

## Iatrogenic events contributing to paediatric intensive care unit admission

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### Summary

**AIMS:** To identify the incidence of iatrogenic events leading to paediatric intensive care unit (PICU) admission and to analyse these patients regarding demographic, illness severity and outcome parameters.

**MATERIAL AND METHODS:** This was a retrospective case series. The computerised charts of all patients admitted to the multidisciplinary, tertiary, 18-bed PICU in 2014 were analysed. Iatrogenic events leading to PICU admission were identified and their preventability assessed. Underlying diseases, causes of iatrogenic events, illness severity at PICU admission, presence of complex chronic conditions, patient origin, length of stay on the PICU and outcome were analysed.

**RESULTS:** There were 138 admissions associated with iatrogenic events out of 1102 admissions (12.5%). Ninety iatrogenic events led to unplanned admissions and 48 cases concerned scheduled admissions, where the iatrogenic event would have led to PICU admission by itself or caused a second, planned PICU admission for re-operation. Iatrogenic complications during surgery (31% of all iatrogenic events), wrong management decisions / delayed diagnoses (20%) and nosocomial infections (14%) were the categories most often involved. Regarding origin of the patients, the greatest difference between iatrogenic event admissions and non-iatrogenic event admissions was found for the ward (21% vs 11%). The patients admitted for iatrogenic events had a higher mean expected mortality (8.4 vs 4.7%,  $p = 0.02$ ) and a higher observed PICU mortality (5.8 vs 3.3%,  $p = 0.15$ ). Of all iatrogenic events, 60.1% were judged to be preventable. The highest preventability rate was found in the categories "nosocomial infections" (100%) and "management decisions / delayed diagnoses" (92.9%).

**CONCLUSION:** In our setting, the number of PICU admissions associated with iatrogenic events is significant and comparable to adult data on admission to ICU caused by iatrogenic events. The categories with most potential for improvement are nosocomial infections and the wrong management decisions / delayed diagnoses. Focused measures on these iatrogenic events may have a major

impact on patient outcome, availability of PICU resources and healthcare costs.

**Keywords:** *iatrogenic event, paediatric intensive care unit, patient safety, nosocomial infection, diagnostic error*

### Introduction

These days medicine has a great value in our society. People rely on doctors doing their best and errors by medical staff are not accepted. However, "to err is human" applies to medicine too [1]. How much and how often are patients affected by errors? There are several reviews dealing with this topic [2–4]. We would like to focus on iatrogenic events as the cause for admission to paediatric intensive care unit (PICU). To our knowledge, there are no studies on iatrogenic events contributing to ICU admission in paediatrics. But this may be a serious problem, for the individual patient and for the care of other patients, when PICU resources are limited. The incidence of iatrogenic events in adult ICUs, responsible for ICU admissions, ranges from 1.2% to 27.4% [1, 5–7]. In adult data, patients admitted for iatrogenic events, compared with patients without an iatrogenic event, had a higher Simplified Acute Physiology Score (SAPS II), were more often admitted for shock, had higher numbers of drugs prescribed before ICU admission and had longer ICU length of stay (LOS) [8].

The aim of our case series was to identify the incidence of iatrogenic events leading to PICU admission and to analyse these patients regarding underlying diseases, cause of the iatrogenic event, preventability of the iatrogenic event, illness severity at PICU admission, LOS in the PICU and outcome. Since at PICU a high number (40–70%) of patients have at least one complex chronic condition (CCC) [9], we also examined how iatrogenic events affect this special group of patients.

We hypothesise that a significant number of PICU admissions are related to an iatrogenic event and that significant PICU resources are spent on this patient group. Furthermore, we hypothesise that patients with CCCs are more at risk for iatrogenic events leading to PICU admission [10]. Our results may provide the foundation for specific preventive strategies and the need for further studies.

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## Material and methods

### Setting and data collection

The study was performed in the multidisciplinary, 18-bed PICU of the University Children's Hospital of Zurich. The unit includes post-cardiac-surgery patients and runs an extra-corporeal membrane oxygenation (ECMO) programme. About 25% of patients are in the neonatal age group, mainly neonates with cardiac and/or surgical pathologies. There are no inborns in our hospital.

We screened retrospectively all patients admitted to the PICU in 2014. Data were collected by screening through the electronic patient records. The main source for the evaluation of iatrogenicity was the medical history at admission. In the admission notes, the reason for the PICU admission is stated. If the reason for admission pointed to a probable iatrogenic event, we verified this by looking at the corresponding notes describing the events, e.g. on the ward. Patient records were screened by two researchers (RS and BF) for the contribution of iatrogenic events to PICU admission, the nature of these iatrogenic events and their preventability. If the two researchers scored differently, consensus was sought by discussion.

When patients had multiple admissions to the PICU every admission was included. Data were collected on Microsoft EXCEL (Version 14.7.2).

The following demographic and illness severity parameters were prospectively collected (minimum data set, MD-Si, Swiss Society of Intensive Care) [11]: age, gender, length of stay on the PICU, nine equivalents of nursing manpower use score (NEMS) [12], severity of illness at admission to PICU (PIM2) [13], type of admission (scheduled/emergency; post procedure), unexpected readmission <48 hours, main diagnosis at PICU admission, outcome. NEMS is a suitable therapeutic index to measure nursing workload in intensive care. PIM2 estimates the expected mortality at PICU admission, that is, the severity of illness. PIM2 score is based on 10 variables. For diagnostic classification, we used the Australian and New Zealand Paediatric Intensive Care Registry (ANZPIC) [14]. Furthermore, the following parameters were captured: cardiopulmonary resuscitation (CPR) immediately prior to PICU admission, and presence of a CCC.

Newborns admitted to PICU because of prematurity or perinatal problems were excluded in our study, because it is very difficult to decide whether there is iatrogenicity or not in perinatal events, even more so when newborns are outborns, as in our hospital. However, once cared for on the ward in our hospital and admitted to PICU or the reason for admission to the intensive care unit was not a perinatal complication, newborn babies were analysed for iatrogenic events. There were no time or age-related exclusion criteria. No imputation was made in place of missing data.

The study was approved by the cantonal Ethics Committee of Zurich (Gesuch BASEC-Nr.:2016-02207).

### Definitions of iatrogenic events and complex chronic conditions

An iatrogenic event was defined as an event, injury, or harm induced by a physician or healthcare professional, including nurses, that was contributing to admission to PICU. We used the criteria from Mercier et al. [8]: (1) the

cause of the iatrogenic event must be in a reasonable time frame in relation to the admission; (2) a known response pattern, previously recorded in the literature, as well as drug side effects (adverse drug events, ADEs); (3) an aggravation of the patient's condition not explained by the underlying disease; (4) nosocomial infections and wound infections after surgery; (5) anatomical criteria for mechanical iatrogenic events; (6) complications that were not to be expected [6]. The criteria one to three specify ADEs. The medication charts were not specifically examined. If there were any medication error documented in the patient records, it was analysed for iatrogenic events, such as drug overdoses, leading to respiratory, cardiovascular or neurological depression. Every medicine was considered to be a potential cause of an iatrogenic event. Other causes of iatrogenic events (medical or surgical procedures, excessive delay in diagnosis or treatment, nosocomial infections) are defined by three out of the six criteria. Nosocomial infections were defined as infections occurring at least 48 hours after admission to hospital. We also included all in-hospital cardiopulmonary resuscitations leading to PICU admission as iatrogenic events, with the justification that one should not miss the deterioration that ultimately led to resuscitation (delay in diagnosis or diagnostic error). CPR was defined as the need for chest compressions and/or bag-mask ventilation. In the event of a resuscitation, the cause was searched for and the classification into the respective iatrogenic event group was made accordingly. We also considered elective admissions when there was an iatrogenic event that would have led to PICU admission by itself or caused a second, planned PICU admission for re-operation. When a patient was admitted to the PICU after sustaining an iatrogenic event caused by surgery and then had a second operation with a planned readmission, we counted only the first admission as associated with an iatrogenic event. Admissions from other hospitals were not primarily counted as iatrogenic events. However, if there was an indication for iatrogenicity causing the admission to our PICU, the case was analysed accordingly.

Iatrogenic events were categorised into one of seven groups: (1) surgery complications; (2) interventions (cardiac catheter, placement of central venous line); (3) medication errors or side effects; (4) complications during anaesthesia; (5) dysfunction of implanted material; (6) nosocomial infections; (7) management decisions (e.g., delayed or incorrect diagnosis or therapy).

For each iatrogenic event, preventability was estimated. A preventable iatrogenic event was defined as one that would not have occurred if the medical handling was the best expected practice. This was a judgement made by the investigators based on their professional experience.

The definition of complex chronic conditions (CCCs) was based on the paediatric complex chronic conditions classification system version 1 with subdivision of chronic conditions into ten different groups [15]. We divided the patients with CCCs into two groups: one CCC or more than one CCC.

### Statistical analysis

Summary statistics are outlined as mean and standard deviation (SD) or median and range, as appropriate. Differences between groups are analysed using the unpaired Stu-

dent's t-test for continuous variables and chi-square test for categorical variables. A p-value of <0.05 was taken as statistically significant (IBM SPSS Statistics, Version 23).

## Results

There were 1158 admissions to the PICU during the year 2014. Fifty-six cases were admitted because of peripartum complications and were not counted, leaving 1102 admissions for analysis.

### Admissions associated with iatrogenic events

One hundred and thirty-eight admissions (12.5%) were associated with iatrogenic events. Demographics, origin, severity of illness and outcome of the admissions associated with iatrogenic events and the admissions without an iatrogenic event are given in table 1. The iatrogenic event categories with their related numbers of CCCs, resuscitations and deaths are shown in table 2. In the iatrogenic event group, 92 patients suffered from one chronic condition and five patients from at least two different chronic conditions. The youngest patient admitted to PICU for an iatrogenic event was a two-day-old baby. This baby underwent CPR on the ward, as a result of hypoglycaemia due

to relevant risk factors (low birth weight, maternal nicotine abuse).

Iatrogenic events in scheduled admissions made nearly one third of all iatrogenic events (48 cases). Most of these occurred during surgery (23 events) and the patients needed re-operation owing to the event with a planned PICU admission afterwards. Two cases were planned for PICU admission after surgery but had significant complications during surgery or anaesthesia caused by an iatrogenic event that would also have led to PICU admission. Ninety of the 138 iatrogenic events led to unplanned PICU admissions.

The 20 cases with nosocomial infection as iatrogenic event accounted for 14.4% of iatrogenic event admissions to the PICU and all 20 cases were counted as preventable. Sixteen patients suffered from one or more chronic conditions. In this group there were no resuscitations nor fatal outcomes.

Sixteen (11.6%) patients were admitted to the PICU after medication errors or medication side effects. Fourteen of these cases suffered from a chronic condition. In this group there were no fatal outcomes nor resuscitations.

**Table 1:** Characteristics of admissions to the paediatric intensive care unit with and without an iatrogenic event.

Characteristics	Admission with IE (n = 138)	Admission without IE (n = 964)	p-value
Age (years), median (range)	4.6 (0.0–17.30)	3.9 (0.0–19.9)	0.15
Gender, male, n (%)	77 (55.8%)	569 (59%)	0.47
<b>Transfer to hospital from, n (%)</b>			0.16
– Other hospital	44 (31.9%)	389 (40.4%)	
– Home	77 (55.8%)	466 (48.3%)	
– Other/undocumented	17 (12.3%)	109 (11.3%)	
<b>Transfer to ICU from, n (%)</b>			0.00
– Ward	29 (21%)	106 (11%)	
– Other ICU	9 (6.5%)	83 (8.6%)	
– IMC/RR/HDU	4 (2.9%)	16 (1.7%)	
– Emergency department	8 (5.8%)	126 (13.1%)	
– Theatre/postinterventional	80 (58%)	504 (52.3%)	
– Other	8 (5.8%)	129 (13.4%)	
Unplanned readmission <48h, n (%)	9 (6.5%)	26 (2.7%)	0.02
LOS (days), median (range)	4.08 (0.02–78.90)	4.64 (0.01–336)	0.55
Resuscitation before ICU admission, n (%)	20 (14.5%)	0 (0%)	0.00
Death in ICU, n (%)	8 (5.8%)	32 (3.3%)	0.15
CCC, n (%)	97 (70.3%)	670 (69.5%)	0.86
NEMS, mean (SD)	346 (960)	330 (789)	0.85
PIM2, mean (SD)	8.35 (17.56)	4.70 (11.02)	0.02

IE = iatrogenic event; ICU = intensive care unit; IMC = intermediate care unit; RR = recovery room; HDU = high dependency unit; LOS = length of stay in ICU; CCC = complex chronic condition; NEMS = nine equivalents of nursing manpower use score; PIM2 = paediatric index of mortality

**Table 2:** Iatrogenic events by categories.

Iatrogenic event categories	All IEs n	CCC n	CPR n	Death n
Surgery complications	43	29	2	0
Management decisions/ delayed diagnoses	28	14	11	7
Nosocomial infections	20	16	0	0
ADE	16	14	2	0
Interventional IE	13	11	3	1
Anaesthesia complications	12	7	2	0
Dysfunction of material	6	6	0	0
<b>Total iatrogenic events</b>	<b>138</b>	<b>97</b>	<b>20</b>	<b>8</b>

IE = iatrogenic event; CCC = complex chronic condition; CPR = cardiopulmonary resuscitation; ADE = adverse drug event

There were 28 (20.3%) admissions to the PICU associated with wrong or delayed diagnosis or a wrong management decision. The leading diseases varied. Five patients had cardiovascular diseases with cardiovascular decompensation leading to admission to PICU. Out of these five patients, two underwent CPR, both with a fatal outcome. Furthermore, there were five patients with abdominal or gastrointestinal problems and three patients with septic shock, all of them diagnosed with a severe delay. There were 11 resuscitations in this group; this is by far the most compared with the other groups.

Thirteen (9.4%) patients had an iatrogenic event during an intervention (cardiac catheter, placement of vascular access). Ten of those were admitted from the theatre. There were three resuscitations with one fatal outcome during cardiac catheter interventions. The event leading to death was not counted as preventable. Out of these patients, 11 had a chronic condition.

The largest group of iatrogenic events were surgery complications, with 43 patients (31.2%). However, there were only two resuscitations and no fatal outcome. Twenty-nine of these patients had a chronic condition. The three most frequent procedures were: tonsillectomy (12 patients, all of them with revisions due to postoperative bleeding), heart surgery (15 patients) and abdominal surgery (10 patients).

Complications during anaesthesia were the reason for 12 (8.7%) admissions to the PICU. Five of the 12 cases suffered from iatrogenic problems during recovery from anaesthesia. The two CPRs were based on problems during induction of anaesthesia, with no fatal outcome. Children with chronic conditions made 7 out of the 12 patients of this group.

Only six (4.4%) patients had an iatrogenic event caused by material dysfunction. Ventriculo-peritoneal shunt dysfunctions accounted for three iatrogenic events. Two patients had problems with pacemaker leads and one case had a broken bar after stabilising spine surgery. All of these children had a chronic condition.

Eight patients died in the PICU after being admitted for an iatrogenic event, and in five of these cases the iatrogenic event was judged as preventable (table 3 and 4).

### Preventable iatrogenic events

In 83 cases out of the 138 iatrogenic events (60.1%), the event was classified as preventable (tables 3 and 4). All of the nosocomial infections and almost all of the incorrect management decisions were judged to be preventable.

The comparison between preventable and non-preventable iatrogenic events is shown in table 3. The percentages for preventability in each group are based on the admissions with iatrogenic events in this group. Table 4 presents the various causes of the preventable iatrogenic events, as well as associated resuscitations, deaths and chronic conditions.

### Discussion

Our study showed that around 12.5% of all admissions to PICU are associated with an iatrogenic event beforehand. Iatrogenic complications during surgery, wrong management decisions / delayed diagnoses and nosocomial infections were the categories most often involved in these iatrogenic events. Most PICU deaths occurred in the category management decisions / delayed diagnoses. The children admitted to PICU because of iatrogenic events had a significantly higher illness severity score (PIM2) (mean expected mortality 8.4% vs 4.7%); their observed mortality was also higher, but this was not significant (5.8% vs 3.3%). There was no difference in the rate of chronic conditions between iatrogenic event admissions and the other admissions. Almost two thirds of the iatrogenic events were judged as preventable.

Sixty percent of all iatrogenic events were judged as preventable. Admissions with preventable iatrogenic events had longer median length of stay in the PICU compared with non-preventable events (4.92 vs 2.80 days,  $p = 0.17$ ). The categories with the highest percentage of preventable iatrogenic events were management decisions / delayed diagnoses and nosocomial infections (table 3). The highest

**Table 3:** Categories and characteristics by preventable vs non-preventable iatrogenic events.

Iatrogenic event categories	Preventable IE (n = 83)	Non-preventable IE (n = 55)	p-value
Management decisions / delayed diagnoses, n (%)	26 (31.3%)	2 (3.6%)	0.00
Nosocomial infections, n (%)	20 (24.1)	0	0.00
Surgery complications, n (%)	16 (19.3%)	27 (49.1%)	0.00
ADE, n (%)	8 (9.6%)	8 (14.5%)	0.38
Interventional IE, n (%)	7 (8.4%)	6 (10.9%)	0.63
Dysfunction of material, n (%)	4 (4.8%)	2 (3.6%)	0.74
Anaesthesia complications, n (%)	2 (2.4%)	10 (18.2%)	0.00
<b>Characteristics</b>			
Age (years), median (range)	4.4 (0.0–17.3)	4.9 (0.0–15.9)	0.58
Gender, male, n (%)	45 (54.2%)	32 (58.2%)	0.65
LOS (days), median (range)	4.92 (0.04–78.9)	2.80 (0.02–50.8)	0.17
Resuscitation, n (%)	14 (16.9%)	6 (10.9%)	0.33
Death in PICU, n (%)	5 (6.0%)	3 (5.5%)	0.89
Unplanned readmissions <48h, n (%)	7 (8.4%)	2 (3.6%)	0.26
CCC, n (%)	63 (75.9%)	34 (61.8%)	0.08
PIM2, mean (SD)	9.25 (17.3)	6.99 (18.01)	0.46

IE = iatrogenic event; ADE = adverse drug event; LOS = length of stay in ICU; PICU = paediatric intensive care unit; CCC = complex chronic condition; PIM2 = paediatric index of mortality

absolute number of preventable iatrogenic events was recorded in the category management decisions / delayed diagnoses. Furthermore, all deaths in the preventable iatrogenic event group occurred in the latter category (table 4). Obviously, these five deaths were potentially preventable. Therefore, the categories with most potential for improvement by implementation of corresponding measures are wrong management decisions / delayed diagnoses and nosocomial infections.

The overall rate of iatrogenic events (12.5%) correlates with results from studies in adult ICUs published over the last 30 years [6–8]. We adopted the definitions of iatrogenic events from these adult studies. To our knowledge, there are no reports about iatrogenic events leading to admission to paediatric intensive care. From this perspective, our results give a first impression of how often children are admitted to PICU for iatrogenic events and with 12.5% of all admissions this is quite a large group of children.

We observed, in comparison with other reports, high numbers of iatrogenic events in the categories “surgery complications” and “wrong management decisions”. ADEs were also an important reason for PICU admission in our study. There were two resuscitations following morphine overdose (one cardiac arrest and one respiratory arrest), fortunately not leading to death. Both events were judged as preventable. Findings from Mercier [8] and Darchy [7] in adult ICUs showed higher iatrogenic event rates for ADEs than we did. This could be due to the fact that we did a retrospective analysis of the computerised patient chart, where medication was not documented comprehensively. If ADEs were not specifically mentioned in the patient chart, we would not have recorded them. Another reason for the low rate of ADEs in our study may be the fact that minor and potential ADEs did not cause ICU admissions or were prevented before ICU admission. We could also show that a high number of nosocomial infections are associated

**Table 4:** Preventable iatrogenic events and aetiology.

Cause of iatrogenic events	n	CPR n	Death in PICU n	CCC n
<b>Management decisions / delayed diagnoses</b>				
Respiratory decompensation	6	4	1	5
Cardiovascular decompensation	5	2	1	5
Septic shock	4	1	2	–
Dehydration and electrolyte shift	4	1	–	–
Laparotomy	2	–	–	1
Compartment syndrome	1	–	–	1
Cranio-cerebral injury	1	1	–	–
Intracerebral bleeding	1	–	–	–
Meningitis	1	–	1	1
Spleen/liver rupture	1	–	–	–
<b>Nosocomial infections</b>				
Postoperative wound infections	6	–	–	5
Central line associated blood stream infection	4	–	–	3
Sepsis, other than central line associated	4	–	–	3
Viral respiratory tract infection	3	–	–	2
Pneumonia	3	–	–	3
<b>Surgery complications</b>				
Heart surgery	6	–	–	6
Thoracic surgery	4	1	–	4
Abdominal surgery	4	1	–	3
Blood vessel surgery	2	–	–	2
<b>ADE</b>				
Morphine overdose	2	2	–	2
Sedative drug events	2	–	–	1
Cardiovascular drug events	1	–	–	1
Anticonvulsant drug	1	–	–	1
Volume overload	1	–	–	1
Electrolyte overdose	1	–	–	1
<b>Interventional IE</b>				
Cardiac catheter	4	1	–	4
Contrast enema	1	–	–	1
Laryngoscopy	1	–	–	1
Aspiration during tube feeding	1	–	–	1
<b>Dysfunction of material</b>				
Cardiac pacemaker dysfunction	2	–	–	2
Broken bar after spine surgery	1	–	–	1
Ventriculo-peritoneal shunt dysfunction	1	–	–	1
<b>Anaesthesia complications</b>				
Problem related to extubation	1	–	–	–
Oxygen saturation drop before intubation	1	–	–	1

IE = iatrogenic event; ADE = adverse drug event; CPR = cardio pulmonary resuscitation; CCC = complex chronic condition

with admission to PICU (27.6%); this is a higher rate than described by Poidevin et al. (8.5%) [16] and Darchy et al. (4.4%) [7].

With regard to the severity of iatrogenic events and outcome after admission, the category “management decisions / delayed diagnoses” is vulnerable: most of the resuscitations and most of the deaths were in this category. Also, for the whole sample, mortality was higher in the iatrogenic event group, although not significantly (5.8% vs 3.3%,  $p = 0.15$ ). But we saw a significantly higher illness severity at PICU admission (PIM2 score) and a longer length of stay in patients admitted due to an iatrogenic event, probably related to the iatrogenic event and the underlying condition. The data regarding ICU mortality after admission due to iatrogenic event is contradictory in the literature. Mercier et al. described a higher mortality in adult patients with iatrogenic event [8]. Poidevin et al. and Darchy et al. recorded the same ICU mortality for admissions with or without an iatrogenic event [7, 16].

We could not see any significant difference between the demographics of the two groups, as shown by Poidevin et al. in adults [16].

Ward admissions were much higher for the iatrogenic event group than the non-iatrogenic event group (21% vs 11%, table 1). This was already reported by Poidevin in 2013 [16] and Mercier in 2009 [8]. These authors mentioned that most medical actions can lead to an iatrogenic event. Documentation on the wards and in the operating room is already very good today, but is much less so in the emergency or the outpatient areas. We also have no records of cases assigned to us by practicing doctors. This may lead to a higher incidence of iatrogenicity for patients on the ward. On the other hand, one might think that there is an increased risk of iatrogenic events in the emergency department, as the predictability and planning of disease progression is much more difficult and could potentially lead to more errors. It could be shown that admissions from the ward had higher odds of mortality and longer stay at the PICU. The implementation of a paediatric early warning score (PEWS) on the ward led to a slight reduction of PIM2 scores and length of stay at the PICU, and so this could improve the clinical outcome of patients and maybe prevent iatrogenic event admission due to a delay in diagnosis [17].

The preventability of the iatrogenic events shows a very high rate (60%) and compares well with adult studies [16]. The highest preventability rate was found in the category “nosocomial infections” (100%). In second place was the category “management decisions / delayed diagnoses”, with a preventability rate of 92.9%. However, in this category, we observed the highest absolute number of preventable iatrogenic events, mainly concerning shock, respiratory failure and water/electrolyte disturbance (table 4).

Nowadays, there are voluntary critical incident reporting systems (CIRS) established in most hospitals. But recent studies showed that with CIRS only a few, and mostly minor adverse events could be captured [18]. Studies using the trigger tool methodology (retrospective or prospective) showed higher rates of significant iatrogenic events [19]. However, they are time consuming. It is important to respond to incidents, learn from them and make necessary changes [20]. We think that the most effective way to tack-

le iatrogenic events is to establish a speak-up policy and to educate and inform staff about the importance and necessity of recognising mistakes and, above all, reacting to them.

Our hypothesis that chronically ill children are more at risk for iatrogenic events and preventable iatrogenic events was not confirmed with our results. This could be due to the fact that two thirds of all patients admitted to the PICU suffered from at least one chronic condition.

Our study has some limitations. First, it was a retrospective analysis. Whereas most data were collected prospectively, the judgement on whether a PICU admission was due to an iatrogenic event or not and whether the iatrogenic event was preventable or not, was made retrospectively. The reviewers (RS and BF) were dependent on the available information on the case histories, and their assessments obviously have some subjectivity. Also, owing to the retrospective design, a more detailed investigation into demographic, patient-specific conditions related to iatrogenic events was not possible. We included all CPRs leading to PICU admission as iatrogenic events, with the justification that one should not miss the deterioration that ultimately led to resuscitation (delay in diagnosis or diagnostic error). We assumed that resuscitations should not have to be performed in the inadequate setting of the ward, which means that deteriorating patients should be transferred to the PICU before they need CPR. In PICU the conditions to stabilise the patient and to perform CPR are much better than in the ward. However, with this definition, some of the cases leading to CPR on the ward may not have been due to delay in diagnosis, as they were just related to the natural history of the disease. We also included planned PICU admissions when there was an iatrogenic event that would have led, according to our assessment, to PICU admission by itself or caused a second, planned PICU admission for re-operation. So these cases did not increase the number of primarily iatrogenic event-caused unplanned PICU admissions. However, it might be that the iatrogenic events of these planned admissions led to increased morbidity and mortality. In most of these cases, PICU admissions were planned for postoperative/postinterventional monitoring or ventilation.

The analysed period of only one year limits the validity of the findings. However, as this is the first paediatric survey analysing the issue of iatrogenicity as a cause for PICU admission, the results have at least a preliminary significance. Further studies in other hospitals should be performed.

## Conclusion

There are no previous studies on the number of PICU admissions associated with iatrogenic events. We were able to point out that in our setting at least one-eighth of all admissions of patients transferred to the PICU are associated with an iatrogenic event. When looking at preventability of these iatrogenic events, the categories with the greatest potential of improvement are wrong management decisions / delayed diagnoses (diagnostic errors) and nosocomial infections. Regarding the origin of the patients, the wards seem to be the most vulnerable location. If we reduced the number of admissions caused by iatrogenic events, we could prevent a lot of harm to our patients and the scarce PICU resources would be available for children in need for

it. Avoidance of these admissions might have a major impact on the cost of the healthcare system.

#### Disclosure statement

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