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Utility of a Pediatric Trigger Tool in a Norwegian Department of Pediatric and Adolescent Medicine

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Title: Utility of a Pediatric Trigger Tool in a Norwegian Department of Pediatric and Adolescent Medicine

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ABSTRACT

Background

Trigger Tool Systems are retrospective methods that measure iatrogenic harm and have been used to identify areas of improvement and for monitoring change over time. The British National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools developed for use in adults. The PTT has not previously been developed or used in Nordic units. We aimed to investigate utility of the NHS PTT in children and adolescents in our department of pediatric and adolescent medicine.

Methods

A convenience sample of medical and surgical patient contacts March-May 2011 were screened for triggers using the NHS PTT of 39 items. The type and rate of harm detected were compared to the department's voluntary incidence reports.

Results

761 acute patient contacts representing 2268 patient days were included. Median age (IQR) for the trigger positive patients was 2.5 (1.0-8.0) years; range 0-18 years. We found only 20 out of the 39 NHS PTT triggers in 242 (31.8%) of the contacts. The highest number of triggers in a patient contact was 4. The most frequent trigger was re-admission within 30 days. Hypoxia which was the second most frequent trigger did not predict any patient harm. The PTT revealed a harm rate of 5% for medical patients, as compared to 0.5% in the incidence reports the same months. PTT screening revealed other types of harm than those reported by health care personnel themselves.

Conclusion

This study showed that the NHS PTT, with certain modifications to our context could, as a supplement to voluntary incidence reporting, be used to calculate the rate of harm and identify areas of care where most harm events are occurring.

ARTICLE SUMMARY

Strengths and limitations of this study

- There is a limited understanding of how structured patient safety work in pediatrics can be performed
- We investigated utility of The British National Health Service Paediatric Trigger Tool (PTT) in a level II pediatric unit and found that the tool needs to be modified to different settings
- Previous to this study, only one major pediatric trigger tool has been published in peer review journal format and none have been applied in outpatient settings
- This review is based on a significant amount of patient data. However, the single-center character and the short study period call for additional studies, preferentially multicenter studies

INTRODUCTION

By identifying recurring medical errors focused efforts can be made to improve patient safety.[1,2] However, medical errors do not always lead to harm to the patient. Patient harm can be caused by medical error, but can also occur as a result of a diagnostic or treatment procedure in the absence of a medical error.[3]

So-called 'trigger tools' focus on patient harm, not errors, and can in combination with more traditional incident reporting in healthcare help departments and hospitals focus their improvement work to reduce the overall rate of patient harm.[4] The global trigger tool (GTT) is a retrospective method for detecting iatrogenic harm [5] and has been used as a benchmarking system and means for monitoring change over time. A trigger has been defined as data present in the patient record that can directly or indirectly, by providing a clue for further investigation, represent an adverse event that caused patient harm.[6,7] The GTT has become a widely used tool in patient safety work. However, the understanding of health care–associated harm in children is limited as compared to adults and only recently a comprehensive pediatric trigger tool has been developed.[8]

The National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools for use in adults with the support of clinicians in nine UK hospitals, and was meant to be useful for district general hospitals, acute teaching hospitals and specialist pediatric centers.[4] However, there is a need for determining utility of such instruments derived from adult care in different institutions and contexts. The items comprising the PTT should be piloted in different settings in order to remove unnecessary or adult-oriented triggers and/or add more relevant triggers.[7]

Hence, we aimed to examine utility of the NHS PTT in the context of a large Nordic department of pediatrics and if needed adjust the tool for use in our patients.

Our primary focus was to examine if or to which extent the PTT detected patient harm in a typical Norwegian pediatric department like ours. A secondary aim was to assess utility of the different triggers, including predictive value of individual triggers for identifying harm.

METHODS

The study was approved as part of quality improvement activities by the institutional review board at Akershus University Hospital (AHUS)

Setting

AHUS is located outside the Norwegian capital Oslo. The hospital is the single largest acute hospital in Norway and offers a full range of medical services except cardiac- and neurosurgery, as well as treatment of severe traumatic injuries. The hospital introduced early warning scoring systems after this study. Routine GTT screening has been performed since 2007.

The Department of Pediatric and Adolescent Medicine is a 37-bed level II unit. Children and adolescents between zero and 18 years of age referred by general physicians for acute specialist care are examined in the children's emergency department (ED) and about 50% are admitted. AHUS does not have a pediatric intensive care unit (PICU), but transfers children below the age of 3 years to a nearby university hospital. Critically ill children between three and 18 years are treated in the intensive care unit (ICU) for adults in AHUS. Registration of patient harm in our unit is exclusively based on voluntary reporting through an electronic incidence reporting system called Extend Quality System (EQS).

PTT screening

We did a manual review of unplanned patient visits to the children's ED using the NHS Paediatric Trigger Tool User guide.[4] For convenience, we included the visits that were documented for the purpose of evaluating the introduction of a pediatric early warning score in our department over a 3 month period.[9] These visits represented 95% of all contacts in the children's ED in the study months. Pediatric (medical), as well orthopedic, general surgical; and ear, nose and throat (ENT) patients below the age of 18 years were included and the results were recorded in Excel spreadsheets (Microsoft Excel 2008 for Mac (Redmond, WA, US)).

The PTT screening was performed by the primary investigator (ALS) who is a consultant pediatrician in the department. Because AHUS is the first hospital in Norway to screen for pediatric triggers, there are no courses or formal training in the

PTT available in Norway. Hence, to get a general idea about the concept of trigger tools, ALS attended a full-day course in the GTT organized by The Norwegian Knowledge Centre for the Health Services. In addition, she received instructions from the GTT team at AHUS based on their review methodology and PTT screening of 10 patient records was performed in collaboration with a representative from the GTT team.

The PTT consists of 39 items described in Table 1. The patient records were reviewed in the following order: Diagnoses and treatment procedures, discharge summaries, medication charts, laboratory results, operation notes, nurse notes, physician notes and admission note. Because only half of the acute referrals result in an admission, our practice differs from most medical departments for adults where a larger proportion of acutely referred patients are being admitted. The PTT user guide dictates a minimum length of stay of 8 hours.[4] However, as we argue that our threshold for admitting patients from the children's ED is high with often only slight differences in disease severity and complexity between those who are admitted and those who are not, we included also acute outpatient visits in our screening. Further, we chose to register all patient contacts with the diagnoses hypo-/hyperkalemia and/or hypo-/hypernatremia as trigger positive regardless of the definitions used in the PTT user guide for these triggers (Table 1). Otherwise, we strictly followed the definitions and guidelines outlined in the user guide.

The PTT uses an adapted version of the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) 'Index for Categorizing Errors'.[10] The rationale for this is that the NHS focuses on adverse events that cause actual patient harm and not medical errors that have a potential for patient harm. Therefore, only the NCC MERP categories E through I are included: Temporary harm to the patient and required intervention (category E), temporary harm to the patient and required initial or prolonged hospitalization (category F), permanent patient harm (category G), intervention required to sustain life (category H), and patient death (category I).

Harm identified through PTT screening was compared to harm identified through voluntary incidence reports in the department.

Voluntary incidence reporting

ALS read and classified patient related incidents regarding pediatric (medical) patients reported in the EQS in March until May 2011. The rate of harm reported in incidence reports during these three months was low. Therefore all reports in an extended period of time, 2010-2012, were included for comparison to the PTT results. Patient harm identified in the incidence reports was classified from E through I for comparison to the findings from the PTT screening.

Statistical analyses

Data were analyzed using PASW®Statistics 18.0 software (SPSS Inc., Chicago, IL). Comparisons between groups were made using the Chi-square test for categorical variables and Mann-Whitney *U* test for continuous variables. P-values <0.05 were considered significant. Positive predictive value (PPV) for triggers was calculated and we calculated number of harm events per 1000 patient days and 100 patient contacts.

RESULTS

From March 15th until Mai 31st 2011 761 patient records, representing 2268 patient days were screened for triggers. Median age (IQR) in years was 3.5 (1.2-11.0) for all patients and 2.5 (1.0-8.0) for the trigger positive patients. Male to female ratio was 352:409 and 113:129 for all patients and the trigger positive patients, respectively.

We identified 20 out of the 39 different NHS triggers in 242 (31.8%) of all patient contacts. In 71.5% of the trigger positive contacts only one trigger was found. The highest number of triggers found in a patient contact was 4. The mean rate of triggers per patient was 1.4.

The most frequently found trigger was re-admission within 30 days. 52.5 % of outpatient visits were an unplanned re-admission or were followed by an unplanned readmission within 30 days and. 42.8% of admissions were or were followed by an unplanned readmission within 30 days. Common reasons for unplanned readmission were surgical site infection, recurrent (respiratory tract) infections, postoperative bleeding and seizures. We found the second most common trigger in our screening to be hypoxia, but no patient harm was associated with this specific trigger.

Of the 242 trigger positive contacts, 177 (73.1%) were admissions and 65 (26.9%) acute outpatient visits. Table 2 shows how trigger positive admissions and outpatient contacts were distributed across specialties.

We identified 48 incidents of harm, representing 21 harm events per 1000 patient days and 6 harm events per 100 consultations.

The PPV of one or more triggers for identifying harm was 19.8%. When calculations were made for admissions (n= 761) and outpatient care (n= 242) separately, PPV was 23.2% and 10.8%, respectively (p=0.03). When we looked at the PPV of individual triggers, PPV varied from zero in the case of hypoxia, thrombocytopenia and electrolyte abnormalities to 100% in the case of surgical site infection and nosocomial pneumonia (Table 3).

The distribution of the 48 patients with identified harm according to status as admitted or outpatient, as well as their distribution across specialties are presented in Table 2. 60.4% of the harm events were in the pediatric (medical) patients, whereas 22.9%

occurred in ENT-patients, 10.4% in orthopedic and 6.3% in general surgical patients.

Harm was detected in 5% of all pediatric contacts with a slightly higher rate of 7% in pediatric admissions. The incidence of harm in all contacts including surgical and ENT patients and in admissions only regardless of specialty was similar, 6.3% and 8.3%, respectively.

Table 4 shows rate of trigger positive contacts, rate of harm and PPV of positive triggers across specialties.

All, but two identified harm events were categorized as harm category F, 'Temporary harm to the patient and required initial or prolonged hospitalization'.

Examples of harm were postoperative pericarditis, ileus after gastrostomy, candida stomatitis after treatment with antibiotics, infection in percutaneous endoscopic gastrostomy, bleeding following placement of nasogastric feeding tube (harm category E) and nosocomial infection (gastroenteritis, pneumonia) for the pediatric patients. In orthopedic patients osteomyelitis after pinning of Bennet's fracture was found and in general surgical patients hematoma after hernia operation (outpatient: harm category E) was found. In the ENT patients bleeding, infection and/or dehydration following adenotonsillectomy were recurring harms.

Voluntary incidence reports

The majority of incidents reported were minor incidents like delay in medication administration not leading to patient harm.

Patient harm as defined by the PTT user guide was found in 51/160 (30.9%) of the incidence reports 2010-2012. 37 harm events were classified as harm category E, 8 category F, 3 category G, 1 category H and 2 category I. This equals 51/5854 (total number of patients admitted acutely with medical diagnoses 2010-2012) = 0.9%. Only three of these incidents were reported in the PTT study months giving a voluntary reported harm rate of 3/584 (number of pediatric patients in the PTT screening) = 0.5% in March-May 2011.

Patient harm reported through the incidence reporting system included unexpected patient death; fall injury; pain and swelling from subcutaneous peripheral venous

catheter; complications to procedure; anaphylactic drug reactions; and prolonged hospitalization due to errors in medication and fluid administration.

DISCUSSION

This is the first report about use of a PTT in a European unit. Despite the fact that only half of the NHS pediatric triggers were found in the patient records screened in this study, we identified a ten times higher harm rate using the PTT than what was reported in the department's voluntary incidence reports in the same period.

Our pediatric centre is the largest acute pediatric unit in Norway, but we do not have a PICU in our hospital. Therefore, we do not treat the most severely ill children, and we only rarely use potent anesthesia medications. This may be one of the reasons why half of the NHS triggers were not found in our review, reflecting that some diagnoses and interventions with a high incidence of complications are not present in the children and adolescents in our unit.

In the recently published Canadian Pediatric Adverse Events Study, the incidence, type and severity of harm among children admitted to academic pediatric centers were compared with those admitted to community hospitals in Canada.[8] In that study, significantly more patient records from academic pediatric centers (38.8%) than from community hospitals (21.6%) were trigger-positive.[8] We found triggers in 31.8% of our patients. The overall rate of harm in the Canadian study was 9.2% with significantly more harm in academic pediatric centers (11.2%) than in community hospitals (3.3%). We found a total rate of harm in admitted children of 8.3%. These results might reflect that, although being an academic teaching unit, our center probably has a patient population with disease severity and complexity somewhere in between the two compared unit levels in the Canadian study.

Kirkendall et al.[7] found 37 harm events per 100 patients and 76 harm events per 1000 patient-days, a significantly higher rate than in our patients. One of the reasons for this may be that the study was conducted in a large US tertiary centre where 32.5% of the patients went to the operating room during their hospital stay and 13.3% were admitted to an ICU during part of or whole stay.

We found a PPV of one or more triggers of 19.8% when both acute outpatient contacts and admissions were included and a higher PPV when only admissions were analyzed. Lemon and Stockwell found a PPV of 34%.[6] One of the possible reasons

for this difference is that Lemon and Stockwell only screened for 11 triggers while we identified 20 different triggers, of which some had an individual PPV of zero.

An important question when performing harm assessment in the PTT is what can be defined as anticipated side effects of medical treatment and calculated risk and what should be defined as iatrogenic harm. Is for example chemotherapy induced leuko- or neutropenia preventable? If the purpose of trigger tool systems is to focus attention towards areas of improvement, harm that cannot be prevented by change in routines and procedures should not necessarily be registered in this system. Lemon and Stockwell classifies harm either as being preventable or nonpreventable[6] whereas Kirkendall et al. did not assess preventability.[7]

Another issue raised is whether only "active delivery of harm" or also omission or substandard care should count as harm in the PTT system.[7] According to the Institute for Healthcare Improvement,[11] harm includes only those adverse events related to the active delivery of harm and not issues related to omission.

Like Kirkendall et al.,[7] we found that some modules, in our case the laboratory module, contained adult-oriented triggers like high INR and diagnostic imaging for embolus that are not applicable to our population and therefore not identified in our chart review. Removal of unnecessary triggers would reduce the overall number of triggers that reviewers must consider. Hypoxia, electrolyte abnormalities and thrombocytopenia had a PPV of zero and may not be worthwhile screening for in our patient population. However, bearing in mind the short study period of 3 months, further studies, ideally multicenter studies are needed before abolishment of some triggers.

Some triggers, e.g. complication of procedure or treatment and surgical site infection are themselves examples of harm. Nosocomial pneumonia and surgical site infection both had a PPV of 100% in our patients.

PTT versus voluntary incidence reporting

It has become evident from our study that patient harm identified through incidence report analysis and PTT screening are different in number and character in our unit. One of the most frequently reported error leading to harm in the incidence reports, 'Error in medication/fluid therapy routines' could not be detected through the PTT

medication module that only detects medication errors requiring antidote, antihistamine and/or antiemetics; as well as abrupt medication stop.

Practical use of the PTT

Trigger tool systems can be used for regular manual screening of a random pick of patient records. It is commonly said that the time spent for screening of individual charts should be limited to 20 minutes. Alternatively, automated electronic screening of all patient records can be performed.

To our knowledge, we are the first group to report the use of a PTT for unplanned outpatient visits. Some trigger tools exist for outpatient care,[12,13] however they are not suitable for children and adolescents. As harm was detected in 7/267 (2.6%) of acute outpatient visits, we believe that identification of these events is important in a unit like ours where the number of acute outpatient visits is substantial.

Regardless, there seems to be a higher PPV of triggers in surgical patients, but the rate of harm was comparable across medical and surgical patients (5-6%), excluding ENT patients with a 35% total harm rate.

Needless to say, the extent to which trigger tools detect harm as intended depends to a large extent on routines for documentation. Like Kirkendall et al.,[7] we noticed that frequently occurring complications like complications to peripheral venous catheters (e.g. phlebitis, subcutaneous edema, tissue necrosis and infection) are infrequently documented in the records of the patients in our unit. The same applies to the incidence reporting system that contains information about only a small fraction of these types of patient harm. Hence, certain types of patient harm that are frequently occurring and should be targeted by interventions are not detected in their full extent neither with the PTT nor through voluntary incidence reporting.

Limitations of the study

The PTT screening and incident report analyses were performed by only one investigator, and inter-rater agreement could not be assessed in this study. Also, this was a relatively small single-center study and the study period was short. Some of the triggers that were not identified during the three study months could possibly have been detected if we screened for a longer period. Generalizability of our results may

be limited to contexts with similar organization of specialist healthcare including referral practices. However, it is important that utility studies performed in different context be published in order for clinicians to judge applicability of the results to their practice.

CONCLUSION

Using the NHS Paediatric Trigger tool we found a rate of trigger positive contacts and a rate of harm comparable to an extensive Canadian review. The PTT made us able to detect more harm among our children and adolescents than what we detect by our routine system for reporting patient harm.

We conclude that the presence of adult-oriented triggers, triggers that were not identified at all, as well as triggers with a low predictive value for harm, highlight the need for modification of trigger tools to the context in which they are intended to be used. The NHS PTT, with certain modifications to our context can, as a supplement to voluntary incidence reporting, be used to calculate the rate of harm and identify areas of care where most harm events are occurring. Hence, it may inform priorities for action and track improvements over time.

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CONTRIBUTOR STATEMENT

ALS was the lead author for this paper and involved in all stages including design of the research, acquisition of data, analysis and interpretation of the data and statistical analysis. BN contributed to the drafting of the manuscript, critical revision of the manuscript and supervision.

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Table 1 The Paediatric Trigger Tool (PTT) items as depicted in the NHS PTT User Guide[4]

	Item
General care	PG1 Early warning score
	PG2 Tissue damage or pressure ulcer
	PG3 Readmission within 30 days
	PG4 Unplanned admission
	PG5 Abnormal cranial imaging
	PG6 Respiratory or cardiac arrest / crash calls
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation
	PG8 Complication of procedure or treatment
	PG9 Transfer to higher level of care
	PG10 Hypoxia O2 sat <85%
	PG11 Cancelled elective procedure / delayed discharge
Surgical care	PS1 Return to theatre
	PS2 Change in planned procedure
	PS3 Surgical site infection or hospital acquired urinary tract infection
	PS4 Removal/injury/repair of organ
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care
Medication	PM1 Vitamin K (except for routine dose in neonates)
	PM2 Naloxone
	PM3 Flumazenil (Romazicon)
	PM4 Glucagon or glucose ≥ 10%
	PM5 Chlorphenamine or antihistamine
	PM6 Anti-emetics
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given
	PM8 Abrupt medication stop
Lab test	PL15 Thrombocytopenia (platelets <100)
	PL1 High INR >5 or aPTT >100
	PL2 Transfusion
	PL3 Abrupt drop in Hb or Hct (>25%)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)
	PL7 Hypoglycemia (<3mmol/l)
	PL8 Hyperglycemia (>12mmol/l)
	PL9 Drug level out of range
Microbiology	PL10 MRSA bacteraemia
	PL11 C. difficile
	PL12 Vanc resistant enterococcus (VRE)
	PL13 Nosocomial pneumonia
	PL14 Positive blood culture
Other	PO1 Other event

Table 2 Distribution of trigger positive admissions and outpatient contacts across specialties

	Pediatric		**Ortopedic**		**General surgical**		**Ear, nose and throat**	
	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient
Total n (%)	356 (47)	228 (30)	70 (9)	13 (2)	41 (5)	22 (3)	27 (3.5)	4 (0.5)
Trigger positive n (%)	148 (61)	59 (24.5)	8 (3.5)	3 (1)	10 (4)	2 (1)	11 (4.5)	1 (0.5)
Harm n	26	3	3	2	1	2	11	0

Table 3 The triggers we identified in our study are presented with positive predictive value (PPV) for identifying harm. The numerator represents number of harm events and the denominator how many times each individual trigger was found in all patient contacts (n=761)

	Item	PPV
General care	PG1 Early warning score	
	PG2 Tissue damage or pressure ulcer	
	PG3 Readmission within 30 days	24/175=13.7%
	PG4 Unplanned admission	
	PG5 Abnormal cranial imaging	
	PG6 Respiratory or cardiac arrest / crash calls	0/1=0%
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation	1/2=50%
	PG8 Complication of procedure or treatment	17/23=73.9%
	PG9 Transfer to higher level of care	3/22=13.6%
	PG10 Hypoxia O2 sat <85%	0/25=0%
	PG11 Cancelled elective procedure / delayed discharge	1/1=100%
Surgical care	PS1 Return to theatre	1/1=100%
	PS2 Change in planned procedure	
	PS3 Surgical site infection or hospital acquired urinary tract infection	6/6=100%
	PS4 Removal/injury/repair of organ	
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care	
Medication	PM1 Vitamin K (except for routine dose in neonates)	
	PM2 Naloxone	
	PM3 Flumazenil (Romazicon)	
	PM4 Glucagon or glucose ≥ 10%	
	PM5 Chlorphenamine or antihistamine	0/1=0%
	PM6 Anti-emetics	
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given	3/19=15.8%
	PM8 Abrupt medication stop	
Lab test	PL15 Thrombocytopenia (platelets <100)	0/7=0%
	PL1 High INR >5 or aPTT >100	
	PL2 Transfusion	2/8=25%
	PL3 Abrupt drop in Hb or Hct (>25%)	2/8=25%
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)	0/1=0%
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)	0/12=0%
	PL7 Hypoglycemia (<3mmol/l)	3/8=37.5%
	PL8 Hyperglycemia (>12mmol/l)	0/1=0%
	PL9 Drug level out of range	
Microbiology	PL10 MRSA bacteraemia	
	PL11 C. difficile	
	PL12 Vanc resistant enterococcus (VRE)	
	PL13 Nosocomial pneumonia	2/2=100%
	PL14 Positive blood culture	1/1=100%
Other	PO1 Other event	

Table 4 Rate of trigger positive contacts, rate of harm and positive predictive value (PPV) of positive triggers across specialties

Specialty	Rate of trigger positive contacts	Rate of harm	PPV
Pediatric	207/584 (35.4%)	29/584 (5.0%)	14%
Orthopedic surgery	11/83 (13.3%)	5/83 (6.0%)	45.5%
General surgery	12/63 (19.0%)	3/63 (4.8%)	25%
Ear, Nose and Throat	12/31 (38.7%)	11/31 (35.5%)	91.7%
Total	242/761 (31.8%)	48/761 (6.3%)	19.8%

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ABSTRACT

Objectives

The British National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools developed for use in adults. The PTT has not previously been developed or used in Nordic units. We aimed to compare harm identified through PTT screening with voluntary incidence reports in our department. A secondary aim was to assess utility of the different triggers, including predictive value for identifying harm. We hypothesized that the NHS PTT would need adjustments for the setting in which it is used.

Setting

A Norwegian level II department of pediatric and adolescent medicine.

Participants

A convenience sample of 761 acute medical and surgical patient contacts March-May 2011. Median age (IQR) for the trigger positive patients was 2.5 (1.0-8.0) years; range 0-18 years.

Primary and secondary outcome measures

The type and rate of identified harm compared to the department's voluntary incidence reports. The type and rate of identified triggers and positive predictive value for harm.

Results

The PTT revealed a harm rate of 5% for medical patients, as compared to 0.5% in the incidence reports the same months. PTT screening revealed other types of harm than those reported by health care personnel themselves. We identified only 20 out of the 39 NHS PTT triggers. The most frequent trigger was re-admission within 30 days. Hypoxia, which was the second most frequent trigger, did not predict any patient harm.

Conclusion

This study showed that the NHS PTT identifies more and other types of harm than voluntary incidence reports. The presence of adult-oriented triggers, triggers that were

not identified at all, as well as triggers with a low predictive value for harm may indicate the need for modification of the PTT to different settings. More studies are needed before a final decision is made to exclude triggers from the screening.

ARTICLE SUMMARY

Strengths and limitations of this study

- There is a limited understanding of how structured patient safety work in pediatrics can be performed
- We investigated utility of The British National Health Service Paediatric Trigger Tool (PTT) in a level II pediatric unit and found that the tool should probably be modified to different settings
- Previous to this study, only one major pediatric trigger tool has been published in peer review journal format and none have been applied in outpatient settings
- This review is based on a significant amount of patient data. However, the single-center character and the short study period call for additional studies, preferentially multicenter studies

INTRODUCTION

By identifying recurring medical errors focused efforts can be made to improve patient safety.[1,2] However, medical errors do not always lead to harm to the patient. Patient harm can be caused by medical error, but can also occur as a result of a diagnostic or treatment procedure in the absence of a medical error.[3]

So-called 'trigger tools' focus on patient harm, not errors, and can in combination with more traditional incident reporting in healthcare help departments and hospitals focus their improvement work to reduce the overall rate of patient harm.[4] The global trigger tool (GTT) is a retrospective method for detecting iatrogenic harm [5] and has been used as a benchmarking system and means for monitoring change over time. A trigger has been defined as data present in the patient record that can directly or indirectly, by providing a clue for further investigation, represent an adverse event that caused patient harm.[6,7] The GTT has become a widely used tool in patient safety work. However, the understanding of health care–associated harm in children is limited as compared to adults and only recently a comprehensive pediatric trigger tool has been developed.[8]

The National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools for use in adults with the support of clinicians in nine UK hospitals, and was meant to be useful for district general hospitals, acute teaching hospitals and specialist pediatric centers.[4] However, there is a need for determining utility of such instruments derived from adult care in different institutions and patient groups. The items comprising the PTT should be piloted in different settings in order to remove unnecessary or adult-oriented triggers and/or add more relevant triggers.[7]

Hence, we aimed to examine utility of the NHS PTT in a large Nordic department of pediatrics and if needed adjust the tool for use in our patients.

Our primary focus was to examine if or to which extent the PTT detected patient harm in medical and surgical patients in our department and compare these results with voluntary incidence reports. A secondary aim was to assess utility of the different triggers, including predictive value of individual triggers for identifying harm.

METHODS

The study was approved as part of quality improvement activities by the institutional review board at Akershus University Hospital (AHUS)

Setting

AHUS is located outside the Norwegian capital Oslo. The hospital is the single largest acute hospital in Norway and offers a full range of medical services except cardiac- and neurosurgery, as well as treatment of severe traumatic injuries. AHUS does not have a pediatric intensive care unit (PICU), but transfers children below the age of 3 years in need for intensive care to a nearby university hospital. Critically ill children between three and 18 years are treated in the intensive care unit (ICU) for adults in AHUS. The hospital introduced early warning scoring systems after this study. Routine GTT screening has been performed since 2007.

The Department of Pediatric and Adolescent Medicine is a 37-bed level II unit. Children and adolescents between zero and 18 years of age referred by general physicians for acute specialist care are examined in the children's emergency department (ED) and about 50% are admitted. Registration of patient harm in our unit is exclusively based on voluntary reporting through an electronic incidence reporting system called Extend Quality System (EQS).

PTT screening

We did a manual review of unplanned patient visits to the children's ED using the NHS Paediatric Trigger Tool User guide.[4] For convenience, we included the visits that were documented for the purpose of evaluating the introduction of a pediatric early warning score in our department over a 3 month period.[9] These visits represented 95% of all contacts in the children's ED in the study months. Pediatric (medical), as well orthopedic, general surgical; and ear, nose and throat (ENT) patients below the age of 18 years were included and the results were recorded in Excel spreadsheets (Microsoft Excel 2008 for Mac (Redmond, WA, US)).

The PTT screening was performed by the primary investigator (ALS) who is a consultant pediatrician in the department. Because AHUS is the first hospital in Norway to screen for pediatric triggers, there are no courses or formal training in the

PTT available in Norway. Hence, to get a general idea about the concept of trigger tools, ALS attended a full-day course in the GTT organized by The Norwegian Knowledge Centre for the Health Services. In addition, she received instructions from the GTT team at AHUS based on their review methodology and PTT screening of 10 patient records was performed in collaboration with a representative from the GTT team.

The PTT consists of 39 items described in Table 1. The patient records were reviewed in the following order: Diagnoses and treatment procedures, discharge summaries, medication charts, laboratory results, operation notes, nurse notes, physician notes and admission note. Because only half of the acute referrals result in an admission, our practice differs from most medical departments for adults where a larger proportion of acutely referred patients are being admitted. The PTT user guide dictates a minimum length of stay of 8 hours.[4] However, as we argue that our threshold for admitting patients from the children's ED is high with often only slight differences in disease severity and complexity between those who are admitted and those who are not, we included also acute outpatient visits in our screening. Further, we chose to register all patient contacts with the diagnoses hypo-/hyperkalemia and/or hypo-/hypernatremia as trigger positive regardless of the definitions used in the PTT user guide for these triggers (Table 1). Otherwise, we strictly followed the definitions and guidelines outlined in the user guide.

The PTT uses an adapted version of the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) 'Index for Categorizing Errors'.[10] The rationale for this is that the NHS focuses on adverse events that cause actual patient harm and not medical errors that have a potential for patient harm. Therefore, only the NCC MERP categories E through I are included: Temporary harm to the patient and required intervention (category E), temporary harm to the patient and required initial or prolonged hospitalization (category F), permanent patient harm (category G), intervention required to sustain life (category H), and patient death (category I).

Harm identified through PTT screening was compared to harm identified through voluntary incidence reports in the department.

Voluntary incidence reporting

ALS read and classified patient related incidents regarding pediatric (medical) patients reported in the EQS in March until May 2011. The rate of harm reported in incidence reports during these three months was low. Therefore all reports in an extended period of time, 2010-2012, were included. Patient harm identified in the incidence reports was classified from E through I for comparison to the findings from the PTT screening.

Statistical analyses

Data were analyzed using PASW®Statistics 18.0 software (SPSS Inc., Chicago, IL). Comparisons between groups were made using the Chi-square test for categorical variables and Mann-Whitney *U* test for continuous variables. P-values <0.05 were considered significant. Positive predictive value (PPV) with 95% confidence interval (CI) for triggers was calculated and we calculated number of harm events per 1000 patient days and 100 patient contacts.

RESULTS

From March 15th until Mai 31st 2011 761 patient records, representing 2268 patient days were screened for triggers. Median age (IQR) in years was 3.5 (1.2-11.0) for all patients and 2.5 (1.0-8.0) for the trigger positive patients. Male to female ratio was 352:409 and 113:129 for all patients and the trigger positive patients, respectively.

We identified 48 incidents of harm, representing 21 harm events per 1000 patient days and 6 harm events per 100 consultations. The distribution of the 48 patients with identified harm according to status as admitted or outpatient, as well as their distribution across specialties are presented in Table 2. 60.4% of the harm events were in the pediatric (medical) patients, whereas 22.9% occurred in ENT-patients, 10.4% in orthopedic and 6.3% in general surgical patients.

Harm was detected in 5% of all pediatric contacts with a slightly higher rate of 7% in pediatric admissions. The incidence of harm in all contacts including surgical and ENT patients and in admissions only regardless of specialty was similar, 6.3% and 8.3%, respectively.

All, but two identified harm events were categorized as harm category F, 'Temporary harm to the patient and required initial or prolonged hospitalization'. Examples of harm were postoperative pericarditis, ileus after gastrostomy, candida stomatitis after treatment with antibiotics, infection in percutaneous endoscopic gastrostomy, bleeding following placement of nasogastric feeding tube (harm category E) and nosocomial infection (gastroenteritis, pneumonia) for the pediatric patients. In orthopedic patients osteomyelitis after pinning of Bennett's fracture was found and in general surgical patients hematoma after hernia operation (outpatient: harm category E) was found. In the ENT patients bleeding, infection and/or dehydration following adenotonsillectomy were recurring harms.

Voluntary incidence reports

About two thirds of the incidents reported were minor incidents like delay in medication administration not leading to patient harm.

Patient harm as defined by the PTT user guide was found in 51/160 (30.9%) of the incidence reports 2010-2012. 37 harm events were classified as harm category E, 8

category F, 3 category G, 1 category H and 2 category I. This equals 51/5854 (total number of patients admitted acutely with medical diagnoses 2010-2012) = 0.9%. Only three of these incidents were reported in the PTT study months giving a voluntary reported harm rate of 3/584 (number of pediatric patients in the PTT screening) = 0.5% in March-May 2011.

Patient harm reported through the incidence reporting system included unexpected patient death; fall injury; pain and swelling from subcutaneous peripheral venous catheter; complications to procedure; anaphylactic drug reactions; and prolonged hospitalization due to errors in medication and fluid administration.

Triggers

We identified one or more out of 20 of the 39 NHS triggers in 242 (31.8%) of all patient contacts. In 71.5% of the trigger positive contacts only one trigger was found. The highest number of triggers found in a patient contact was 4. The mean rate of triggers per patient was 1.4.

The most frequently found trigger was readmission within 30 days. Common reasons for unplanned readmission were surgical site infection, recurrent (respiratory tract) infections, postoperative bleeding and seizures. We found the second most common trigger in our screening to be hypoxia, but no patient harm was associated with this specific trigger.

Of the 242 trigger positive contacts, 177 (73.1%) were admissions and 65 (26.9%) acute outpatient visits. Table 2 shows how trigger positive admissions and outpatient contacts were distributed across specialties.

The PPV of one or more triggers for identifying harm was 19.8%. When calculations were made for admissions (n= 761) and outpatient care (n= 242) separately, PPV was 23.2% and 10.8%, respectively (p=0.03). When we looked at the PPV of individual triggers, PPV varied from zero in the case of hypoxia, thrombocytopenia and electrolyte abnormalities to 100% in the case of surgical site infection and nosocomial pneumonia (Table 3).

Table 4 shows rate of trigger positive contacts, rate of harm and PPV of triggers across specialties.

DISCUSSION

This is the first report about use of a PTT in a European unit. Despite the fact that only half of the NHS pediatric triggers were found in the patient records screened in this study, we identified a ten times higher harm rate using the PTT than what was reported in the department's voluntary incidence reports in the same period. Patient harm identified through incidence report analysis and PTT screening was different in number and character in our unit.

Our pediatric centre is the largest acute pediatric unit in Norway, but we do not have a PICU in our hospital. Therefore, we do not treat the most severely ill children, and we only rarely use potent anesthesia medications. This may be one of the reasons why half of the NHS triggers were not found in our review, reflecting that some diagnoses and interventions with a high incidence of complications are not present in the children and adolescents in our unit.

In the recently published Canadian Pediatric Adverse Events Study, the incidence, type and severity of harm among children admitted to academic pediatric centers were compared with those admitted to community hospitals in Canada.[8] In that study, significantly more patient records from academic pediatric centers (38.8%) than from community hospitals (21.6%) were trigger-positive.[8] We found triggers in 31.8% of our patients. The overall rate of harm in the Canadian study was 9.2% with significantly more harm in academic pediatric centers (11.2%) than in community hospitals (3.3%). We found a total rate of harm in admitted children of 8.3%. These results might reflect that, although being an academic teaching unit, our center probably has a patient population with disease severity and complexity somewhere in between the two compared unit levels in the Canadian study.

Kirkendall et al.[7] found 37 harm events per 100 patients and 76 harm events per 1000 patient-days, a significantly higher rate than in our patients. One of the reasons for this may be that the study was conducted in a large US tertiary centre where 32.5% of the patients went to the operating room during their hospital stay and 13.3% were admitted to an ICU during part of or whole stay.

We found a PPV of one or more triggers of 19.8% when both acute outpatient contacts and admissions were included and a higher PPV when only admissions were

analyzed. Lemon and Stockwell found a PPV of 34%.[6] One of the possible reasons for this difference is that Lemon and Stockwell only screened for 11 triggers while we identified 20 different triggers, of which some had an individual PPV of zero. Another important difference is that Lemon and Stockwell reported results from a 4-year period whereas we only screened for a three-month period, which limits generalizability.

Like Kirkendall et al.,[7] we found that some modules, in particular the laboratory module, contained adult-oriented triggers like high INR and diagnostic imaging for embolus that were not identified in our chart review. Removal of unnecessary triggers would reduce the overall number of triggers that reviewers must consider. Hypoxia, electrolyte abnormalities and thrombocytopenia had a PPV of zero and may not be worthwhile screening for in our patient population. However, bearing in mind the short study period of 3 months, further studies, ideally multicenter studies are needed before abolishment of some triggers.

To our knowledge, we are the first group to report the use of a PTT for unplanned outpatient visits. Some trigger tools exist for outpatient care,[12,13] however they are not suitable for children and adolescents. As harm was detected in 7/267 (2.6%) of acute outpatient visits, we believe that identification of these events is important in a unit like ours where the number of acute outpatient visits is substantial.

Regardless, there seems to be a higher PPV of triggers in surgical patients, but the rate of harm was comparable across medical and surgical patients (5-6%), excluding ENT patients with a 35% total harm rate.

Needless to say, the extent to which trigger tools detect harm as intended depends to a large extent on routines for documentation. Like Kirkendall et al.,[7] we noticed that frequently occurring complications like complications to peripheral venous catheters, e.g. phlebitis, subcutaneous edema, tissue necrosis and infection, are infrequently documented in the records of the patients in our unit. The same applies to the incidence reporting system that contains information about only a small fraction of these types of patient harm. Hence, certain types of patient harm that are frequently occurring and should be targeted by interventions are not detected in their full extent neither with the PTT nor through voluntary incidence reporting.

Limitations of the study

The PTT screening and incident report analyses were performed by only one investigator, and inter-rater agreement could not be assessed in this study. The judgment regarding whether harm was present and how severe was left to one person, with no one to validate the findings. To our knowledge, the PTT is not established in any Norwegian pediatric unit, and we did not succeed in finding a person with both time and experience to validate the findings. For the same reason, this was a relatively small single-center study and the study period was short. Some of the triggers that were not identified during the three study months could possibly have been detected if we screened for a longer period. The decision to also screen unplanned outpatient contacts as well as including all sodium and potassium levels out of range were deviations from the PTT user guide that could potentially bias our results. However, as the outpatient contacts and admissions are to a large extent reported separately, and as the sodium and potassium trigger did not predict harm in any of our patients, we believe that these factors did not influence the main conclusions of the study. Generalizability of our results may be limited to settings with similar organization of specialist healthcare including referral practices. However, it is important that utility studies performed in various patient groups be published in order for clinicians to judge applicability of the results to their practice.

CONCLUSION

Using the NHS Paediatric Trigger tool we found a rate of trigger positive contacts and a rate of harm comparable to an extensive Canadian review. The PTT made us able to detect more and different types of harm among our children and adolescents than what we detect by our routine system for reporting patient harm.

The presence of adult-oriented triggers, triggers that were not identified at all, as well as triggers with a low predictive value for harm, indicate a need for modification of trigger tools to the setting in which they are intended to be used. The NHS PTT, with certain modifications can, as a supplement to voluntary incidence reporting, be used to calculate the rate of harm and identify areas of care where most harm events are occurring. Hence, it may inform priorities for action and track improvements over time.

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CONTRIBUTOR STATEMENT

ALS was the lead author for this paper and involved in all stages including design of the research, acquisition of data, analysis and interpretation of the data and statistical analysis. BN contributed to the drafting of the manuscript, critical revision of the manuscript and supervision.

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DATA SHARING STATEMENT

No additional data available

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Table 1 The Paediatric Trigger Tool (PTT) items as depicted in the NHS PTT User Guide[4]

	Item
General care	PG1 Early warning score
	PG2 Tissue damage or pressure ulcer
	PG3 Readmission within 30 days
	PG4 Unplanned admission
	PG5 Abnormal cranial imaging
	PG6 Respiratory or cardiac arrest / crash calls
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation
	PG8 Complication of procedure or treatment
	PG9 Transfer to higher level of care
	PG10 Hypoxia O2 sat <85%
	PG11 Cancelled elective procedure / delayed discharge
Surgical care	PS1 Return to theatre
	PS2 Change in planned procedure
	PS3 Surgical site infection or hospital acquired urinary tract infection
	PS4 Removal/injury/repair of organ
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care
Medication	PM1 Vitamin K (except for routine dose in neonates)
	PM2 Naloxone
	PM3 Flumazenil (Romazicon)
	PM4 Glucagon or glucose ≥ 10%
	PM5 Chlorphenamine or antihistamine
	PM6 Anti-emetics
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given
	PM8 Abrupt medication stop
Lab test	PL15 Thrombocytopenia (platelets <100)
	PL1 High INR >5 or aPTT >100
	PL2 Transfusion
	PL3 Abrupt drop in Hb or Hct (>25%)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)
	PL7 Hypoglycemia (<3mmol/l)
	PL8 Hyperglycemia (>12mmol/l)
	PL9 Drug level out of range
Microbiology	PL10 MRSA bacteraemia
	PL11 C. difficile
	PL12 Vanc resistant enterococcus (VRE)
	PL13 Nosocomial pneumonia
	PL14 Positive blood culture
Other	PO1 Other event

Table 2 Distribution of trigger positive admissions and outpatient contacts across specialties

	Pediatric		**Ortopedic**		**General surgical**		**Ear, nose and throat**	
	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient
Total n (%)	356 (47)	228 (30)	70 (9)	13 (2)	41 (5)	22 (3)	27 (3.5)	4 (0.5)
Trigger positive n (%)	148 (61)	59 (24.5)	8 (3.5)	3 (1)	10 (4)	2 (1)	11 (4.5)	1 (0.5)
Harm n	26	3	3	2	1	2	11	0

Table 3 The triggers we identified in our study are presented with positive predictive value (PPV) with 95% confidence interval (CI) for identifying harm. The numerator represents number of harm events and the denominator how many times each individual trigger was found in all patient contacts (n=761)

	Item	PPV (CI)%
General care	PG1 Early warning score	
	PG2 Tissue damage or pressure ulcer	
	PG3 Readmission within 30 days	24/175=14 (9-20)
	PG4 Unplanned admission	
	PG5 Abnormal cranial imaging	
	PG6 Respiratory or cardiac arrest / crash calls	0/1=0 (0-95)
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation	1/2=50 (3-97)
	PG8 Complication of procedure or treatment	17/23=74 (51-89)
	PG9 Transfer to higher level of care	3/22=14 (4-36)
	PG10 Hypoxia O2 sat <85%	0/25=0 (0-17)
	PG11 Cancelled elective procedure / delayed discharge	1/1=100 (5-100)
Surgical care	PS1 Return to theatre	1/1=100 (5-100)
	PS2 Change in planned procedure	
	PS3 Surgical site infection or hospital acquired urinary tract infection	6/6=100 (52-100)
	PS4 Removal/injury/repair of organ	
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care	
Medication	PM1 Vitamin K (except for routine dose in neonates)	
	PM2 Naloxone	
	PM3 Flumazenil (Romazicon)	
	PM4 Glucagon or glucose ≥ 10%	
	PM5 Chlorphenamine or antihistamine	0/1=0 (0-95)
	PM6 Anti-emetics	
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given	3/19=16 (4-40)
	PM8 Abrupt medication stop	
Lab test	PL15 Thrombocytopenia (platelets <100)	0/7=0 (0-44)
	PL1 High INR >5 or aPTT >100	
	PL2 Transfusion	2/8=25 (4-64)
	PL3 Abrupt drop in Hb or Hct (>25%)	2/8=25 (4-64)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)	0/1=0 (0-95)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)	0/12=0 (0-30)
	PL7 Hypoglycemia (<3mmol/l)	3/8=38 (10-74)
	PL8 Hyperglycemia (>12mmol/l)	0/1=0 (0-95)
	PL9 Drug level out of range	
Microbiology	PL10 MRSA bacteraemia	
	PL11 C. difficile	
	PL12 Vanc resistant enterococcus (VRE)	
	PL13 Nosocomial pneumonia	2/2=100 (20-100)
	PL14 Positive blood culture	1/1=100 (5-100)
Other	PO1 Other event	

Table 4 Rate of trigger positive contacts, rate of harm and positive predictive value (PPV) of positive triggers across specialties

Specialty	Rate of trigger positive contacts	Rate of harm	PPV
Pediatric	207/584 (35.4%)	29/584 (5.0%)	14%
Orthopedic surgery	11/83 (13.3%)	5/83 (6.0%)	45.5%
General surgery	12/63 (19.0%)	3/63 (4.8%)	25%
Ear, Nose and Throat	12/31 (38.7%)	11/31 (35.5%)	91.7%
Total	242/761 (31.8%)	48/761 (6.3%)	19.8%

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Title: Utility of a Pediatric Trigger Tool in a Norwegian Department of Pediatric and Adolescent Medicine

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ABSTRACT

~~**Background**~~

~~Trigger Tool Systems are retrospective methods that measure iatrogenic harm and have been used to identify areas of improvement and for monitoring change over time.~~

Objectives

The British National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools developed for use in adults. ~~We aimed to investigate utility of the NHS PTT in children and adolescents in our unit.~~ The PTT has not previously been developed or used in Nordic units. We aimed to compare harm identified through PTT screening with voluntary incidence reports in our department. A secondary aim was to assess utility of the different triggers, including predictive value for identifying harm. We hypothesized that the NHS PTT would need adjustments for the setting in which it is used.

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~~**Methods**~~

Setting

A Norwegian level II department of pediatric and adolescent medicine.

Participants

A convenience sample of 761 acute medical and surgical patient contacts ~~representing 2268 patient days in~~ March-May 2011 ~~were screened for triggers using the NHS PTT of 39 items. Both medical and surgical patients were included.~~ . Median age (IQR) for the trigger positive patients was 2.5 (1.0-8.0) years; range 0-18 years.

Primary and secondary outcome measures

The type and rate of identified harm ~~detected were~~ compared to the department's voluntary incidence reports. The type and rate of identified triggers and positive predictive value for harm.

Results

~~Median age (IQR) for the trigger positive patients was 2.5 (1.0-8.0) years; range 0-18 years.~~

The PTT revealed a harm rate of 5% for medical patients, as compared to 0.5% in the incidence reports the same months. PTT screening revealed other types of harm than those reported by health care personnel themselves. We ~~found~~identified only 20 out of the 39 NHS PTT triggers ~~in 242 of the contacts (=31.8%). The highest number of triggers in a patient contact was 4.~~ The most frequent trigger was re-admission within 30 days. ~~The~~Hypoxia, which was the second most ~~common~~frequent trigger, ~~hypoxia, had a predictive value for detecting~~did not predict any patient harm ~~of zero.~~

~~For the medical patients, the PTT revealed a harm rate of 5%, as compared to 1,7% in the incidence reports for the same months. The types of harm detected through PTT screening differed from patient harm that health care personnel chose to report themselves.~~

Conclusion

This study showed that the NHS PTT ~~, with certain modifications to our context, could, as a supplement to~~ identifies more and other types of harm than voluntary incidence ~~reporting, be used to calculate the rate of harm and identify areas of care where most harm events are occurring.~~ reports. The presence of adult-oriented triggers, triggers that were not identified at all, as well as triggers with a low predictive value for harm may indicate the need for modification of the PTT to different settings. More studies are needed before a final decision is made to exclude triggers from the screening.

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Strengths and limitations of this study

- There is a limited understanding of how structured patient safety work in pediatrics can be performed
- We investigated utility of The British National Health Service Paediatric Trigger Tool (PTT) in a level II pediatric unit and found that the tool should probably be modified to different settings
- Previous to this study, only one major pediatric trigger tool has been published in peer review journal format and none have been applied in outpatient settings
- This review is based on a significant amount of patient data. However, the single-center character and the short study period call for additional studies, preferentially multicenter studies

INTRODUCTION

~~So-called 'trigger tools' in combination with more traditional incident reporting in healthcare can help departments and hospitals focus their improvement work to reduce the overall rate of patient harm.~~By identifying recurring medical errors focused efforts can be made to improve patient safety.[1~~]~~,2] ~~The Global trigger tool (GTT) is a retrospective method for detecting harm caused by healthcare, i.e. iatrogenic harm~~

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However, medical errors do not always lead to harm to the patient. Patient harm can be caused by medical error, but can also occur as a result of a diagnostic or treatment procedure in the absence of a medical error.[2]3] ~~and has been used as a benchmarking system and means for monitoring change over time. A 'trigger' is not the harm itself, but may lead the attention to patients who have experienced iatrogenic harm that can be identified by a more thorough chart review. A trigger has been defined as data present in the patient record that can directly or indirectly, by providing a clue for further investigation of the chart, represent an adverse event that caused patient harm.~~

So-called 'trigger tools' focus on patient harm, not errors, and can in combination with more traditional incident reporting in healthcare help departments and hospitals focus their improvement work to reduce the overall rate of patient harm.[3,4]

~~The Norwegian three-year patient safety campaign, "In Safe Hands", was launched in January 2011 by the Norwegian Ministry of Health.~~ The global trigger tool (GTT) is a retrospective method for detecting iatrogenic harm [5] ~~with the aim to reduce patient harm. One of the important efforts of the campaign is to establish the GTT in Norwegian hospitals. The administrators of the patient safety campaign acknowledge that they found it difficult to embrace all fields of medicine in their efforts, and children were one of the groups they would not include in their campaign.~~

~~The Norwegian patient safety campaign reflects the fact that there is a limited~~ and has been used as a benchmarking system and means for monitoring change over time. A trigger has been defined as data present in the patient record that can directly or indirectly, by providing a clue for further investigation, represent an adverse event that caused patient harm.[6,7] The GTT has become a widely used tool in patient safety work. However, the understanding of health care–associated harm in children is limited as compared to adults and only recently~~,~~ a comprehensive pediatric trigger tool has been developed.[~~6~~]8]

The National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools for use in adults with the support of clinicians in nine UK hospitals, and was meant to be useful for district general hospitals, acute teaching hospitals and specialist pediatric centers.[~~1~~]4] However, there is a need for determining utility of such instruments derived from adult care in different institutions

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and ~~contexts.~~ patient groups. The items comprising the PTT should be piloted in different settings in order to remove unnecessary or adult-oriented triggers and~~-~~/or add more relevant triggers.[~~4~~]7]

Hence, we aimed to examine utility of the NHS PTT in ~~the context of~~ a large Nordic department of pediatrics and if needed adjust the tool for use in our patients.

Our primary focus was to examine ~~the extent~~ if or to which extent the PTT detected patient harm in medical and surgical patients in our department~~.~~ and compare these results with voluntary incidence reports. A secondary aim was to assess utility of the different triggers, including predictive value of individual triggers for identifying harm.

METHODS

The study was approved as part of quality improvement activities by the ~~hospital's~~ institutional review board~~.~~

~~**Context**~~

at Akershus University Hospital (AHUS)

Setting

AHUS is located outside the Norwegian capital Oslo. The hospital is the single largest acute hospital in Norway~~, but does not treat severe traumatic injuries~~ and ~~does not perform~~offers a full range of medical services except cardiac- ~~or~~ and neurosurgery, as well as treatment of severe traumatic injuries. AHUS does not have a pediatric intensive care unit (PICU), but transfers children below the age of 3 years in need for intensive care to a nearby university hospital. Critically ill children between three and 18 years are treated in the intensive care unit (ICU) for adults in AHUS. The hospital ~~did not at the time of this study routinely use~~introduced early warning scoring systems ~~and does not have a so-called rapid response team.~~

~~All patient documentation including laboratory results and medications has since October 2011 been stored in electronic patient records. AHUS has adopted the GTT and has performed routine GTT-screening since 2008.~~after this study. Routine GTT screening has been performed since 2007.

The Department of Pediatric and Adolescent Medicine is a 37-bed ~~unit (excluding the neonatal intensive care unit (NICU)) with 112.000 patients from 0-18 years of age in its catchment area.~~level II unit. Children and adolescents between zero and 18 years of age referred by general physicians for acute specialist care are ~~being~~ examined in

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the children's emergency department (ED) and about 50% ~~of them are judged to need hospital admission. The remaining 50%~~ are ~~being registered as 'acute outpatient contacts', defined as requiring hospital stay, usually in the children's ED, of less than five hours.~~

~~Due to its geographical closeness to large tertiary centers at Oslo University Hospital (OUS), AHUS does not have a Pediatric Intensive Care Unit (PICU), but transfers children below the age of three years in need for intensive care to OUS. Critically ill children between three and 18 years are treated in the intensive care unit (ICU) for adults in AHUS.~~

admitted. Registration of patient harm in our unit is exclusively based on voluntary reporting through an electronic incidence reporting system called Extend Quality System (EQS).

PTT screening

~~From March 15th until Mai 31st 2011 761~~We did a manual review of unplanned patient ~~records, representing 2268 patient days and 95% of all acute referrals in this period were screened for triggers~~visits to the children's ED using the NHS Paediatric Trigger Tool User guide.[~~1~~]4] ~~Pediatric (medical), as well orthopedic general surgical; and ear, nose and throat (ENT) patients below the age of 18 years were included. Data from these patients in relation to the~~ For convenience, we included the visits that were documented for the purpose of evaluating the introduction of a pediatric early warning score in our department ~~is reported elsewhere~~over a 3 month period.[~~7~~]9] These visits represented 95% of all contacts in the children's ED in the study months. Pediatric (medical), as well orthopedic, general surgical; and ear, nose and throat (ENT) patients below the age of 18 years were included and the results were recorded in Excel spreadsheets (Microsoft Excel 2008 for Mac (Redmond, WA, US)).

The PTT screening was performed by the primary investigator~~,~~ (ALS~~,~~) who is a consultant pediatrician in the department. Because AHUS is the first hospital in Norway to screen for pediatric triggers, there ~~is~~ are no courses or formal training in the PTT available in Norway. Hence, to get a general idea about the concept of trigger tools, ALS attended a full-day course in the GTT organized by The Norwegian Knowledge Centre for the Health Services. In addition, she received instructions from

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the GTT team at AHUS based on their review methodology and PTT screening of 10 patient records was performed ~~by~~ in collaboration with a representative from the GTT team ~~to assess inter-rater agreement.~~.

The PTT consists of 39 items described in Table 1. ~~The General Care, Laboratory Test and Medication components (triggers) should always be looked for. The other components should only be used if applicable.~~The patient records were reviewed in the following order: Diagnoses and treatment procedures, discharge summaries, medication charts, laboratory results, operation notes, nurse notes, physician notes and admission note. Because only half of the acute referrals result in an admission, our practice differs from most medical departments for adults where a larger proportion of acutely referred patients are being admitted. The PTT user guide dictates a minimum length of stay of 8 hours.[~~1~~]4] ~~In~~However, as we argue that our ~~study all 39 triggers were looked~~threshold for~~.~~

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~~Table 1 The Paediatric Trigger Tool (PTT) items as depicted in~~ admitting patients from the ~~NHS PTT User Guide[1]~~children's ED is high with often only slight differences in disease severity and complexity between those who are admitted and those who are not, we included also acute outpatient visits in our ~~comments to some of the items. PICU = Pediatric intensive care unit, PPV = Positive predictive value~~

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	~~Item~~	~~Our comment~~	~~PPV~~
~~General care~~	~~PG1 Early warning score~~	~~An early warning score system was not implemented as a routine assessment tool at the time of our PTT study~~	
	~~PG2 Tissue damage or pressure ulcer~~	~~Tissue damage associated with peripheral venous catheters does occur in our unit. However, they are infrequently documented in the patient records~~	
	~~PG3 Readmission within 30~~	~~We included contacts that were a readmission within 30~~	~~24/175=13.7%~~

	days	days or were followed by a readmission within 30 days	
	PG4 Unplanned admission	Nearly all admissions are unplanned in our unit	
	PG5 Abnormal cranial imaging	We do not have a PICU (patients do not experience severe hypotension etc.) Congenital anomalies on cranial imaging should not be considered a trigger	
	PG6 Respiratory or cardiac arrest / crash calls		0/1=0%
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation	Rarely applicable in our unit due to no PICU	1/2=50%
	PG8 Complication of procedure or treatment		17/23=73.9%
	PG9 Transfer to higher level of care (including specialist unit/ICU/HDU)	In our unit this often means transfer to another hospital as we do not have a PICU	3/22=13.6%
	PG10 Hypoxia O2 sat <85%	We chose to redefine this item to "received supplementary oxygen"	0/25=0%
	PG11 Cancelled elective procedure / delayed discharge		1/1=100%
Surgical care	PS1 Return to theatre		1/1=100%
	PS2 Change in planned procedure		
	PS3 Surgical site infection or hospital acquired urinary tract infection		6/6=100%
	PS4 Removal/injury/repair of organ		
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care		
Medication	PM1 Vitamin K (except for routine dose in neonates)		
	PM2 Naloxone		
	PM3 Flumazenil (Romazicon)		
	PM4 Glucagon or glucose ≥ 10%		
	PM5 Chlorphenamine or antihistamine		0/1=0%
	PM6 Anti-emetics		
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given		3/19=15.8%
	PM8 Abrupt medication stop		
Lab test	PL15 Thrombocytopenia (platelets <100)		0/7=0%
	PL1 High INR >5 or aPTT >100		
	PL2 Transfusion		2/8=25%
	PL3 Abrupt drop in Hb or Hct (>25%)		2/8=25%
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)		0/1=0%
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)	We registered all Na- and K-abnormalities as diagnosis, regardless of the limits proposed by the NHS.	0/12=0%
	PL7 Hypoglycemia (<3mmol/l)		3/8=37.5%
	PL8 Hyperglycemia (>12mmol/l)		0/1=0%
	PL9 Drug level out of range		
Microbiology	PL10 MRSA bacteraemia	Very rare in Norway	
	PL11 C. difficile	Rare in our unit	
	PL12 Vanc resistant enterococcus (VRE)	Very rare in Norway	
	PL13 Nosocomial pneumonia		2/2=100%
	PL14 Positive blood culture		1/1=100%
Other	PO1 Other event		

Because about half of the acutely referred children are treated as outpatients in our pediatric ED, our practice differs from medical departments for adults where a larger proportion of acutely referred patients are being admitted. Therefore, we chose to

~~screen acute outpatient contacts for triggers even though the PTT user guide dictates a minimum length of stay of 8 hours.[1]~~

screening. Further, we chose to register all patient contacts with the diagnoses hypo-/hyperkalemia and/or hypo-/hypernatremia as trigger positive regardless of the definitions used in the PTT user guide for these triggers (Table 1). Otherwise, we strictly followed the definitions and guidelines outlined in the user guide.

The PTT uses an adapted version of the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) 'Index for Categorizing Errors'.[~~8~~10]~~.~~

The rationale for this is that the NHS focuses on adverse events that cause actual patient harm and not medical errors that have a potential for patient harm. Therefore, only the NCC MERP categories E through I are included: Temporary harm to the patient and required intervention

~~F Temporary~~ (category E), temporary harm to the patient and required initial or prolonged hospitalization

(category F), permanent patient harm (category G ~~Permanent patient harm~~

~~H Intervention~~), intervention required to sustain life

~~I Patient~~ (category H), and patient death (category I).

~~PTT screening results with regards to identified triggers and harm were compared to GTT screening results from AHUS.~~ Harm identified through PTT screening was ~~also~~ compared to harm identified through voluntary incidence reports in the department.

Voluntary incidence reporting

ALS read and classified patient related incidents regarding pediatric (medical) patients reported in the EQS in March until May 2011. The rate of harm reported in incidence reports during these three months was low~~, and~~. Therefore all reports in an extended period of time, ~~i.e.~~ 2010~~, 2011 and~~ -2012, were included ~~for comparison to the PTT results.~~ . Patient harm identified in the incidence reports was classified from E through I for comparison to the findings from the PTT screening.

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Statistical analyses

Data were analyzed using PASW®Statistics 18.0 software (SPSS Inc., Chicago, IL). Comparisons between groups were made using the Chi-square test for categorical variables and Mann-Whitney *U* test for continuous variables. P-values <0.05 were considered significant. Positive predictive value (PPV) with 95% confidence interval (CI) for triggers was calculated and we calculated number of harm events per 1000 patient days and 100 patient contacts.

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RESULTS

~~PTT screening~~

~~*General*~~

From March 15th until Mai 31st 2011 761 patient records, representing 2268 patient days were screened for triggers. Median age (IQR) in years was 3~~,~~.5 (1~~,~~.2-11~~,~~.0) for all patients and 2~~,~~.5 (1~~,~~.0-8~~,~~.0) for the trigger positive patients. Male to female ratio was 352:409 and 113:129 for all patients and the trigger positive patients, respectively.

~~Figure 1 shows the distribution of contacts between the different specialties for admissions and outpatient visits, respectively.~~ We identified 48 incidents of harm, representing 21 harm events per 1000 patient days and 6 harm events per 100 consultations. The distribution of the 48 patients with identified harm according to status as admitted or outpatient, as well as their distribution across specialties are presented in Table 2. 60.4% of the harm events were in the pediatric (medical) patients, whereas 22.9% occurred in ENT-patients, 10.4% in orthopedic and 6.3% in general surgical patients.

Harm was detected in 5% of all pediatric contacts with a slightly higher rate of 7% in pediatric admissions. The incidence of harm in all contacts including surgical and ENT patients and in admissions only regardless of specialty was similar, 6.3% and 8.3%, respectively.

All, but two identified harm events were categorized as harm category F, 'Temporary harm to the patient and required initial or prolonged hospitalization'. Examples of harm were postoperative pericarditis, ileus after gastrostomy, candida stomatitis after treatment with antibiotics, infection in percutaneous endoscopic gastrostomy, bleeding following placement of nasogastric feeding tube (harm category E) and nosocomial infection (gastroenteritis, pneumonia) for the pediatric patients. In orthopedic patients osteomyelitis after pinning of Bennett's fracture was found and in general surgical patients hematoma after hernia operation (outpatient: harm category

E) was found. In the ENT patients bleeding, infection and/or dehydration following adenotonsillectomy were recurring harms.

Voluntary incidence reports

About two thirds of the incidents reported were minor incidents like delay in medication administration not leading to patient harm.

Patient harm as defined by the PTT user guide was found in 51/160 (30.9%) of the incidence reports 2010-2012. 37 harm events were classified as harm category E, 8 category F, 3 category G, 1 category H and 2 category I. This equals 51/5854 (total number of patients admitted acutely with medical diagnoses 2010-2012) = 0.9%. Only three of these incidents were reported in the PTT study months giving a voluntary reported harm rate of 3/584 (number of pediatric patients in the PTT screening) = 0.5% in March-May 2011.

Patient harm reported through the incidence reporting system included unexpected patient death; fall injury; pain and swelling from subcutaneous peripheral venous catheter; complications to procedure; anaphylactic drug reactions; and prolonged hospitalization due to errors in medication and fluid administration.

Triggers

We identified ~~20~~ one or more out of 20 of the 39 ~~different~~ NHS triggers in 242 (31~~,~~,8%) of ~~the~~ all patient contacts. In 71~~,~~,5% of the trigger positive contacts only one trigger was found. The highest number of triggers found in a patient contact was 4 ~~(3 contacts = 1,2%).~~ The mean rate of triggers per patient was 1~~,~~,4.

The most frequently found trigger was re-admission within 30 days. ~~52,5 % of outpatient visits were a re-admission or were followed by a readmission within 30 days and 42,8% of admissions were or were followed by a readmission within 30 days.~~ Common reasons for unplanned readmission were surgical site infection, recurrent (respiratory tract) infections, postoperative bleeding and seizures. ~~The~~ We found the second most common trigger in our screening ~~was~~ to be hypoxia~~.~~, but no patient harm was associated with this specific trigger.

Of the 242 trigger positive contacts, 177 (73~~,~~,1%) were admissions and 65 (26~~,~~,9%) acute outpatient visits. ~~Figure~~Table 2 shows how trigger positive admissions and

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outpatient contacts were distributed across specialties.

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~~Table 2 Rate of trigger positive contacts, rate of harm and positive predictive value (PPV) across specialties~~

~~Specialty~~	~~Rate of trigger positive contacts~~	~~Rate of harm~~	~~PPV~~
~~Pediatric~~	~~207/584 (35.4%)~~	~~29/584 (5.0%)~~	~~14%~~
~~Orthopedic surgery~~	~~11/83 (13.3%)~~	~~5/83 (6.0%)~~	~~45.5%~~
~~General surgery~~	~~12/63 (19.0%)~~	~~3/63 (4.8%)~~	~~25%~~
~~Ear, Nose and Throat~~	~~12/31 (38.7%)~~	~~11/31 (35.5%)~~	~~91.7%~~
~~Total~~	~~242/761 (31.8%)~~	~~48/761 (6.3%)~~	~~19.8%~~

~~***Harm***~~

~~We identified a total of 48 incidents of harm, representing 21 harm events per 1000 patient days and 6 harm events per 100 consultations/admissions.~~

The PPV of one or more triggers for identifying harm was 19,8~~% in the entire material.~~%. When calculations were made for admissions (n= 761) and outpatient care (n= 242) separately, PPV was 23,2% and 10,8%, respectively (p~~=~~=0,03).~~-~~ When we looked at the PPV of individual triggers, PPV varied from zero in the case of hypoxia, thrombocytopenia and electrolyte abnormalities to 100% in the case of surgical site infection and nosocomial pneumonia (Table ~~1~~3).

~~The distribution of the 48 patients with identified harm according to status as admitted or outpatient, as well as their distribution across specialties are presented in Figure 3.~~

~~60,4% of the harm events were in the pediatric (medical) patients, whereas 22,9% occurred in ENT patients, 10,4% in orthopedic and 6,3% in general surgical patients.~~

~~Harm was detected in 5% of all pediatric contacts, whereas in the pediatric admissions we found a 7% harm rate. The incidence of harm in all contacts and in admissions only regardless of specialty was 6,3% and 8,3%, respectively.~~

Table ~~2~~4 shows rate of trigger positive contacts, rate of harm and PPV ~~across specialties.~~

~~*Categories* of *harm*~~

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~~All, but two (E) identified harm events were categorized as harm category F, 'Temporary harm to the patient and required initial or prolonged hospitalization'.~~

~~*Examples of harm*~~

~~Pediatric~~

~~- Postoperative pericarditis~~

~~- Ileus after gastrostomy.~~

~~- Candida stomatitis after treatment with antibiotics~~

~~- Infection in percutaneous endoscopic gastrostomy (PEG)~~

~~- Bleeding following placement of nasogastric feeding tube (harm category E)~~

~~- Nosocomial infection (gastroenteritis, pneumonia)~~

~~Orthopedic~~

~~- Osteomyelitis after pinning of Bennet's fracture~~

~~General surgical~~

~~- Hematoma scrotum after hernia operation (outpatient: category E)~~

~~Ear, Nose and Throat~~

~~- Bleeding infection and/or dehydration following adenotonsillectomy~~

~~**Inter-rater agreement**~~

~~In the 10 patient records that were screened by the AHUS GTT team as well as by ALS, inter-rater agreement was high both with regards to the~~ triggers ~~identified, and as to whether harm had detected or not.~~ across specialties.

~~**Compared to GTT data in our hospital**~~

~~Screening of 200 patient records representing 1145 patient days revealed 45 incidents of harm (22,5% of the patients (equals 22,5 per 100 patients) or 39 per 1000 patient days).[9] In our patients, readmissions and hypoxia were the most frequent triggers, whereas the most frequently found triggers in the adults were urinary tract infection, pneumonia, drug related harm and pressure ulcer (not published).~~

~~**Voluntary incidence reports**~~

~~The majority of incidents reported were minor incidents like delay in medication administration not leading to patient harm.~~

~~Patient harm as defined by the PTT user guide was found in 51/160 (30,9%) of the incidence reports 2010-2012. 37 harm events were classified as harm category E, 8 category F, 3 category G, 1 category H and 2 category I. This equals 51/5854 (total number of patients admitted acutely with medical diagnoses 2010-2012) = 0,9%. Only three of these incidents were reported in the PTT study months giving a voluntary reported harm rate of 3/584 (number of pediatric patients in the PTT screening) = 0,5% in March-May 2011.~~

~~Patient harm reported though the incidence reporting system included unexpected patient death; fall injury; pain and swelling from subcutaneous peripheral venous catheter; complications to procedure; anaphylactic drug reactions; and prolonged hospitalization due to errors in medication and fluid administration.~~

DISCUSSION

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~~Our pediatric centre is the largest acute pediatric unit in Norway, but we do not have a PICU in our hospital. Therefore, we do not treat the most severely ill children, and we only rarely use potent anesthesia medications. This is probably the reason.~~ This is the first report about use of a PTT in a European unit. Despite the fact that only half of the NHS pediatric triggers were found in the patient records screened in this study, we identified a ten times higher harm rate using the PTT than what was reported in the department's voluntary incidence reports in the same period. Patient harm identified through incidence report analysis and PTT screening was different in number and character in our unit.

Our pediatric centre is the largest acute pediatric unit in Norway, but we do not have a PICU in our hospital. Therefore, we do not treat the most severely ill children, and we only rarely use potent anesthesia medications. This may be one of the reasons why half of the NHS triggers were not found in our ~~material~~review, reflecting that some diagnoses and interventions with a high incidence of complications are not present in the children and adolescents in our unit.

In the recently published Canadian Pediatric Adverse Events Study, the incidence, type~~,~~ and severity ~~and preventability~~ of harm among children admitted to academic pediatric centers were compared with those admitted to community hospitals in Canada.[~~6~~8] In that study, ~~academic pediatric centers were defined as pediatric hospitals with a full-time core postgraduate training program in pediatrics and pediatric surgery in addition to a level 3 NICU. Community hospitals were defined as having 1000 or more pediatric admissions, including newborns, per year, a NICU or~~

special care nursery, and no full-time core pediatric or pediatric surgical residency training. Our pediatric centre, although being an academic teaching unit, probably has a patient population with disease severity and complexity somewhere in between the two compared unit levels in the Canadian study.

In the Canadian Pediatric Adverse Events Study significantly more patient chartsrecords from academic pediatric centers (38-,-8%) than from community hospitals (21-,-6%) were trigger-positive.[6]8] We found triggers in 31-,-8% of our patients. This might reflect our status as somewhere in between a level 2 and level 3 pediatric unit.

The overall rate of harm in the Canadian study was 9-,-2% with significantly more harms in academic pediatric centers (11-,-2%) than in community hospitals (3-,-3%). We found a total rate of harm in admitted children of 8-,-3%, again possibly in accordance with our department's "in between" status.%. These results might reflect that, although being an academic teaching unit, our center probably has a patient population with disease severity and complexity somewhere in between the two compared unit levels in the Canadian study.

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Kirkendall et al.[4]7] found 37 harm events per 100 patients and 76 harm events per 1000 patient-days, a significantly higher rate thatthan in our patients. One of the reasons for this may be that the study was conducted in a large US tertiary centre where 32-,-5% of the patients went to the operating room during their hospital stay and 13-,-3% were admitted to an ICU during part of or whole stay.

We found a PPV of one or more triggers of 19-,-8% when both acute outpatient contacts and admissions were included and a higher PPV when only admissions were analyzed. Lemon and Stockwell found a PPV of 34%.[3]6] One of the possible reasons for this difference is that Lemon and Stockwell only screened for 11 triggers while we identified 20 different triggers, of which some had an individual PPV of zero. Another important difference is that Lemon and Stockwell reported results from a 4-year period whereas we only screened for a three-month period, which limits generalizability.

Compared to GTT data in our hospital

In addition to the different spectrum of triggers, two important distinctions between the GTT and our PTT screening were that in the GTT accidental trauma outside hospital and other health care institutions (i.e. harm not caused by health care) as well as febrile neutropenias (induced by chemotherapy) were defined as incidents of harm.

This raises the important question of what can be defined as anticipated *side effects* of medical treatment and calculated risk and what should be defined as iatrogenic harm. Is for example chemotherapy induced leuko- or neutropenia preventable? If the purpose of trigger tool systems is to focus attention towards areas of improvement, harm that cannot be prevented by change in routines and procedures should not necessarily be registered in this system. Lemon and Stockwell classifies harm either as being preventable or nonpreventableLike Kirkendall et al.,[3][7] whereas Kirkendall et al. did not assess preventability.[4]

Another issue raised is whether only "active delivery of harm" or also omission (substandard care) should count as harm in the PTT system.[4] According to the Institute for Healthcare Improvement,[2] harm includes only those adverse events related to the active delivery of harm (commission) and not issues related to substandard care (omission).

Trigger versus harm

Like Kirkendall et al.,[4] we found that some modules, in our case the laboratory module, contained adult-oriented triggers like high INR and diagnostic imaging for embolus that are not applicable to our population and therefore not identified in our chart review. Removal of unnecessary triggers would reduce the overall number of triggers that reviewers must consider.

Some triggers, e.g. complication of procedure or treatment and surgical site infection are themselves examples of harm. Nosocomial pneumonia and surgical site infection both had a PPV of 100% in our patients. Hypoxia, electrolyte abnormalities and thrombocytopenia had a PPV of zero and may not be worthwhile screening for with the PTT in our patient population.

PTT versus voluntary incidence reporting

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~~It has become evident from our study that patient harm identified through incidence report analysis and PTT screening are different in number and character in our unit. One of the most frequently reported error leading to harm in the incidence reports, 'Error in medication/fluid therapy routines' could not be detected through the PTT medication module that only detects medication errors requiring antidote, antihistamine and/or antiemetics; as well as abrupt medication stop.~~

~~Classen et al.[10] found that the GTT identified more than 10 times more serious events than voluntary safety reports or the Agency for Healthcare Research and Quality's Patient Safety Indicators. We found a 3 times higher harm rate in the PTT screening (pediatric patients) than in the incidence reporting system.~~

~~**Practical use of the PTT**~~

~~There are two published ways to use a trigger tool detection system:~~

~~1. For regular manual screening of a random pick of patient records. In this case, it is commonly said that the time spent for screening of individual charts should be limited to 20 minutes.~~

~~2. For automated electronic screening of all patient records.~~

we found that some modules, in particular the laboratory module, contained adult-oriented triggers like high INR and diagnostic imaging for embolus that were not identified in our chart review. Removal of unnecessary triggers would reduce the overall number of triggers that reviewers must consider. Hypoxia, electrolyte abnormalities and thrombocytopenia had a PPV of zero and may not be worthwhile screening for in our patient population. However, bearing in mind the short study period of 3 months, further studies, ideally multicenter studies are needed before abolishment of some triggers.

To our knowledge, we are the first group to report the use of a PTT for unplanned outpatient visits. Some trigger tools exist for outpatient care,[~~11,~~12~~]~~,13] however they are not suitable for children and adolescents. As harm was detected in 7/267 (2~~,~~.6%) of acute outpatient visits, we believe that identification of these events is important in a unit like ours where the number of acute outpatient visits is substantial.

Regardless, there seems to be a higher PPV of triggers in surgical patients, but the rate of harm was comparable across medical and surgical patients (5-6%), excluding ENT patients with a 35% total harm rate.

Needless to say, the extent to which trigger tools detect harm as intended depends to a large extent on routines for documentation. Like Kirkendall et al.,[4~~]~~7] we noticed that frequently occurring complications like complications to peripheral venous catheters~~(~~, e.g. phlebitis, subcutaneous edema, tissue necrosis and infection~~),~~ are infrequently documented in the records of the patients in our unit. The same ~~is the case for~~applies to the incidence reporting system that contains information about only a small fraction of these types of patient harm. Hence, certain types of patient harm that are frequently occurring and should be targeted by interventions are not detected in ~~its~~their full extent neither with the PTT nor through voluntary incidence reporting.

Limitations of the study

The PTT screening and incident report analyses were ~~mainly~~ performed by only one investigator, and inter-rater agreement could not be ~~properly~~ assessed in this study. ~~Also, this was a relatively small single-center study and generalizability of our results is~~ The judgment regarding whether harm was present and how severe was left to one person, with no one to validate the findings. To our knowledge, the PTT is not established in any Norwegian pediatric unit, and we did not succeed in finding a person with both time and experience to validate the findings. For the same reason, this was a relatively small single-center study and the study period was short. Some of the triggers that were not identified during the three study months could possibly have been detected if we screened for a longer period. The decision to also screen unplanned outpatient contacts as well as including all sodium and potassium levels out of range were deviations from the PTT user guide that could potentially bias our results. However, as the outpatient contacts and admissions are to a large extent reported separately, and as the sodium and potassium trigger did not predict harm in any of our patients, we believe that these factors did not influence the main conclusions of the study. Generalizability of our results may be limited to ~~contexts~~settings with similar organization of specialist healthcare including referral practices. However, it is important that utility studies performed in ~~different context be publishes~~various patient groups be published in order for clinicians to judge

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applicability of the results to their practice.

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CONCLUSION

Using the NHS Paediatric Trigger tool we found a rate of trigger positive contacts and a rate of harm comparable to an extensive Canadian review. The PTT made us able to detect more and different types of harm among our children and adolescents than what we detect by our routine system for reporting patient harm.

~~Like Kendall et al.[4] we conclude that the~~The presence of adult-oriented triggers, triggers that were not identified at all, as well as triggers with a low predictive value for harm, ~~highlight the~~ indicate a need for modification of trigger tools to the ~~context~~setting in which they are intended to be used. The NHS PTT, with certain modifications ~~to our context~~ can, as a supplement to voluntary incidence reporting, be used to calculate the rate of harm and identify areas of care where most harm events are occurring. Hence, it may inform priorities for action and track improvements over time.

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CONTRIBUTOR STATEMENT

ALS was the lead author for this paper and involved in all stages including design of the research, acquisition of data, analysis and interpretation of the data and statistical analysis. BN contributed to the drafting of the manuscript, critical revision of the manuscript and supervision.

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Table 1 The Paediatric Trigger Tool (PTT) items as depicted in the NHS PTT User Guide[4]

	Item
General care	PG1 Early warning score
	PG2 Tissue damage or pressure ulcer
	PG3 Readmission within 30 days
	PG4 Unplanned admission
	PG5 Abnormal cranial imaging
	PG6 Respiratory or cardiac arrest / crash calls
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation
	PG8 Complication of procedure or treatment
	PG9 Transfer to higher level of care
	PG10 Hypoxia O2 sat <85%
	PG11 Cancelled elective procedure / delayed discharge
Surgical care	PS1 Return to theatre
	PS2 Change in planned procedure
	PS3 Surgical site infection or hospital acquired urinary tract infection
	PS4 Removal/injury/repair of organ
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care
Medication	PM1 Vitamin K (except for routine dose in neonates)
	PM2 Naloxone
	PM3 Flumazenil (Romazicon)
	PM4 Glucagon or glucose ≥ 10%
	PM5 Chlorphenamine or antihistamine
	PM6 Anti-emetics
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given
	PM8 Abrupt medication stop
Lab test	PL15 Thrombocytopenia (platelets <100)
	PL1 High INR >5 or aPTT >100
	PL2 Transfusion
	PL3 Abrupt drop in Hb or Hct (>25%)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)
	PL7 Hypoglycemia (<3mmol/l)
	PL8 Hyperglycemia (>12mmol/l)
	PL9 Drug level out of range
Microbiology	PL10 MRSA bacteraemia
	PL11 C. difficile
	PL12 Vanc resistant enterococcus (VRE)
	PL13 Nosocomial pneumonia
	PL14 Positive blood culture
Other	PO1 Other event

Table 2 Distribution of trigger positive admissions and outpatient contacts across specialties

	Pediatric		Ortopedic		General surgical		Ear, nose and throat	
	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient
Total n (%)	356 (47)	228 (30)	70 (9)	13 (2)	41 (5)	22 (3)	27 (3.5)	4 (0.5)
Trigger positive n (%)	148 (61)	59 (24.5)	8 (3.5)	3 (1)	10 (4)	2 (1)	11 (4.5)	1 (0.5)
Harm n	26	3	3	2	1	2	11	0

Table 3 The triggers we identified in our study are presented with positive predictive value (PPV) with 95% confidence interval (CI) for identifying harm. The numerator represents number of harm events and the denominator how many times each individual trigger was found in all patient contacts (n=761)

	Item	PPV (CI)%
General care	PG1 Early warning score	
	PG2 Tissue damage or pressure ulcer	
	PG3 Readmission within 30 days	24/175=14 (9-20)
	PG4 Unplanned admission	
	PG5 Abnormal cranial imaging	
	PG6 Respiratory or cardiac arrest / crash calls	0/1=0 (0-95)
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation	1/2=50 (3-97)
	PG8 Complication of procedure or treatment	17/23=74 (51-89)
	PG9 Transfer to higher level of care	3/22=14 (4-36)
	PG10 Hypoxia O2 sat <85%	0/25=0 (0-17)
	PG11 Cancelled elective procedure / delayed discharge	1/1=100 (5-100)
Surgical care	PS1 Return to theatre	1/1=100 (5-100)
	PS2 Change in planned procedure	
	PS3 Surgical site infection or hospital acquired urinary tract infection	6/6=100 (52-100)
	PS4 Removal/injury/repair of organ	
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care	
Medication	PM1 Vitamin K (except for routine dose in neonates)	
	PM2 Naloxone	
	PM3 Flumazenil (Romazicon)	
	PM4 Glucagon or glucose ≥ 10%	
	PM5 Chlorphenamine or antihistamine	0/1=0 (0-95)
	PM6 Anti-emetics	
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given	3/19=16 (4-40)
	PM8 Abrupt medication stop	
Lab test	PL15 Thrombocytopenia (platelets <100)	0/7=0 (0-44)
	PL1 High INR >5 or aPTT >100	
	PL2 Transfusion	2/8=25 (4-64)
	PL3 Abrupt drop in Hb or Hct (>25%)	2/8=25 (4-64)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)	0/1=0 (0-95)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)	0/12=0 (0-30)
	PL7 Hypoglycemia (<3mmol/l)	3/8=38 (10-74)
	PL8 Hyperglycemia (>12mmol/l)	0/1=0 (0-95)
	PL9 Drug level out of range	
Microbiology	PL10 MRSA bacteraemia	
	PL11 C. difficile	
	PL12 Vanc resistant enterococcus (VRE)	
	PL13 Nosocomial pneumonia	2/2=100 (20-100)
	PL14 Positive blood culture	1/1=100 (5-100)
Other	PO1 Other event	

Table 4 Rate of trigger positive contacts, rate of harm and positive predictive value (PPV) of positive triggers across specialties

Specialty	Rate of trigger positive contacts	Rate of harm	PPV
Pediatric	207/584 (35.4%)	29/584 (5.0%)	14%
Orthopedic surgery	11/83 (13.3%)	5/83 (6.0%)	45.5%
General surgery	12/63 (19.0%)	3/63 (4.8%)	25%
Ear, Nose and Throat	12/31 (38.7%)	11/31 (35.5%)	91.7%
Total	242/761 (31.8%)	48/761 (6.3%)	19.8%

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Title: Utility of a Pediatric Trigger Tool in a Norwegian Department of Pediatric and Adolescent Medicine

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ABSTRACT

Objectives

The British National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools developed for use in adults. The PTT has not previously been developed or used in Nordic units. We aimed to compare harm identified through PTT screening with voluntary incidence reports in our department. A secondary aim was to assess utility of the different triggers, including predictive value for identifying harm. We hypothesized that the NHS PTT would need adjustments for the setting in which it is used.

Setting

A Norwegian level II department of pediatric and adolescent medicine.

Participants

A convenience sample of 761 acute medical and surgical patient contacts March-May 2011. Median age (IQR) for the trigger positive patients was 2.5 (1.0-8.0) years; range 0-18 years.

Primary and secondary outcome measures

The type and rate of identified harm compared to the department's voluntary incidence reports. The type and rate of identified triggers and positive predictive value for harm.

Results

The PTT revealed a harm rate of 5% for medical patients, as compared to 0.5% in the incidence reports the same months. PTT screening revealed other types of harm than those reported by health care personnel themselves. We identified only 20 out of the 39 NHS PTT triggers. The most frequent trigger was re-admission within 30 days. Hypoxia, which was the second most frequent trigger, did not predict any patient harm.

Conclusion

This study showed that the NHS PTT identifies more and other types of harm than voluntary incidence reports. The presence of adult-oriented triggers, triggers that were

not identified at all, as well as triggers with a low predictive value for harm may indicate the need for modification of the PTT to different settings. More studies are needed before a final decision is made to exclude triggers from the screening.

ARTICLE SUMMARY

Strengths and limitations of this study

- There is a limited understanding of how structured patient safety work in pediatrics can be performed
- We investigated utility of The British National Health Service Paediatric Trigger Tool (PTT) in a level II pediatric unit and found that the tool should probably be modified to different settings
- Previous to this study, only one major pediatric trigger tool has been published in peer review journal format and none have been applied in outpatient settings
- This review is based on a significant amount of patient data. However, the single-center character and the short study period call for additional studies, preferentially multicenter studies

INTRODUCTION

By identifying recurring medical errors focused efforts can be made to improve patient safety.[1,2] However, medical errors do not always lead to harm to the patient. Patient harm can be caused by medical error, but can also occur as a result of a diagnostic or treatment procedure in the absence of a medical error.[3]

So-called 'trigger tools' focus on patient harm, not errors, and can in combination with more traditional incident reporting in healthcare help departments and hospitals focus their improvement work to reduce the overall rate of patient harm.[4] The global trigger tool (GTT) is a retrospective method for detecting iatrogenic harm [5] and has been used as a benchmarking system and means for monitoring change over time. A trigger has been defined as data present in the patient record that can directly or indirectly, by providing a clue for further investigation, represent an adverse event that caused patient harm.[6,7] The GTT has become a widely used tool in patient safety work. However, the understanding of health care–associated harm in children is limited as compared to adults and only recently a comprehensive pediatric trigger tool has been developed.[8]

The National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools for use in adults with the support of clinicians in nine UK hospitals, and was meant to be useful for district general hospitals, acute teaching hospitals and specialist pediatric centers.[4] However, there is a need for determining utility of such instruments derived from adult care in different institutions and patient groups. The items comprising the PTT should be piloted in different settings in order to remove unnecessary or adult-oriented triggers and/or add more relevant triggers.[7]

Hence, we aimed to examine utility of the NHS PTT in a large Nordic department of pediatrics and if needed adjust the tool for use in our patients.

Our primary focus was to examine if or to which extent the PTT detected patient harm in medical and surgical patients in our department and compare these results with voluntary incidence reports. A secondary aim was to assess utility of the different triggers, including predictive value of individual triggers for identifying harm.

METHODS

The study was approved as part of quality improvement activities by the institutional review board at Akershus University Hospital (AHUS)

Setting

AHUS is located outside the Norwegian capital Oslo. The hospital is the single largest acute hospital in Norway and offers a full range of medical services except cardiac- and neurosurgery, as well as treatment of severe traumatic injuries. AHUS does not have a pediatric intensive care unit (PICU), but transfers children below the age of three years in need for intensive care to a nearby university hospital. Critically ill children between three and 18 years are treated in the intensive care unit (ICU) for adults in AHUS. The hospital introduced early warning scoring systems after this study. Routine GTT screening has been performed since 2007.

The Department of Pediatric and Adolescent Medicine is a 37-bed level II unit. Children and adolescents between zero and 18 years of age referred by general physicians for acute specialist care are examined in the children's emergency department (ED) and about 50% are admitted. Registration of patient harm in our unit is exclusively based on voluntary reporting through an electronic incidence reporting system called Extend Quality System (EQS).

PTT screening

We did a manual review of unplanned patient visits to the children's ED using the NHS Paediatric Trigger Tool User guide.[4] For convenience, we included the visits that were documented for the purpose of evaluating the introduction of a pediatric early warning score in our department over a three month period.[9] These visits represented 95% of all contacts in the children's ED in the study months. Pediatric (medical), as well orthopedic, general surgical; and ear, nose and throat (ENT) patients below the age of 18 years were included and the results were recorded in Excel spreadsheets (Microsoft Excel 2008 for Mac (Redmond, WA, US)).

The PTT screening was performed by the primary investigator (ALS) who is a consultant pediatrician in the department. Because AHUS is the first hospital in Norway to screen for pediatric triggers, there are no courses or formal training in the

PTT available in Norway. Hence, to get a general idea about the concept of trigger tools, ALS attended a full-day course in the GTT organized by The Norwegian Knowledge Centre for the Health Services. In addition, she received instructions from the GTT team at AHUS based on their review methodology and PTT screening of 10 patient records was performed in collaboration with a representative from the GTT team.

The PTT consists of 39 items described in Table 1. The patient records were reviewed in the following order: Diagnoses and treatment procedures, discharge summaries, medication charts, laboratory results, operation notes, nurse notes, physician notes and admission note. Because only half of the acute referrals result in an admission, our practice differs from most medical departments for adults where a larger proportion of acutely referred patients are being admitted. The PTT user guide dictates a minimum length of stay of 8 hours.[4] However, as we argue that our threshold for admitting patients from the children's ED is high with often only slight differences in disease severity and complexity between those who are admitted and those who are not, we included also acute outpatient visits in our screening. In our unit fluid replacement therapy has been an area of improvement. In an attempt to increase detection rates for harm causes by intravenous fluid therapy, we chose to register all patient contacts with the diagnoses hypo-/hyperkalemia and/or hypo-/hypernatremia as trigger positive regardless of the definitions used in the PTT user guide for these triggers (Table 1). Otherwise, we strictly followed the definitions and guidelines outlined in the user guide.

The PTT uses an adapted version of the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) 'Index for Categorizing Errors'.[10] The rationale for this is that the NHS focuses on adverse events that cause actual patient harm and not medical errors that have a potential for patient harm. Therefore, only the NCC MERP categories E through I are included: Temporary harm to the patient and required intervention (category E), temporary harm to the patient and required initial or prolonged hospitalization (category F), permanent patient harm (category G), intervention required to sustain life (category H), and patient death (category I).

Harm identified through PTT screening was compared to harm identified through voluntary incidence reports in the department.

Voluntary incidence reporting

ALS read and classified patient related incidents regarding pediatric (medical) patients reported in the EQS in March until May 2011. The rate of harm reported in incidence reports during these three months was low. Therefore all reports in an extended period of time, 2010-2012, were included. Patient harm identified in the incidence reports was classified from E through I for comparison to the findings from the PTT screening.

Statistical analyses

Data were analyzed using PASW®Statistics 18.0 software (SPSS Inc., Chicago, IL). Comparisons between groups were made using the Chi-square test for categorical variables and Mann-Whitney *U* test for continuous variables. P-values <0.05 were considered significant. Positive predictive value (PPV) with 95% confidence interval (CI) for triggers was calculated and we calculated number of harm events per 1000 patient days and 100 patient contacts.

RESULTS

From March 15th until Mai 31st 2011 761 patient records, representing 2268 patient days were screened for triggers. Median age (IQR) in years was 3.5 (1.2-11.0) for all patients and 2.5 (1.0-8.0) for the trigger positive patients. Male to female ratio was 352:409 and 113:129 for all patients and the trigger positive patients, respectively.

We identified 48 incidents of harm, representing 21 harm events per 1000 patient days and 6 harm events per 100 consultations. The distribution of the 48 patients with identified harm according to status as admitted or outpatient, as well as their distribution across specialties are presented in Table 2. 60.4% of the harm events were in the pediatric (medical) patients, whereas 22.9% occurred in ENT-patients, 10.4% in orthopedic and 6.3% in general surgical patients.

Harm was detected in 5% of all pediatric contacts with a slightly higher rate of 7% in pediatric admissions. The incidence of harm in all contacts including surgical and ENT patients and in admissions only regardless of specialty was similar, 6.3% and 8.3%, respectively.

All, but two identified harm events were categorized as harm category F, 'Temporary harm to the patient and required initial or prolonged hospitalization'. Examples of harm were postoperative pericarditis, ileus after gastrostomy, candida stomatitis after treatment with antibiotics, infection in percutaneous endoscopic gastrostomy, bleeding following placement of nasogastric feeding tube (harm category E) and nosocomial infection (gastroenteritis, pneumonia) for the pediatric patients. In orthopedic patients osteomyelitis after pinning of Bennett's fracture was found and in general surgical patients hematoma after hernia operation (outpatient: harm category E) was found. In the ENT patients bleeding, infection and/or dehydration following adenotonsillectomy were recurring harms.

Voluntary incidence reports

About two thirds of the incidents reported were minor incidents like delay in medication administration not leading to patient harm.

Patient harm as defined by the PTT user guide was found in 51/160 (30.9%) of the incidence reports 2010-2012. 37 harm events were classified as harm category E, 8

category F, 3 category G, 1 category H and 2 category I. This equals 51/5854 (total number of patients admitted acutely with medical diagnoses 2010-2012) = 0.9%. Only three of these incidents were reported in the PTT study months giving a voluntary reported harm rate of 3/584 (number of pediatric patients in the PTT screening) = 0.5% in March-May 2011.

Patient harm reported through the incidence reporting system included unexpected patient death; fall injury; pain and swelling from subcutaneous peripheral venous catheter; complications to procedure; anaphylactic drug reactions; and prolonged hospitalization due to errors in medication and fluid administration.

Triggers

We identified one or more out of 20 of the 39 NHS triggers in 242 (31.8%) of all patient contacts. In 71.5% of the trigger positive contacts only one trigger was found. The highest number of triggers found in a patient contact was 4. The mean rate of triggers per patient was 1.4.

The most frequently found trigger was readmission within 30 days. Common reasons for unplanned readmission were surgical site infection, recurrent (respiratory tract) infections, postoperative bleeding and seizures. We found the second most common trigger in our screening to be hypoxia, but no patient harm was associated with this specific trigger.

Of the 242 trigger positive contacts, 177 (73.1%) were admissions and 65 (26.9%) acute outpatient visits. Table 2 shows how trigger positive admissions and outpatient contacts were distributed across specialties.

The PPV of one or more triggers for identifying harm was 19.8%. When calculations were made for admissions (n= 761) and outpatient care (n= 242) separately, PPV was 23.2% and 10.8%, respectively (p=0.03). When we looked at the PPV of individual triggers, PPV varied from zero in the case of hypoxia, thrombocytopenia and electrolyte abnormalities to 100% in the case of surgical site infection and nosocomial pneumonia (Table 3).

Table 4 shows rate of trigger positive contacts, rate of harm and PPV of triggers across specialties.

DISCUSSION

This is the first report about use of a PTT in a European unit. Despite the fact that only half of the NHS pediatric triggers were found in the patient records screened in this study, we identified a ten times higher harm rate using the PTT than what was reported in the department's voluntary incidence reports in the same period. Patient harm identified through incidence report analysis and PTT screening was different in number and character in our unit.

Our pediatric centre is the largest acute pediatric unit in Norway, but we do not have a PICU in our hospital. Therefore, we do not treat the most severely ill children, and we only rarely use potent anesthesia medications. This may be one of the reasons why half of the NHS triggers were not found in our review, reflecting that some diagnoses and interventions with a high incidence of complications are not present in the children and adolescents in our unit.

In the recently published Canadian Pediatric Adverse Events Study, the incidence, type and severity of harm among children admitted to academic pediatric centers were compared with those admitted to community hospitals in Canada.[8] In that study, significantly more patient records from academic pediatric centers (38.8%) than from community hospitals (21.6%) were trigger-positive.[8] We found triggers in 31.8% of our patients. The overall rate of harm in the Canadian study was 9.2% with significantly more harm in academic pediatric centers (11.2%) than in community hospitals (3.3%). We found a total rate of harm in admitted children of 8.3%. These results might reflect that, although being an academic teaching unit, our center probably has a patient population with disease severity and complexity somewhere in between the two compared unit levels in the Canadian study.

Kirkendall et al.[7] found 37 harm events per 100 patients and 76 harm events per 1000 patient-days, a significantly higher rate than in our patients. One of the reasons for this may be that the study was conducted in a large US tertiary centre where 32.5% of the patients went to the operating room during their hospital stay and 13.3% were admitted to an ICU during part of or whole stay.

We found a PPV of one or more triggers of 19.8% when both acute outpatient contacts and admissions were included and a higher PPV when only admissions were

analyzed. Lemon and Stockwell found a PPV of 34%.[6] One of the possible reasons for this difference is that Lemon and Stockwell only screened for 11 triggers while we identified 20 different triggers, of which some had an individual PPV of zero. Another important difference is that Lemon and Stockwell reported results from a four-year period whereas we only screened for a three-month period, which limits generalizability.

Like Kirkendall et al.,[7] we found that some modules, in particular the laboratory module, contained adult-oriented triggers like high INR and diagnostic imaging for embolus that were not identified in our chart review. Removal of unnecessary triggers would reduce the overall number of triggers that reviewers must consider. Hypoxia, electrolyte abnormalities and thrombocytopenia had a PPV of zero and may not be worthwhile screening for in our patient population. However, bearing in mind the short study period of 3 months, further studies, ideally multicenter studies are needed before abolishment of some triggers.

To our knowledge, we are the first group to report the use of a PTT for unplanned outpatient visits. Some trigger tools exist for outpatient care,[11,12] however they are not suitable for children and adolescents. As harm was detected in 7/267 (2.6%) of acute outpatient visits, we believe that identification of these events is important in a unit like ours where the number of acute outpatient visits is substantial.

Regardless, there seems to be a higher PPV of triggers in surgical patients, but the rate of harm was comparable across medical and surgical patients (5-6%), excluding ENT patients with a 35% total harm rate.

Needless to say, the extent to which trigger tools detect harm as intended depends to a large extent on routines for documentation. Like Kirkendall et al.,[7] we noticed that frequently occurring complications like complications to peripheral venous catheters, e.g. phlebitis, subcutaneous edema, tissue necrosis and infection, are infrequently documented in the records of the patients in our unit. The same applies to the incidence reporting system that contains information about only a small fraction of these types of patient harm. Hence, certain types of patient harm that are frequently occurring and should be targeted by interventions are not detected in their full extent neither with the PTT nor through voluntary incidence reporting.

Limitations of the study

The PTT screening and incident report analyses were performed by only one investigator, and inter-rater agreement could not be assessed in this study. The judgment regarding whether harm was present and how severe was left to one person, with no one to validate the findings. To our knowledge, the PTT is not established in any Norwegian pediatric unit, and we did not succeed in finding a person with both time and experience to validate the findings. For the same reason, this was a relatively small single-center study and the study period was short. Some of the triggers that were not identified during the three study months could possibly have been detected if we screened for a longer period. The decision to also screen unplanned outpatient contacts as well as including all sodium and potassium levels out of range were deviations from the PTT user guide that could potentially bias our results. However, as the outpatient contacts and admissions are to a large extent reported separately, and as the sodium and potassium trigger did not predict harm in any of our patients, we believe that these factors did not influence the main conclusions of the study. Generalizability of our results may be limited to settings with similar organization of specialist healthcare including referral practices. However, it is important that utility studies performed in various patient groups be published in order for clinicians to judge applicability of the results to their practice.

CONCLUSION

Using the NHS Paediatric Trigger tool we found a rate of trigger positive contacts and a rate of harm comparable to an extensive Canadian review. The PTT made us able to detect more and different types of harm among our children and adolescents than what we detect by our routine system for reporting patient harm.

The presence of adult-oriented triggers, triggers that were not identified at all, as well as triggers with a low predictive value for harm, indicate a need for modification of trigger tools to the setting in which they are intended to be used. The NHS PTT, with certain modifications can, as a supplement to voluntary incidence reporting, be used to calculate the rate of harm and identify areas of care where most harm events are occurring. Hence, it may inform priorities for action and track improvements over time.

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CONTRIBUTOR STATEMENT

ALS was the lead author for this paper and involved in all stages including design of the research, acquisition of data, analysis and interpretation of the data and statistical analysis. BN contributed to the drafting of the manuscript, critical revision of the manuscript and supervision.

COMPETING INTEREST

None

DATA SHARING STATEMENT

No additional data available

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Table 1 The Paediatric Trigger Tool (PTT) items as depicted in the NHS PTT User Guide[4]

	Item
General care	PG1 Early warning score
	PG2 Tissue damage or pressure ulcer
	PG3 Readmission within 30 days
	PG4 Unplanned admission
	PG5 Abnormal cranial imaging
	PG6 Respiratory or cardiac arrest / crash calls
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation
	PG8 Complication of procedure or treatment
	PG9 Transfer to higher level of care
	PG10 Hypoxia O2 sat <85%
	PG11 Cancelled elective procedure / delayed discharge
Surgical care	PS1 Return to theatre
	PS2 Change in planned procedure
	PS3 Surgical site infection or hospital acquired urinary tract infection
	PS4 Removal/injury/repair of organ
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care
Medication	PM1 Vitamin K (except for routine dose in neonates)
	PM2 Naloxone
	PM3 Flumazenil (Romazicon)
	PM4 Glucagon or glucose ≥ 10%
	PM5 Chlorphenamine or antihistamine
	PM6 Anti-emetics
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given
	PM8 Abrupt medication stop
Lab test	PL15 Thrombocytopenia (platelets <100)
	PL1 High INR >5 or aPTT >100
	PL2 Transfusion
	PL3 Abrupt drop in Hb or Hct (>25%)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)
	PL7 Hypoglycemia (<3mmol/l)
	PL8 Hyperglycemia (>12mmol/l)
	PL9 Drug level out of range
Microbiology	PL10 MRSA bacteraemia
	PL11 C. difficile
	PL12 Vanc resistant enterococcus (VRE)
	PL13 Nosocomial pneumonia
	PL14 Positive blood culture
Other	PO1 Other event

Table 2 Distribution of trigger positive admissions and outpatient contacts across specialties

	Pediatric		**Ortopedic**		**General surgical**		**Ear, nose and throat**	
	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient
Total n (%)	356 (47)	228 (30)	70 (9)	13 (2)	41 (5)	22 (3)	27 (3.5)	4 (0.5)
Trigger positive n (%)	148 (61)	59 (24.5)	8 (3.5)	3 (1)	10 (4)	2 (1)	11 (4.5)	1 (0.5)
Harm n	26	3	3	2	1	2	11	0

Table 3 The triggers we identified in our study are presented with positive predictive value (PPV) with 95% confidence interval (CI) for identifying harm. The numerator represents number of harm events and the denominator how many times each individual trigger was found in all patient contacts (n=761)

	Item	PPV (CI)%
General care	PG1 Early warning score	
	PG2 Tissue damage or pressure ulcer	
	PG3 Readmission within 30 days	24/175=14 (9-20)
	PG4 Unplanned admission	
	PG5 Abnormal cranial imaging	
	PG6 Respiratory or cardiac arrest / crash calls	0/1=0 (0-95)
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation	1/2=50 (3-97)
	PG8 Complication of procedure or treatment	17/23=74 (51-89)
	PG9 Transfer to higher level of care	3/22=14 (4-36)
	PG10 Hypoxia O2 sat <85%	0/25=0 (0-17)
	PG11 Cancelled elective procedure / delayed discharge	1/1=100 (5-100)
Surgical care	PS1 Return to theatre	1/1=100 (5-100)
	PS2 Change in planned procedure	
	PS3 Surgical site infection or hospital acquired urinary tract infection	6/6=100 (52-100)
	PS4 Removal/injury/repair of organ	
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care	
Medication	PM1 Vitamin K (except for routine dose in neonates)	
	PM2 Naloxone	
	PM3 Flumazenil (Romazicon)	
	PM4 Glucagon or glucose ≥ 10%	
	PM5 Chlorphenamine or antihistamine	0/1=0 (0-95)
	PM6 Anti-emetics	
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given	3/19=16 (4-40)
	PM8 Abrupt medication stop	
Lab test	PL15 Thrombocytopenia (platelets <100)	0/7=0 (0-44)
	PL1 High INR >5 or aPTT >100	
	PL2 Transfusion	2/8=25 (4-64)
	PL3 Abrupt drop in Hb or Hct (>25%)	2/8=25 (4-64)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)	0/1=0 (0-95)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)	0/12=0 (0-30)
	PL7 Hypoglycemia (<3mmol/l)	3/8=38 (10-74)
	PL8 Hyperglycemia (>12mmol/l)	0/1=0 (0-95)
	PL9 Drug level out of range	
Microbiology	PL10 MRSA bacteraemia	
	PL11 C. difficile	
	PL12 Vanc resistant enterococcus (VRE)	
	PL13 Nosocomial pneumonia	2/2=100 (20-100)
	PL14 Positive blood culture	1/1=100 (5-100)
Other	PO1 Other event	

Table 4 Rate of trigger positive contacts, rate of harm and positive predictive value (PPV) of positive triggers across specialties

Specialty	Rate of trigger positive contacts	Rate of harm	PPV
Pediatric	207/584 (35.4%)	29/584 (5.0%)	14%
Orthopedic surgery	11/83 (13.3%)	5/83 (6.0%)	45.5%
General surgery	12/63 (19.0%)	3/63 (4.8%)	25%
Ear, Nose and Throat	12/31 (38.7%)	11/31 (35.5%)	91.7%
Total	242/761 (31.8%)	48/761 (6.3%)	19.8%

Title: Utility of a Pediatric Trigger Tool in a Norwegian Department of Pediatric and Adolescent Medicine

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ABSTRACT

Objectives

The British National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools developed for use in adults. The PTT has not previously been developed or used in Nordic units. We aimed to compare harm identified through PTT screening with voluntary incidence reports in our department. A secondary aim was to assess utility of the different triggers, including predictive value for identifying harm. We hypothesized that the NHS PTT would need adjustments for the setting in which it is used.

Setting

A Norwegian level II department of pediatric and adolescent medicine.

Participants

A convenience sample of 761 acute medical and surgical patient contacts March-May 2011. Median age (IQR) for the trigger positive patients was 2.5 (1.0-8.0) years; range 0-18 years.

Primary and secondary outcome measures

The type and rate of identified harm compared to the department's voluntary incidence reports. The type and rate of identified triggers and positive predictive value for harm.

Results

The PTT revealed a harm rate of 5% for medical patients, as compared to 0.5% in the incidence reports the same months. PTT screening revealed other types of harm than those reported by health care personnel themselves. We identified only 20 out of the 39 NHS PTT triggers. The most frequent trigger was re-admission within 30 days. Hypoxia, which was the second most frequent trigger, did not predict any patient harm.

Conclusion

This study showed that the NHS PTT identifies more and other types of harm than voluntary incidence reports. The presence of adult-oriented triggers, triggers that were

not identified at all, as well as triggers with a low predictive value for harm may indicate the need for modification of the PTT to different settings. More studies are needed before a final decision is made to exclude triggers from the screening.

ARTICLE SUMMARY

Strengths and limitations of this study

- There is a limited understanding of how structured patient safety work in pediatrics can be performed
- We investigated utility of The British National Health Service Paediatric Trigger Tool (PTT) in a level II pediatric unit and found that the tool should probably be modified to different settings
- Previous to this study, only one major pediatric trigger tool has been published in peer review journal format and none have been applied in outpatient settings
- This review is based on a significant amount of patient data. However, the single-center character and the short study period call for additional studies, preferentially multicenter studies

INTRODUCTION

By identifying recurring medical errors focused efforts can be made to improve patient safety.[1,2] However, medical errors do not always lead to harm to the patient. Patient harm can be caused by medical error, but can also occur as a result of a diagnostic or treatment procedure in the absence of a medical error.[3]

So-called 'trigger tools' focus on patient harm, not errors, and can in combination with more traditional incident reporting in healthcare help departments and hospitals focus their improvement work to reduce the overall rate of patient harm.[4] The global trigger tool (GTT) is a retrospective method for detecting iatrogenic harm [5] and has been used as a benchmarking system and means for monitoring change over time. A trigger has been defined as data present in the patient record that can directly or indirectly, by providing a clue for further investigation, represent an adverse event that caused patient harm.[6,7] The GTT has become a widely used tool in patient safety work. However, the understanding of health care–associated harm in children is limited as compared to adults and only recently a comprehensive pediatric trigger tool has been developed.[8]

The National Health Service (NHS) Paediatric Trigger Tool (PTT) was made based on various trigger tools for use in adults with the support of clinicians in nine UK hospitals, and was meant to be useful for district general hospitals, acute teaching hospitals and specialist pediatric centers.[4] However, there is a need for determining utility of such instruments derived from adult care in different institutions and patient groups. The items comprising the PTT should be piloted in different settings in order to remove unnecessary or adult-oriented triggers and/or add more relevant triggers.[7]

Hence, we aimed to examine utility of the NHS PTT in a large Nordic department of pediatrics and if needed adjust the tool for use in our patients.

Our primary focus was to examine if or to which extent the PTT detected patient harm in medical and surgical patients in our department and compare these results with voluntary incidence reports. A secondary aim was to assess utility of the different triggers, including predictive value of individual triggers for identifying harm.

METHODS

The study was approved as part of quality improvement activities by the institutional review board at Akershus University Hospital (AHUS)

Setting

AHUS is located outside the Norwegian capital Oslo. The hospital is the single largest acute hospital in Norway and offers a full range of medical services except cardiac- and neurosurgery, as well as treatment of severe traumatic injuries. AHUS does not have a pediatric intensive care unit (PICU), but transfers children below the age of ~~3~~ three years in need for intensive care to a nearby university hospital. Critically ill children between three and 18 years are treated in the intensive care unit (ICU) for adults in AHUS. The hospital introduced early warning scoring systems after this study. Routine GTT screening has been performed since 2007.

The Department of Pediatric and Adolescent Medicine is a 37-bed level II unit. Children and adolescents between zero and 18 years of age referred by general physicians for acute specialist care are examined in the children's emergency department (ED) and about 50% are admitted. Registration of patient harm in our unit is exclusively based on voluntary reporting through an electronic incidence reporting system called Extend Quality System (EQS).

PTT screening

We did a manual review of unplanned patient visits to the children's ED using the NHS Paediatric Trigger Tool User guide.[4] For convenience, we included the visits that were documented for the purpose of evaluating the introduction of a pediatric early warning score in our department over a ~~3~~three month period.[9] These visits represented 95% of all contacts in the children's ED in the study months. Pediatric (medical), as well orthopedic, general surgical; and ear, nose and throat (ENT) patients below the age of 18 years were included and the results were recorded in Excel spreadsheets (Microsoft Excel 2008 for Mac (Redmond, WA, US)).

The PTT screening was performed by the primary investigator (ALS) who is a consultant pediatrician in the department. Because AHUS is the first hospital in Norway to screen for pediatric triggers, there are no courses or formal training in the

PTT available in Norway. Hence, to get a general idea about the concept of trigger tools, ALS attended a full-day course in the GTT organized by The Norwegian Knowledge Centre for the Health Services. In addition, she received instructions from the GTT team at AHUS based on their review methodology and PTT screening of 10 patient records was performed in collaboration with a representative from the GTT team.

The PTT consists of 39 items described in Table 1. The patient records were reviewed in the following order: Diagnoses and treatment procedures, discharge summaries, medication charts, laboratory results, operation notes, nurse notes, physician notes and admission note. Because only half of the acute referrals result in an admission, our practice differs from most medical departments for adults where a larger proportion of acutely referred patients are being admitted. The PTT user guide dictates a minimum length of stay of 8 hours.[4] However, as we argue that our threshold for admitting patients from the children's ED is high with often only slight differences in disease severity and complexity between those who are admitted and those who are not, we included also acute outpatient visits in our screening. ~~Further~~In our unit fluid replacement therapy has been an area of improvement. In an attempt to increase detection rates for harm causes by intravenous fluid therapy, we chose to register all patient contacts with the diagnoses hypo-/hyperkalemia and/or hypo-/hypernatremia as trigger positive regardless of the definitions used in the PTT user guide for these triggers (Table 1). Otherwise, we strictly followed the definitions and guidelines outlined in the user guide.

The PTT uses an adapted version of the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) 'Index for Categorizing Errors'.[10] The rationale for this is that the NHS focuses on adverse events that cause actual patient harm and not medical errors that have a potential for patient harm. Therefore, only the NCC MERP categories E through I are included: Temporary harm to the patient and required intervention (category E), temporary harm to the patient and required initial or prolonged hospitalization (category F), permanent patient harm (category G), intervention required to sustain life (category H), and patient death (category I).

Harm identified through PTT screening was compared to harm identified through voluntary incidence reports in the department.

Voluntary incidence reporting

ALS read and classified patient related incidents regarding pediatric (medical) patients reported in the EQS in March until May 2011. The rate of harm reported in incidence reports during these three months was low. Therefore all reports in an extended period of time, 2010-2012, were included. Patient harm identified in the incidence reports was classified from E through I for comparison to the findings from the PTT screening.

Statistical analyses

Data were analyzed using PASW® Statistics 18.0 software (SPSS Inc., Chicago, IL). Comparisons between groups were made using the Chi-square test for categorical variables and Mann-Whitney *U* test for continuous variables. P-values <0.05 were considered significant. Positive predictive value (PPV) with 95% confidence interval (CI) for triggers was calculated and we calculated number of harm events per 1000 patient days and 100 patient contacts.

RESULTS

From March 15th until Mai 31st 2011 761 patient records, representing 2268 patient days were screened for triggers. Median age (IQR) in years was 3.5 (1.2-11.0) for all patients and 2.5 (1.0-8.0) for the trigger positive patients. Male to female ratio was 352:409 and 113:129 for all patients and the trigger positive patients, respectively.

We identified 48 incidents of harm, representing 21 harm events per 1000 patient days and 6 harm events per 100 consultations. The distribution of the 48 patients with identified harm according to status as admitted or outpatient, as well as their distribution across specialties are presented in Table 2. 60.4% of the harm events were in the pediatric (medical) patients, whereas 22.9% occurred in ENT-patients, 10.4% in orthopedic and 6.3% in general surgical patients.

Harm was detected in 5% of all pediatric contacts with a slightly higher rate of 7% in pediatric admissions. The incidence of harm in all contacts including surgical and ENT patients and in admissions only regardless of specialty was similar, 6.3% and 8.3%, respectively.

All, but two identified harm events were categorized as harm category F, 'Temporary harm to the patient and required initial or prolonged hospitalization'. Examples of harm were postoperative pericarditis, ileus after gastrostomy, candida stomatitis after treatment with antibiotics, infection in percutaneous endoscopic gastrostomy, bleeding following placement of nasogastric feeding tube (harm category E) and nosocomial infection (gastroenteritis, pneumonia) for the pediatric patients. In orthopedic patients osteomyelitis after pinning of Bennett's fracture was found and in general surgical patients hematoma after hernia operation (outpatient: harm category E) was found. In the ENT patients bleeding, infection and/or dehydration following adenotonsillectomy were recurring harms.

Voluntary incidence reports

About two thirds of the incidents reported were minor incidents like delay in medication administration not leading to patient harm.

Patient harm as defined by the PTT user guide was found in 51/160 (30.9%) of the incidence reports 2010-2012. 37 harm events were classified as harm category E, 8 category F, 3 category G, 1 category H and 2 category I. This equals 51/5854 (total number of patients admitted acutely with medical diagnoses 2010-2012) = 0.9%. Only three of these incidents were reported in the PTT study months giving a voluntary reported harm rate of 3/584 (number of pediatric patients in the PTT screening) = 0.5% in March-May 2011.

Patient harm reported through the incidence reporting system included unexpected patient death; fall injury; pain and swelling from subcutaneous peripheral venous catheter; complications to procedure; anaphylactic drug reactions; and prolonged hospitalization due to errors in medication and fluid administration.

Triggers

We identified one or more out of 20 of the 39 NHS triggers in 242 (31.8%) of all patient contacts. In 71.5% of the trigger positive contacts only one trigger was found. The highest number of triggers found in a patient contact was 4. The mean rate of triggers per patient was 1.4.

The most frequently found trigger was readmission within 30 days. Common reasons for unplanned readmission were surgical site infection, recurrent (respiratory tract) infections, postoperative bleeding and seizures. We found the second most common trigger in our screening to be hypoxia, but no patient harm was associated with this specific trigger.

Of the 242 trigger positive contacts, 177 (73.1%) were admissions and 65 (26.9%) acute outpatient visits. Table 2 shows how trigger positive admissions and outpatient contacts were distributed across specialties.

The PPV of one or more triggers for identifying harm was 19.8%. When calculations were made for admissions (n= 761) and outpatient care (n= 242) separately, PPV was 23.2% and 10.8%, respectively (p=0.03). When we looked at the PPV of individual triggers, PPV varied from zero in the case of hypoxia, thrombocytopenia and

electrolyte abnormalities to 100% in the case of surgical site infection and nosocomial pneumonia (Table 3).

Table 4 shows rate of trigger positive contacts, rate of harm and PPV of triggers across specialties.

DISCUSSION

This is the first report about use of a PTT in a European unit. Despite the fact that only half of the NHS pediatric triggers were found in the patient records screened in this study, we identified a ten times higher harm rate using the PTT than what was reported in the department's voluntary incidence reports in the same period. Patient harm identified through incidence report analysis and PTT screening was different in number and character in our unit.

Our pediatric centre is the largest acute pediatric unit in Norway, but we do not have a PICU in our hospital. Therefore, we do not treat the most severely ill children, and we only rarely use potent anesthesia medications. This may be one of the reasons why half of the NHS triggers were not found in our review, reflecting that some diagnoses and interventions with a high incidence of complications are not present in the children and adolescents in our unit.

In the recently published Canadian Pediatric Adverse Events Study, the incidence, type and severity of harm among children admitted to academic pediatric centers were compared with those admitted to community hospitals in Canada.[8] In that study, significantly more patient records from academic pediatric centers (38.8%) than from community hospitals (21.6%) were trigger-positive.[8] We found triggers in 31.8% of our patients. The overall rate of harm in the Canadian study was 9.2% with significantly more harm in academic pediatric centers (11.2%) than in community hospitals (3.3%). We found a total rate of harm in admitted children of 8.3%. These results might reflect that, although being an academic teaching unit, our center probably has a patient population with disease severity and complexity somewhere in between the two compared unit levels in the Canadian study.

Kirkendall et al.[7] found 37 harm events per 100 patients and 76 harm events per 1000 patient-days, a significantly higher rate than in our patients. One of the reasons for this may be that the study was conducted in a large US tertiary centre where

32.5% of the patients went to the operating room during their hospital stay and 13.3% were admitted to an ICU during part of or whole stay.

We found a PPV of one or more triggers of 19.8% when both acute outpatient contacts and admissions were included and a higher PPV when only admissions were analyzed. Lemon and Stockwell found a PPV of 34%.[6] One of the possible reasons for this difference is that Lemon and Stockwell only screened for 11 triggers while we identified 20 different triggers, of which some had an individual PPV of zero. Another important difference is that Lemon and Stockwell reported results from a 4four-year period whereas we only screened for a three-month period, which limits generalizability.

Like Kirkendall et al.,[7] we found that some modules, in particular the laboratory module, contained adult-oriented triggers like high INR and diagnostic imaging for embolus that were not identified in our chart review. Removal of unnecessary triggers would reduce the overall number of triggers that reviewers must consider. Hypoxia, electrolyte abnormalities and thrombocytopenia had a PPV of zero and may not be worthwhile screening for in our patient population. However, bearing in mind the short study period of 3 months, further studies, ideally multicenter studies are needed before abolishment of some triggers.

To our knowledge, we are the first group to report the use of a PTT for unplanned outpatient visits. Some trigger tools exist for outpatient care,[11,12,~~13~~] however they are not suitable for children and adolescents. As harm was detected in 7/267 (2.6%) of acute outpatient visits, we believe that identification of these events is important in a unit like ours where the number of acute outpatient visits is substantial.

Regardless, there seems to be a higher PPV of triggers in surgical patients, but the rate of harm was comparable across medical and surgical patients (5-6%), excluding ENT patients with a 35% total harm rate.

Needless to say, the extent to which trigger tools detect harm as intended depends to a large extent on routines for documentation. Like Kirkendall et al.,[7] we noticed that frequently occurring complications like complications to peripheral venous catheters, e.g. phlebitis, subcutaneous edema, tissue necrosis and infection, are infrequently documented in the records of the patients in our unit. The same applies to the

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The presence of adult-oriented triggers, triggers that were not identified at all, as well as triggers with a low predictive value for harm, indicate a need for modification of trigger tools to the setting in which they are intended to be used. The NHS PTT, with certain modifications can, as a supplement to voluntary incidence reporting, be used to calculate the rate of harm and identify areas of care where most harm events are occurring. Hence, it may inform priorities for action and track improvements over time.

ACKNOWLEDGEMENT

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CONTRIBUTOR STATEMENT

ALS was the lead author for this paper and involved in all stages including design of the research, acquisition of data, analysis and interpretation of the data and statistical analysis. BN contributed to the drafting of the manuscript, critical revision of the manuscript and supervision.

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Table 1 The Paediatric Trigger Tool (PTT) items as depicted in the NHS PTT User Guide[4]

	Item
General care	PG1 Early warning score
	PG2 Tissue damage or pressure ulcer
	PG3 Readmission within 30 days
	PG4 Unplanned admission
	PG5 Abnormal cranial imaging
	PG6 Respiratory or cardiac arrest / crash calls
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation
	PG8 Complication of procedure or treatment
	PG9 Transfer to higher level of care
	PG10 Hypoxia O2 sat <85%
	PG11 Cancelled elective procedure / delayed discharge
Surgical care	PS1 Return to theatre
	PS2 Change in planned procedure
	PS3 Surgical site infection or hospital acquired urinary tract infection
	PS4 Removal/injury/repair of organ
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care
Medication	PM1 Vitamin K (except for routine dose in neonates)
	PM2 Naloxone
	PM3 Flumazenil (Romazicon)
	PM4 Glucagon or glucose ≥ 10%
	PM5 Chlorphenamine or antihistamine
	PM6 Anti-emetics
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given
	PM8 Abrupt medication stop
Lab test	PL15 Thrombocytopenia (platelets <100)
	PL1 High INR >5 or aPTT >100
	PL2 Transfusion
	PL3 Abrupt drop in Hb or Hct (>25%)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)
	PL7 Hypoglycemia (<3mmol/l)
	PL8 Hyperglycemia (>12mmol/l)
	PL9 Drug level out of range
Microbiology	PL10 MRSA bacteraemia
	PL11 C. difficile
	PL12 Vanc resistant enterococcus (VRE)
	PL13 Nosocomial pneumonia
	PL14 Positive blood culture
Other	PO1 Other event

Table 2 Distribution of trigger positive admissions and outpatient contacts across specialties

	Pediatric		**Ortopedic**		**General surgical**		**Ear, nose and throat**	
	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient	Admitted	Outpatient
Total n (%)	356 (47)	228 (30)	70 (9)	13 (2)	41 (5)	22 (3)	27 (3.5)	4 (0.5)
Trigger positive n (%)	148 (61)	59 (24.5)	8 (3.5)	3 (1)	10 (4)	2 (1)	11 (4.5)	1 (0.5)
Harm n	26	3	3	2	1	2	11	0

Table 3 The triggers we identified in our study are presented with positive predictive value (PPV) with 95% confidence interval (CI) for identifying harm. The numerator represents number of harm events and the denominator how many times each individual trigger was found in all patient contacts (n=761)

	Item	PPV (CI)%
General care	PG1 Early warning score	
	PG2 Tissue damage or pressure ulcer	
	PG3 Readmission within 30 days	24/175=14 (9-20)
	PG4 Unplanned admission	
	PG5 Abnormal cranial imaging	
	PG6 Respiratory or cardiac arrest / crash calls	0/1=0 (0-95)
	PG7 Diagnostic imaging for embolus / thrombus +/- confirmation	1/2=50 (3-97)
	PG8 Complication of procedure or treatment	17/23=74 (51-89)
	PG9 Transfer to higher level of care	3/22=14 (4-36)
	PG10 Hypoxia O2 sat <85%	0/25=0 (0-17)
	PG11 Cancelled elective procedure / delayed discharge	1/1=100 (5-100)
Surgical care	PS1 Return to theatre	1/1=100 (5-100)
	PS2 Change in planned procedure	
	PS3 Surgical site infection or hospital acquired urinary tract infection	6/6=100 (52-100)
	PS4 Removal/injury/repair of organ	
Intensive care	IP1 Readmission to Intensive Care or High Dependency Care	
Medication	PM1 Vitamin K (except for routine dose in neonates)	
	PM2 Naloxone	
	PM3 Flumazenil (Romazicon)	
	PM4 Glucagon or glucose ≥ 10%	
	PM5 Chlorphenamine or antihistamine	0/1=0 (0-95)
	PM6 Anti-emetics	
	PM7 IV Bolus ≥ 10ml/kg colloid or crystalloid given	3/19=16 (4-40)
	PM8 Abrupt medication stop	
Lab test	PL15 Thrombocytopenia (platelets <100)	0/7=0 (0-44)
	PL1 High INR >5 or aPTT >100	
	PL2 Transfusion	2/8=25 (4-64)
	PL3 Abrupt drop in Hb or Hct (>25%)	2/8=25 (4-64)
Biochemistry	PL4 Rising urea or creatinine (>2x baseline)	0/1=0 (0-95)
	PL5/PL6 Electrolyte abnormalities (Na+ <130 or >150, K+ <3.0 or >6.0)	0/12=0 (0-30)
	PL7 Hypoglycemia (<3mmol/l)	3/8=38 (10-74)

	PL8 Hyperglycemia (>12mmol/l)	0/1=0 (0-95)
	PL9 Drug level out of range	
Microbiology	PL10 MRSA bacteraemia	
	PL11 C. difficile	
	PL12 Vanc resistant enterococcus (VRE)	
	PL13 Nosocomial pneumonia	2/2=100 (20-100)
	PL14 Positive blood culture	1/1=100 (5-100)
Other	PO1 Other event	

Table 4 Rate of trigger positive contacts, rate of harm and positive predictive value (PPV) of positive triggers across specialties

Specialty	Rate of trigger positive contacts	Rate of harm	PPV
Pediatric	207/584 (35.4%)	29/584 (5.0%)	14%
Orthopedic surgery	11/83 (13.3%)	5/83 (6.0%)	45.5%
General surgery	12/63 (19.0%)	3/63 (4.8%)	25%
Ear, Nose and Throat	12/31 (38.7%)	11/31 (35.5%)	91.7%
Total	242/761 (31.8%)	48/761 (6.3%)	19.8%