data on all EMS responses considering patients born in 1996 or later, occurring in the Helsinki City area during the period of Jan 1, 2012 to Dec 31, 2012, were obtained from the Helsinki EMS electronic patient record system (MerlotMedi®, CGI Suomi Oy), as well as statistical data on all EMS responses for comparison. The Helsinki EMS is the only emergency medical service in the City of Helsinki meeting emergency patients. Thus, the data cover practically all the paediatric OOH emergencies in the study

population. Patient characteristics, diagnoses, medical treatments, procedures, vital measurements and outcome of OOH treatment were available for analysis.

We consulted the patient records of the district's paediatric hospitals and clinics for each non-transported patient to find out whether they had had any secondary contacts during the 3 days following the initial EMS contact. If this was the case, an EM physician (H.H.) and a paediatrician (H.S./E.R.) evaluated the accuracy of the emergency care to find out whether the patient had been exposed to a potential risk or true harm. In case of any suspicion of inaccurate EM care, we then obtained a second opinion from an independent, experienced EM physician.

Demographic data were acquired from Statistics Finland (Statistics Finland 2014).

Statistical analysis

Data were analysed using descriptive statistics with PASW Statistics version 18 (SPSS Inc., Chicago, IL, USA).

Ethical aspects

Our study was a register-based study. The patients were not contacted for study purposes, nor did the study affect their treatment. Thus, an approval from an ethical committee was not considered necessary, and the study protocol was approved by the institutional review board of Helsinki University Hospital (§188 November the 30th 2011 and § 232 December the 3rd 2012, HYKS Operatiivinen

tulosyksikkö). Informed patient or parental consent to access medical records was not required.

Results

During the one-year study period there were 1863 EMS responses concerning paediatric patients. This formed 4.5% of all responses. The incidence of EMS -treated paediatric OOH emergencies was 3.8/1000 inhabitants and 20/

Table 2 The triage codes for dispatching and transportation by age group. The last column illustrates the most common symptom codes for dispatching in each triage class and age group.

Triage code	Age group years	Code for dispatching* N (%)	Code for transportation† N (%)	The most common symptom code for dispatching*
A High risk/unstable patient	0–16	66 (3.5%)	29 (3%)	Traffic accident (26%)
	< 1	7	2	Heart arrest (43%)
	1–3	12	3	Dyspnoea (33%)
	4–6	13	10	Seizures (38%)
	7–9	7	4	Traffic accident (43%)
	10–12	10	3	Traffic accident (50%)
	> 12	17	7	Traffic accident (35%)
B Moderate or unclear risk/stabilized patient	0–16	807 (43%)	83 (8%)	Seizures (19%)
	< 1	108	6	Dyspnoea (28%)
	1–3	256	25	Seizures (30%)
	4–6	114	14	Seizures (25%)
	7–9	65	10	Fall (high energy) (15%)
	10–12	82	10	Dyspnoea (16%)
	> 12	182	18	Poisoning (14%)
C Low risk/stabile patient	0–16	980 (53%)	681 (65%)	Fall (low energy) (23%)
	< 1	77	63	Fall (low energy) (29%)
	1–3	217	153	Fall (low energy) (32%)
	4–6	118	89	Fall (low energy) (23%)
	7–9	94	59	Fall (low energy) (28%)
	10–12	102	79	Fall (low energy) (26%)
	> 12	372	238	Poisoning (23%)
D No risk/patient does not need emergency care on scene, but is not able to use another form of transportation	0–16	8 (0.4%)	133 (13%)	–§
	< 1	0	12	–
	1–3	2	26	–
	4–6	1	10	–
	7–9	0	8	–
	10–12	1	19	–
	> 12	4	58	–
Triage code not available	0–16	2 (0.1%)	124 (12%)	
Total		1863 (100%)	1050 (101%)‡	

*Evaluated by the dispatcher. †Evaluated by the EMS personnel. ‡Due to rounding up the percentiles exceed 100%. §All patients had different symptom codes.

1000 1–16-year-old inhabitants. The distribution of the triage codes for dispatching and transportation are shown in Table 2. The leading causes for both the calls and the transportations were high-energy falls, breathing difficulties and seizures, forming 41% of all calls and 38% of transports. The patient suffered from a medical condition in 1,185 (64%) cases and from trauma in 676 (36%) cases.

The five leading dispatching codes for paediatric patients in the Helsinki city area were 'high-energy falls' (16%), 'breathing difficulties' (13%), 'seizures' (12%), 'intoxications' (7.1%) and 'traffic accidents' (6.2%). The leading dispatching codes for the whole population during the study period were 'high-energy falls' (14%), 'sudden deterioration of general condition' (11%), 'chest pain' (10%), 'breathing difficulties' (8.9%) and 'poisonings' (6.3%). The most common symptom codes for dispatching in each triage class are shown in Table 2.

There were 366 days in 2012. The number of EMS responses concerning paediatric patients varied between 0 and 13 a day, mean 5.1. The days with the highest number were October 22 and November 9. The mean number of responses per month was 156, minimum 129 (November) and maximum 200 (May), during the year 2012. There was no seasonal variation in the number of responses. The distribution by the time of day is shown in Fig. 1.

In 71/1,863 (4%) of the cases, the MICU, and in 63/1,863 (3%) of the cases, the medical supervisor unit was dispatched. Of these cases, in 28/71 (39%) the MICU, and in 12/63 (19%), the medical supervisor unit was dispatched after the first response unit had consulted the physician. The physician accompanied the patient to hospital in 16/71 cases (23%), and the medical supervisor in 8/63 cases (13%). The emergency physician was consulted by phone in 328 cases (18%). During the study period, 2.9% of all calls of the MICU and 4.3% of all calls of the medical supervisor unit concerned paediatric emergencies.

The mean age of the patients was 8 years, and 975 (52%) of the patients were male. The number of the EMS responses by the age group is shown in Fig. 2. According to the EMS patient record, a previous health problem was documented in 382 cases (21%), the other 1481 patients being previously healthy.

In 1050 cases (56%), the patient was transported to hospital by ambulance. In other cases, the EM personnel were either able to treat the patient on scene, decide that the patient did not need to visit the emergency department (ED) at all, or decide that the patient needed the ED visit but not the ambulance transportation. Of the 813 non-transported patients, 136 (17%) had a secondary contact in three days after the original EMS contact. There were 6 secondary EMS responses and altogether 133 visits to the

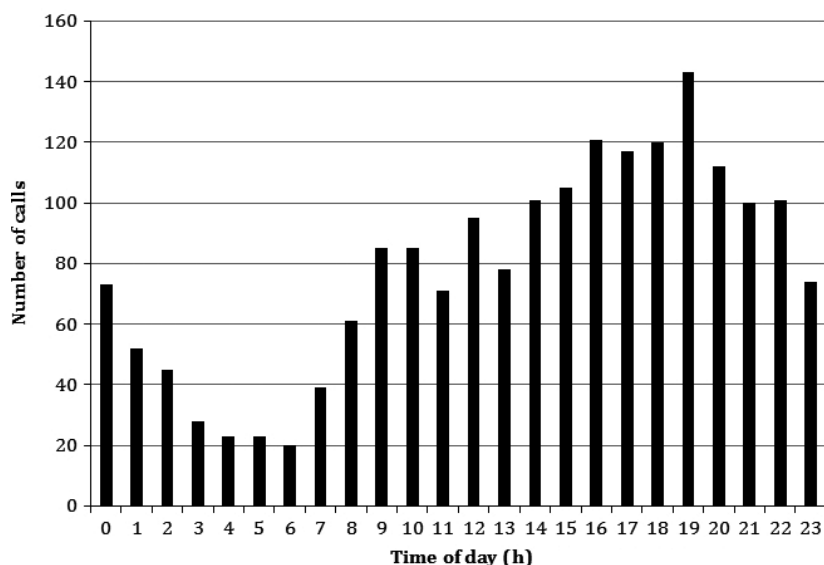


Fig. 1. Ambulance call distribution by the time of day (the time the emergency call was received).

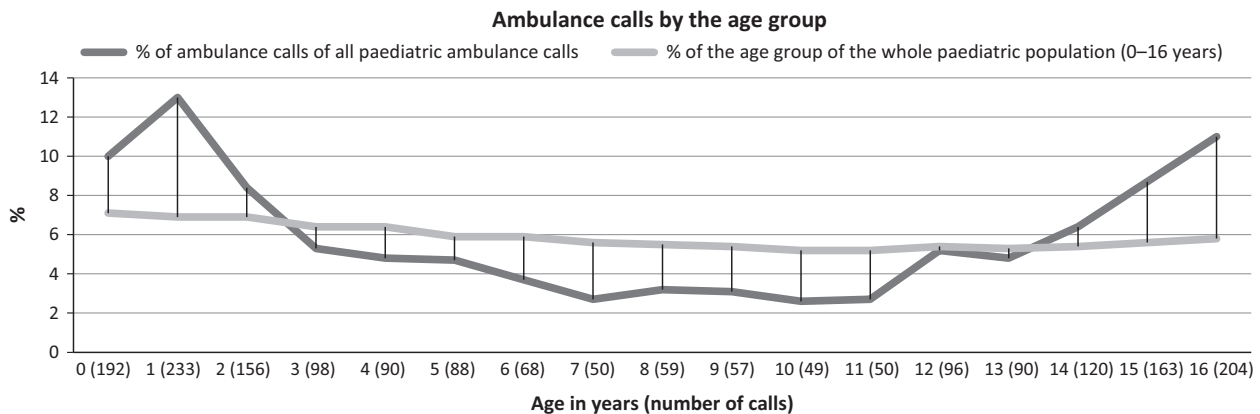


Fig. 2. The ambulance calls by the age group. The black line shows the distribution (%) of ambulance calls by each age group. The grey line shows the distribution (%) of these age groups in the whole population. Absolute numbers of ambulance calls are shown on the x-axis.

ED. Three of the non-transported patients had died during a 2-year follow-up. None of the deaths were associated with the original EMS response. In 103 of the ED visits, the EM personnel had instructed the patient or the parents to contact the ED, but the ambulance transport was not judged to be needed. Thus, the visits were premeditated. There were altogether 30 unpremeditated ED visits. This formed 3.7% of all non-transported patients. The patients are described in Fig. 3.

We found that the pre-hospital care, investigations or patient records were inadequate in 9 of the 813 non-transported patients. We evaluated that in four cases, the potential risk for the patient had been low, and in five cases, it was moderate. All these patients were under 2 years old, and the physician had not been asked about the need for transportation. In three cases, the EM personnel did not recognize transient seizures described by parents despite otherwise adequate pre-hospital investigations. In three

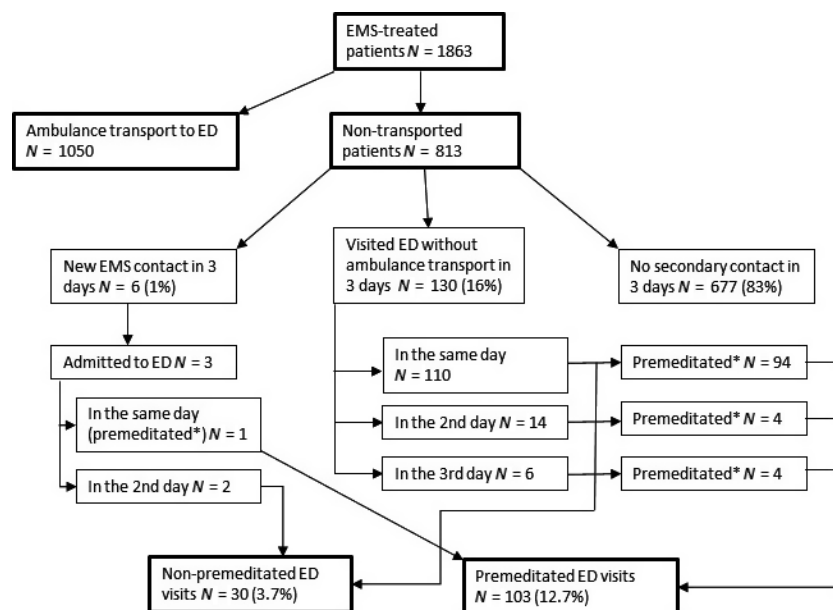


Fig. 3. The paediatric EMS-treated patients in 2012 in Helsinki.

ED = emergency department

EMS = emergency medical services

* The patient or the parents had been instructed by emergency medical personnel to visit ED without an ambulance transport

cases, the patient obviously did not need transportation, but the patient records and investigations were not comprehensive. In three other cases, the EM personnel had failed to recognize a need for ambulance transportation of an infant with signs of infection because of incomplete investigations.

During the year 2012, there were 10 paediatric OOH cardiac arrests. In nine cases, the patient died on scene. Two of these were caused by trauma (traffic accident), and eight by medical emergencies.

In 257 (14%) cases, there were no documented objective measurements, e.g. blood pressure or heart rate. 129 (5%) of these patients did not need ambulance transportation. In seven cases, the triage code of call was A (high risk), and in 85 cases, it was B (moderate or unknown risk). Only two patients were transported with triage code A and seven patients with triage code B without any measurements. Among the patients without any measurements, the mean age was 5 years (range 0–16). 162 (63%) of the calls concerned some kind of trauma.

All the medicines used for paediatric OOH patients are described in Table 1. Nine patients were intubated on the scene; four by an emergency medical physician and five by a medical supervisor.

Discussion

The vast majority (79%) of OOH emergencies concerned previously healthy children, most of whom did not have a life-threatening condition. After evaluation and treatment, the EM personnel judged that 44% of all the paediatric patients did not need transportation to emergency department by ambulance. These patients could either be managed on scene, or required hospital treatment but did not need transportation by an ambulance.

These results are consistent with previous studies^{7,11} showing that relatively few paediatric OOH emergency calls seem to concern situations that are judged emergencies by professionals, and that a paediatric emergency call should not directly imply ambulance transport to ER. We found that the proportion of non-transported children (44%) was even higher than previously reported^{7,9,12}; we also had less transports judged

urgent than did Richards et al.⁷. These differences may reflect the dispatching system and the fact that in our publicly funded system, financial interests (e.g. ability to pay or interest to charge for the transport) do not influence the figures. In the Finnish system, the dispatcher evaluates the risk with a standardized, sensitive but not very specific protocol. The proportion of the non-transported paediatric patients (44%) is also comparable to the amount of all non-transported patients in Helsinki during the study period (42%).

It is important to note that the decision to not transport the patient by ambulance only concerns the means of transport, not the need for medical attention; the EM personnel may refer the patient to ED without ambulance transport, if other means of transport are sufficient. Only 3.7% of the non-transported patients visited ED unpremeditatedly, without EM personnel's advice. In only nine non-transported cases (1%), we evaluated the pre-hospital care to have been inadequate. No harm came to these patients even transiently. Thus, the study suggests that, in a properly organized and educated urban or suburban EMS system, it is reasonable not to transport all EMS-treated patients.

Avoiding unnecessary transports improves the availability of emergency medical and emergency department services for 'true' emergencies. Thus, EMS plays an important role by directing and redirecting patients to the right hospitals at the right time. However, in this approach, safety highly depends on the EM personnel's ability to assess the child's condition and accurately determine the need for transport. It is probable that standardized methods to evaluate the child's condition and the possibility to consult with a specialist, e.g. an emergency physician, would improve patient safety. However, it has been suggested that the EM personnel tend to use standardized methods less frequently when evaluating a child's condition^{13,14} and that measurements are not always performed.^{2,7,15} This is probably due to lack of expertise and the confusion caused by varying normal ranges in different age groups. Indeed, our results, with 14% of the paediatric OOH patients having none of the objective parameters measured, and the fact that all the nine non-transported patients whose pre-hospital care

was inadequate were below 2 years old, suggest that similar confusion still exists.

EM personnel very seldom faced paediatric out-of-hospital cardiac arrests (OHCA). This is consistent with previous studies.^{1,2,6,7,9} Prognosis of a paediatric OHCA is often poor, regardless of the resuscitation efforts.^{5,16} Thus, it seems rather disproportionate that, currently, much of the emergency medical personnel's paediatric training is targeted at performing cardiopulmonary resuscitation (CPR) on children. While this critical skill obviously needs to be acquired and maintained, it seems reasonable to focus training towards the most frequent situations, e.g. evaluation of vital signs in different paediatric age groups and treatment of seizures and dyspnoea. This aspect, naturally, needs to be confirmed with intervention studies.

There were no clear seasonal or weekday-to-weekend variations in the amount of EMS responses concerning paediatric patients. A longer study period and a specific analysis of different subgroups would be necessary to find significant variation in these parameters.

The distribution of EMS responses by the age group was uneven. In the age group of 3–13 year-olds there were less EMS responses in relation to the size of the group than in the age groups of 0–2 and 14–16 year-olds (Fig. 2). This may represent true age-related differences in the occurrence of OOH emergencies. Particularly, the increased frequency of OOH emergencies in the older age groups may reflect the effects of teenagers' risk behaviour, resulting in more OOH emergencies. On the other hand, the overrepresentation of young (0–2 years) children may also reflect the difficulties encountered by caregivers and professionals when evaluating nonverbal children.

Medication was rarely used on the scene (Table 1). One cannot rule out the possibility that drugs were seldom administered because the EM personnel do not recognize the need for medication, or they feel uncomfortable about administering drugs for paediatric patients.

Our results, resulting from a population-based approach to EMS responses, may not be directly comparable to pre-existing ones. First, many previous studies on childhood OOH emergencies have focused on the use of helicopter emergency medical services,^{4,17} to certain medical

conditions¹⁷ or patient data have been derived retrospectively from referral hospitals.⁸ These studies do not offer epidemiologic knowledge, as they are likely to include significant selection bias (e.g. more severe cases are more likely to require air transport). Second, the EMSs and their operating areas differ between countries, even inside Europe. Comparison of the results from the studies aiming at an epidemiologic approach should be done with caution; for instance, the figures published by Richard et al. 2006⁷ were from both urban and rural areas, which may explain their higher ambulance transport rate and more frequent transports in urgent or semi-urgent triage classes. In the Finnish EMS system, professional dispatchers evaluate the emergency calls; the ambulance is dispatched only when a real emergency is probable. The area in our study is urban or suburban and the distances short with advanced public transport services. Thus, it is unnecessary to send an ambulance as a means of transport only, as seems to be the case in some other EM systems.¹¹ Consequently, we believe that our approach and our cohort of patients represent all paediatric OOH emergency patients well.

Our data were consistent with pre-existing studies^{2,6,7} on the distribution of causes of paediatric OOH emergencies. The proportion of trauma-related emergencies seems to be between 25% and 30% in all of them, the majority being related to 'illnesses'. This was true for both EMS responses and ambulance transports in our study. Only Suruda et al.¹⁰ reported a higher incidence of paediatric OOH trauma (76%) in transported patients. These findings may have implications for the paediatric ED where the patients are transported. In addition to adhering to a strict trauma protocol as often is the case, the ED team should be prepared to encounter patients with medical conditions (e.g. intoxication, dyspnoea) with equally pre-meditated protocols.

Our study has its limitations. Although our approach was population based and we had practically full coverage on all EMS responses, some minor patient groups may have been left aside. For instance, babies born out of hospital were not found in our data search. However, the number of newborn babies needing OOH is likely to be very small, as only 0.14% of deliv-

eries occurred out-of-hospital in Finland in 2012.¹⁸ In addition, the population is defined upon the geographical distribution of the emergency calls; the part of population temporarily residing out of Helsinki has not been included, and some emergency calls in Helsinki area concerned non-residents. However, to our understanding, our data represent the population reasonably well. In future studies, to improve the representativeness of this kind of studies, rural areas and preferably international comparison should be included.

In conclusion, our population-based study shows that paediatric OOH emergencies are rare and their causes differ from the adult population. The leading causes for paediatric ambulance transportations are traumas, dyspnoea and seizures, whereas the incidence of a paediatric OHCA is extremely low. Accordingly, EM personnel's paediatric training should emphasize the leading causes of paediatric OOH emergencies and systematic evaluation of vital signs in different paediatric age groups. A paediatric emergency call probably should not imply ambulance transportation, as, after adequate evaluation by the EM personnel with consultation possibilities, almost half of the patients could be safely treated on scene or use other transport facilities. Still, especially the practice of paediatric OOH non-transport warrants further studies, as wide differences seem to exist between different EMS systems.

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