Applying the Global Trigger Tool in German Hospitals: A Pilot in Surgery and Neurosurgery

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Objective: The aim of the study was to assess the feasibility and potential of the Global Trigger Tool (GTT) for identifying adverse events (AEs) in different specialties in German hospitals.

Methods: A total of 120 patient records were randomly selected from two surgical and one neurosurgery departments of three university hospitals in Germany for a period of 2 months per department between January and July 2017. The records were reviewed using an adaptation of the German version of the Institute for Healthcare Improvement GTT.

Results: Thirty-nine records (32.5%) contained at least one AE. A total of 53 AEs were found in these 39 records. The incidences of AEs were 18.9% and 35.9% in the two surgical departments and 45.3% in neurosurgery. This corresponded to AE rates of 25.5 to 72.1 per 1000 patient-days and from 25.0 to 60.0 per 100 admissions across the three departments. A total of 71.7% of all identified AEs resulted in temporary harm (category E), 26.4% in temporary harm, requiring prolonged hospitalization (category F), and 1.9% in permanent patient harm. We also identified practical challenges, such as the necessary adaptation of the GTT relative to the respective department.

Conclusions: The application of the GTT is feasible and represents an effective instrument for quality measurement when adapted to the departmental specifics. The trigger detection with the GTT is a valuable addition for proactive analyses of high-risk processes.

Key Words: patient safety, adverse events, Global Trigger Tool, medical record, record review, risk management, patient harm

(*J Patient Saf* 2020;16: e340–e351)

The identification of treatment-related critical incidents is an essential component of patient safety research and improvement.[1] By systematically recording such incidents, indications of critical processes in the system of care may be identified and thus form a starting point for in-depth analyses and targeted interventions for safer patient care.

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The authors disclose no conflict of interest.

The study was funded by BONFOR-Research Funding Programme of the Faculty of Medicine of the University of Bonn.

To date, a spectrum of methodological approaches has been used to measure and characterize patient safety incidents, including systems for critical incident reporting and analysis, observational and ethnographic studies, patient-experience surveys, routine collection of safety metrics, and automated data extraction from electronic patient records.[2–4] Most of these methods are regarded by clinicians as external quality assurance and thus disconnected from local practice because of a lack of clinician involvement. This perception may create obstacles to the acceptance of the reported findings and to the implementation of recommendations in clinical practice.[5] One way to overcome this issue is to use instruments that involve clinicians directly in the measurement of indicators of the quality and safety of care, thus increasing clinicians' participation and encouraging local learning processes.

One such method, currently regarded as one of the most reliable and recognized methods of quality and safety assessment in hospitals, is the systematic analysis of patient records.[6] One specific tool receiving increasing attention is the Global Trigger Tool (GTT) developed by the Institute for Healthcare Improvement (IHI).[7] The GTT supports clinicians in the identification of adverse events (AEs) by systematically reviewing randomly selected patient records. The GTT has already been used in various countries[2,8–12] (e.g., as a standard measure in all hospitals in Sweden[13] and Norway[14]). Although the GTT has also been adapted and translated for the German healthcare context,[15] its implementation in German hospitals has been very limited and so far no published evidence based on GTT studies is available. Therefore, this study aims to explore the potential of applying the GTT in different specialties in Germany and to understand more about the practical challenges.

METHODS

Study Design and Setting

We conducted a retrospective cross-sectional study in three different departments of three German university hospitals using retrospective patient record review using the German version of the GTT.[15] General surgery was selected because this specialty has so far produced the most published data.[8,16–19] Neurosurgery (NS) was included as a high-risk surgical specialty for which only a single report of GTT use was available at the time of this study.[20] Thus, two departments of general surgery (GS1 and GS2) with 72 and 91 beds and a 44-bed department of NS participated in this study.

The ethics committee of the Faculty of Medicine, University of Bonn, approved the study (Ldf. Nr. 310/14). The local ethics committees of participating hospitals accepted the ethical approval from Bonn. As required by the German professional code of conduct for physicians (§15 of the professional code), the ethic committees ensured that all participating physicians were aware of the ethical and professional issues associated with the project. All data were collected and analyzed retrospectively from January to July 2017.

Global Trigger Tool

The basis for the GTT is to review medical records from randomly selected patients to detect AEs and patient harm by searching for warning signals, so called triggers.[7] A trigger may indicate that an AE has occurred. For example, the trigger G4 (*Positive blood culture*) may indicate a hospital-associated infection. The original IHI version of the GTT includes 53 triggers grouped into the following six modules: two general modules concerning care and medication process and four specific modules for different departments (i.e., surgery, intensive care unit, perinatal unit, emergency department). In this study, we used a version of the GTT that was adapted for use in German hospital settings.[15,21] The German GTT version includes 56 triggers. Specifically, we applied the two general modules concerning care and medication process and the specific module for surgery. For NS, we also used selected triggers from the National Institute for Health and Welfare of Finland concerning specific neurosurgical issues.[20]

Patient Record Review

At each participating department, a local study coordinator was appointed to manage the entire process of patient record review in cooperation with the project lead and the local physicians. All modifications of the trigger lists were made by a multiprofessional expert panel who discussed each trigger, checking whether it was easy to understand and applicable in the respective department. If not, the panel discussed and made linguistic and content-related adjustments to the triggers or proposed new triggers. The adapted tool was then tested on patient records of the respective department by the local study coordinator before finalizing the tool.

Sampling of Patient Records

The local study coordinators selected random samples of ten patient records, which were collected retrospectively every 2 weeks for a period of 2 months. This resulted in 40 patient records from each department and a total of 120 records for the study. In addition, six more records were selected per month in each department as replacements in case of incomplete patient records (12 replacement patient records in each department). The selection of all records was based on the recommended IHI criteria: patients 18 years or older; 24 hours or more in hospital, and, by the time of the review, discharged 30 days or more.[7]

Review Team

In accordance with the IHI recommendations, all review teams consisted of two primary reviewers and one secondary reviewer.[7] The local study coordinator was responsible for recruiting reviewers. Requirements for the primary reviewer were clinical background, detailed knowledge of the local patient records, and local treatment paths. The secondary reviewer was a physician

from the respective department. Details of reviewer team members are shown in Table 1.

Reviewer Training

Before reviewing patient records, each team attended a 1-day training on the GTT and review techniques. The aims of the training were to familiarize reviewers with the triggers and to ensure consistent rating practice within teams and across departments. During the training, participants practiced using three to five records from the respective department.

Review Process

The review process was performed in two stages. At stage 1, all patient records of the random sample were reviewed independently by the primary reviewers. They screened the records for triggers and possible AEs associated with those triggers. Following the IHI recommendations,[7] each record was reviewed for a maximum of 20 minutes. Reviewers then held consensus discussions on the presence of triggers and AEs. To check the reliability, a total of 15 of the 40 records were reviewed by both primary and secondary reviewers.

In stage 2, the secondary reviewer screened the records together with the primary reviewers, and in cases of disagreement, consensus discussions occurred to confirm or reject triggers and AEs. If an AE was identified, the secondary reviewer also categorized it into five groups (E–I) regarding their severity based on the National Coordination Council for Medication Error Reporting and Prevention Index[22] (Box 1).

Box 1: Categories of harm severity based on the National Coordination Council for Medication Error Reporting and Prevention Index[22]

Category E: Temporary harm to the patient and required intervention

Category F: Temporary harm to the patient and required initial or prolonged hospitalization

Category G: Permanent patient harm

Category H: Intervention required to sustain life

Category I: Patient death

Statistical Analysis

Descriptive statistics were used to describe sample characteristics, AE rates per 1000 patient-days, AE rates per 100 admissions, percentage of admissions with AEs, and severity of AEs. An interrater reliability (IRR) analysis using the Cohen's κ statistics

TABLE 1. AE Rates for All Departments

Department	GS1	GS2	NS
AE rate (per 1000 patient-days/per 100 admissions)	25.5/25.0	36.3/47.5	72.1/60.0
Incidence of AEs	10	19	24
Length of hospital stay, mean (95% CI)	9.8 (6.4–13.2)	13.1 (8.4–17.7)	8.3 (6.6–10.1)
Reviewer, primary/secondary	Two medical doctoral students/One surgeon	Two surgeons/One surgeon	One anesthetist, one nurse/One neurosurgeon

GS1, first department of general surgery; GS2, second department of general surgery; NS, Department of Neurosurgery.

test was performed to determine consistency of the detection of a trigger by the primary reviewers in each department. Cut-offs for κ statistics were determined as follows: poor (<0.00), slight (0.00–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and excellent (0.81–1.00).[23] All data analyses were performed using the SPSS V. 24 for Windows.

RESULTS

Adaptation of the Tool

We used the German GTT translation adapted to the respective specialty area. Individual triggers were adapted in terms of linguistics and/or content and new triggers were added. No triggers were removed. During the development of new triggers, selected

triggers of the National Institute for Health and Welfare of Finland[20] were also used for the module in NS. Table 2 summarizes all adaptations per department. All 31 triggers from care and medication modules were identical for all departments; 20 of these were used without any adaptation. 17 triggers from the surgery module were also used in all departments. In NS, we added 11 triggers. Altogether, 48 triggers were used in two surgical departments and 59 triggers in NS. For the sake of simplicity, only the original English triggers are used in the main text, whereas details on the adapted and actually used triggers are provided in Table 3.

Sampling of Patient Records

A total of 120 patient records were reviewed (40 records per department). The mean length of hospital stay across departments was 10.4 (95% confidence interval [CI] = 8.3–12.4) days.

TABLE 2. Number and Adaptations of Triggers Used

Module		GS1, n (%)	GS2, n (%)	NS, n (%)
Care	Total of triggers used in the module	17	17	17
	Original triggers*	11 (64.7%)	11 (64.7%)	11 (64.7%)
	Content adaptation*	3 (17.6%)	3 (17.6%)	3 (17.6%)
	Content change*	1 (5.9%)	1 (5.9%)	1 (5.9%)
	Linguistic change*	—	—	—
	Newly developed	2 (11.8%)	2 (11.8%)	2 (11.8%)
Medication	Total of triggers used in the module	14	14	14
	Original triggers*	9 (64.3%)	9 (64.3%)	9 (64.3%)
	Content adaptation*	—	—	—
	Content change*	3 (21.4%)	3 (21.4%)	3 (21.4%)
	Linguistic change*	—	—	—
	Newly developed	2 (14.3%)	2 (14.3%)	2 (14.3%)
Surgery	Total of triggers used in the module	17	17	17
	Original triggers*	11 (64.7%)	11 (64.7%)	3 (17.6%)
	Content adaptation*	1 (5.9%)	1 (5.9%)	1 (5.9%)
	Content change*	3 (17.6%)	3 (17.6%)	11 (64.7%)
	Linguistic change*	1 (5.9%)	1 (5.9%)	1 (5.9%)
	Newly developed	1 (5.9%)	1 (5.9%)	1 (5.9%)
NS	Total of triggers used in the module	NA	NA	11
	Original trigger	NA	NA	NA*
	Content adaptation	NA	NA	NA*
	Content change	NA	NA	NA*
	Linguistic change	NA	NA	NA*
	Newly developed/taken from National Institute for Health and Welfare of Finland[20] instrument (total)	NA	NA	5/6 (11) (100.0%)
Entire tool	Total	48	48	59
	Original triggers*	31 (64.6%)	31 (64.6%)	23 (39.0%)
	Content adaptation*	4 (8.3%)	4 (8.3%)	4 (6.8%)
	Content change*	7 (14.6%)	7 (14.6%)	15 (25.4%)
	Linguistic change*	1 (2.1%)	1 (2.1%)	1 (1.7%)
	Newly developed/taken from National Institute for Health and Welfare of Finland[20] instrument (total)	5 (10.4%)	5 (10.4%)	10/6 (16) (27.1%)

Percentages within the modules refer to total of triggers used in the module in each department. In NS, interventions were included in all operation-related triggers.

*Refers to the German translation of the GTT.

GS1, first department of general surgery; GS2, second department of general surgery; NA, not applicable; NA*, not applicable, trigger taken from the National Institute for Health and Welfare instrument[20]; NS, Department of Neurosurgery.

TABLE 3. Actually Used Triggers and Their Association With an AE

Module	Trigger	Description	GS1		GS2		NS	
			No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†	No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†	No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†
Care	G1	Transfusion or use of blood products‡ [Bluttransfusion oder Transfusion von Blutprodukten]	7 (6.0%)	1	5 (7.0%)	7	4 (2.0%)	1
	G2	Code/arrest/rapid response team‡ [Ruf des Herzalarm–Teams, Reanimation oder Herz- und Atemstillstand und starke Verschlechterung des Patienten]	—	—	—	—	—	—
	G3	Acute dialysis‡ [Akute Dialyse]	—	—	1 (1.4%)	2	—	—
	G4	Positive blood culture‡ [Abnahme von Blutkulturen]	2 (1.7%)	2	5 (7.0%)	6	2 (1.0%)	—
	G5	X-ray or Doppler studies for emboli or DVT‡ [CT- oder Ultraschalluntersuchungen bzgl. Embolie oder Phlebothrombose]	—	—	—	—	—	—
	G6	Decrease of greater than 25% in hemoglobin or hematocrit‡ [Plötzliches Fallen des Hb oder Hkt ≥ 25%]	10 (8.6%)	9	3 (4.2%)	5	7 (3.5%)	3
	G7	Patient fall‡ [Sturz des Patienten]	—	—	1 (1.4%)	1	3 (1.5%)	3
	G8	Pressure ulcers‡ [Dekubitus]	1 (0.9%)	—	—	—	1 (0.5%)	2
	G9	Readmission within 30 days‡ [Wiederaufnahme innerhalb von 30 Tagen]	10 (8.6%)	2	2 (2.8%)	1	4 (2.0%)	3
	G10	Restraint use‡ [Fixierung des Patienten]	—	—	—	—	1 (0.5%)	1
	G11	Healthcare-associated infection‡ [Im Krankenhaus erworbene Infektionen]	4 (3.5%)	6	4 (5.6%)	6	1 (0.5%)	—
	G12	In-hospital stroke‡ [Schlaganfall im Krankenhaus]	—	—	—	—	—	—
	G13	Transfer to higher level of care‡ [Verlegung auf ein höheres Pflege- oder Behandlungsniveau]	1 (0.9%)	2	1 (1.4%)	3	—	—
	G14	Any procedure complication‡ [Komplikationen]	3 (2.6%)	2	1 (1.4%)	3	2 (1.0%)	1
	G15	Other‡ [Sonstiges]	9 (7.8%)	7	2 (2.8%)	3	3 (1.5%)	4

TABLE 3. (Continued)

Module	Trigger	Description	GS1		GS2		NS	
			No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†	No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†	No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†
	G16	Sudden interruption of blood transfusion or transfusion of blood products§ [Plötzlicher Stopp der Bluttransfusion oder Transfusion von Blutprodukten]	—	—	—	—	—	—
	G17	Hospital-acquired colonization with multiresistant germs§ [Im Krankenhaus erworbene Besiedlung mit multiresistenten Keimen]	—	—	—	—	—	—
Medication	M1	Clostridium difficile positive stool‡ [Clostridium difficile in der Stuhlprobe]	—	—	—	—	—	—
	M2	Partial thromboplastin time greater than 100 second‡ [PTT > 100 Sekunden]	2 (1.7%)	1	1 (1.4%)	2	—	—
	M3	INR greater than 6‡ [INR (int. norm. ratio) > 4]	—	—	1 (1.4%)	2	—	—
	M4	Glucose less than 50 mg/dL‡ [Interventionsbedürftige Hypoglykämie]	—	—	—	—	—	—
	M5	Rising BUN or serum creatinine greater than 2 times baseline‡ [Erhöhung des Kreatinins um mehr als 0,3 oder Anstieg des Harnstoffs, 2fach über Normalwert]	6 (5.2%)	4	6 (8.5%)	9	2 (1.0%)	4
	M6	Vitamin K administration‡ [Gabe von Vitamin K (Konaktion)]	2 (1.7%)	1	2 (2.8%)	5	2 (1.0%)	2
	M7	Benadryl (Diphenhydramine) use‡ [Kurzzeitige Gabe von Antihistaminika/Kortikoide]	2 (1.7%)	2	—	—	19 (9.5%)	11
	M8	Romazicon (Flumazenil) use‡ [Gabe von Flumazenil (Anexate)]	1 (0.9%)	1	—	—	1 (0.5%)	1
	M9	Naloxone (Narcan) use‡ [Gabe von Naloxon]	1 (0.9%)	1	—	—	—	—
	M10	Antiemetic use‡ [Gabe von Antiemetika]	4 (3.5%)	2	6 (8.5%)	9	20 (10.0%)	15
	M11	Oversedation/hypotension‡ [Hypotonie/Übersedierung]	—	—	—	—	1 (0.5%)	—
	M12	Abrupt medication stop‡ [Plötzlicher Stopp der Medikation]	—	—	—	—	2 (1.0%)	1
	M13	Hyperglycemia requiring intervention§ [Interventionsbedürftige Hyperglykämie]	1 (0.9%)	1	—	—	7 (3.5%)	9
	M14	Relevant increase of leukocytes or other serological infection values during the hospital stay§ [Größerer Anstieg von Leukozyten oder anderen serologischen Infekt-Werten während des Aufenthalts]	15 (13.0%)	6	9 (12.7%)	13	7 (3.5%)	9

Surgery							
K1	Return to surgery[‡] [Erneute Operation]	1 (0.9%)	2	1 (1.4%)	3	2 (1.0%)	—
K2	Change in procedure[‡] [Änderung des Eingriffes]	3 (2.6%)	2	3 (4.2%)	2	1 (0.5%)	—
K3	Admission to intensive care postop[‡] [Verlegung auf die Intensivstation nach der Operation]	1 (0.9%)	2	1 (1.4%)	3	—	—
K4	Intubation/reintubation/BiPap in PACU[‡] [Intubation/Reintubation/CPAP im Aufwachraum]	—	—	1 (1.4%)	3	—	—
K5	X-ray intraop or in PACU[‡] [Röntgenuntersuchung während der Operation oder im Aufwachraum]	—	—	1 (1.4%)	1	19 (9.5%)	11
K6	Intraop or postop death[‡] [Tod während oder direkt nach der Operation (innerhalb von 24 h)]	—	—	—	—	—	—
K7	Mechanical ventilation greater than 24 hours postop[‡] [Postoperative Beatmung >24 Stunden]	—	—	—	—	1 (0.5%)	—
K8	Intraop epinephrine, norepinephrine, naloxone, or romazicon[‡] [Intraoperative Gabe von einen der folgenden Medikamente: Epinephrin, Norepinephrin]	22 (19.0%)	9	1 (1.4%)	2	29 (14.4%)	21
K9	Postop troponin level greater than 1.5 ng/mL[‡] [Postoperativer Anstieg des Troponins (Troponin T/Troponin I) Niveaus über Normwert]	—	—	2 (2.8%)	4	2 (1.0%)	2
K10	Change in the type of anesthesia during surgery[‡] [Änderung der Form der Anästhesie während der Operation]	—	—	—	—	—	—
K11	Consultation of another specialist in the recovery room[‡] [Hinzuziehen eines anderen Spezialisten im Aufwachraum]	—	—	—	—	1 (0.5%)	4
K12	Pathological samples are not related to preoperative diagnosis[‡] ["Falsche" pathologische Befunde, die nicht in Verbindung zur prä-operativen Diagnose stehen]	—	—	—	—	—	—
K13	Establishing an arterial catheter or CVC during the operation[‡] [Anlegen eines Arterienkatheters oder eines ZVK während der Operation]	—	—	—	—	—	—
K14	Operating time significantly longer than expected[‡] [Operationszeit signifikant länger als geplant]	1 (0.9%)	1	1 (1.4%)	—	1 (0.5%)	1
K15	Injury, repair, or removal of organ[‡] [Entfernung, Schaden oder Reparatur von Schäden an Organen während der Operation]	—	—	—	—	3 (1.5%)	7
K16	Any operative complication[‡] [Postoperative Komplikationen]	4 (3.5%)	3	6 (8.5%)	9	4 (2.0%)	6

TABLE 3. *(Continued)*

Module	Trigger	Description	GS1		GS2		NS	
			No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†	No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†	No. Patient Records With Detected Trigger, n (%)*	No. AE Found in the Same Patient Records, n†
	K17	CT after surgery with suspected fluid accumulation§ [CT nach Operation mit Verdacht auf Flüssigkeitsansammlung]	3 (2.6%)	3	4 (5.6%)	6	—	—
NS	T1	Deterioration of neurological condition (e.g., decrease of 3 or more points on GCS)‖ [Postoperative Verschlechterung des neurologischen Zustandes (z.B. Abnahme von 2 oder mehr Punkten auf dem GCS)]	NA	NA	NA	NA	4 (2.0%)	6
	T2	X-ray imaging of any kind and not routine for the procedure postoperatively in ICU or normal ward‖ [Bildgebende Diagnostik jeglicher Art und keine postoperativen Routineverfahren auf der Intensivstation oder der Normalstation]	NA	NA	NA	NA	19 (9.5%)	17
	T3	Wound problem (e.g., CSF leak, poor wound edge adhesion)‖ [Postoperative Wundprobleme (z.B. Liquorleck, schlechte Wundrandhaftung)]	NA	NA	NA	NA	2 (1.0%)	1
	T4	CSF circulation disturbances (e.g., hydrocephalus)‖ [Postoperative Störung der Zirkulation des Liquors (z.B. Hydrocephalus)]	NA	NA	NA	NA	—	—
	T5	Prolonged ICU treatment due to other than primary cause (e.g., infection, ventilator treatment)‖ [Längere postoperative Behandlung auf der Intensivstation aufgrund einer anderen Ursache, als die primäre Ursache (z.B. Infektionen, Behandlung mittels Atemgerät)]	NA	NA	NA	NA	4 (2.0%)	4
	T6	Electrolyte balance disturbances needing treatment‖ [Postoperative Störung des Elektrolythaushaltes mit erforderlicher Behandlung]	NA	NA	NA	NA	6 (3.0%)	1
	T7	Postoperative neuropsychric symptoms§ [Postoperative neuropsychiatrische Symptome]	NA	NA	NA	NA	7 (3.5%)	5
	T8	Unforeseen, perioperative administration of antiplatelet agents§ [Unvorhergesehene, perioperative Gabe von Thrombozytenaggregationshemmer]	NA	NA	NA	NA	—	—
	T9	Postoperative electrophysiological examination§ [Postoperative elektrophysiologische Untersuchung]	NA	NA	NA	NA	—	—

T10	Administration of anticonvulsants§ [Gabe von Antikonvulsiva]	NA	NA	NA	1 (0.5%)	—
T11	Administration of coagulants§ [Gabe von Gerinnungsprodukten]	NA	NA	NA	5 (2.5%)	4

In NS, interventions on all operation-related triggers were included.
*Refers to all the triggers found in this department (details of the total number of triggers found per department can be seen in Table 4).
†The trigger occurred during an AE but does not necessarily lead directly to the AE.
‡Original GTT trigger.
§New developed item.
‖Trigger of the National Institute for Health and Welfare.[20]
—, trigger was not found; BUN, blood urea nitrogen; CPAP, continuous positive airway pressure; CSF, cerebrospinal fluid; CT, computer tomography [Computertomographie]; CVC, centra venous catheter; DVT, deep vein thrombosis; GCS, Glasgow Coma Scale; GS1, first department of general surgery; GS2, second department of general surgery; ICU, intensive care unit; INR, international normalized ratio; NA, triggers that were not used in the GTT for the respective department; NS, Department of Neurosurgery; PACU, Post Anesthesia Care Unit.

Interrater Reliability

The IRR on the presence of triggers between primary reviewers was substantial in GS1 ($\kappa = 0.7$, 95% CI = 0.7–0.8) and NS ($\kappa = 0.7$, 95% CI = 0.6–0.7). In GS2, only the consensus of the primary reviewers on the presence of triggers was documented and thus, IRR could not be calculated.

Triggers

Overall, 388 triggers were identified (Table 4). The most frequently detected trigger across all departments was trigger K8 (*Intraop epinephrine, norepinephrine, naloxone, or romazicon*, n = 52). The most frequent trigger in GS1 and NS was trigger K8 (*Intraop epinephrine, norepinephrine, naloxone, or romazicon*, n = 22, n = 29), whereas in GS2 trigger M14 (*Relevant increase of leukocytes or other serological infection values during the hospital stay*, n = 9) was most frequent. Figure 1 shows the three most frequently detected triggers for each department.

The total number of triggers detected in patient records with AEs for all departments was 24 different triggers for GS1, 25 different triggers for GS2, and 30 different triggers for NS (Table 3). The trigger most frequently connected to the identification of an AE across all departments was trigger K8 (*Intraop epinephrine, norepinephrine, naloxone, or romazicon*, n = 32). Figure 2 shows the three most frequently detected triggers occurring in the records with an AE. It should be noted that these triggers did not necessarily lead to AEs.

In GS1, trigger G6 (*Decrease of greater than 25% in hemoglobin or hematocrit*, n = 9) and trigger K8 (*Intraop epinephrine, norepinephrine, naloxone, or romazicon*, n = 9), and in GS2, trigger M14 (*Relevant increase of leukocytes or other serological infection values during the hospital stay*, n = 13) was most frequently identified in records with an AE. In NS trigger, K8 (*Intraop epinephrine, norepinephrine, naloxone, or romazicon*, n = 21) most commonly led to identification of an AE (Figure 2).

Eleven triggers were never identified in any of the three departments: Care triggers G2 (*Code/arrest/rapid response team*), G5 (*X-ray or Doppler studies for emboli or DVT*), G12 (*In-hospital stroke*), G16 (*Sudden interruption of blood transfusion or transfusion of blood products*), G17 (*Hospital-acquired colonization with multiresistant germs*), medication triggers M1 (*Clostridium difficile positive stool*), M4 (*Glucose less than 50 mg/dL*), surgical triggers K6 (*Intraop or postop death*), K10 (*Change in the type of anesthesia during surgery*), K12 (*Pathological samples are not related to preoperative diagnosis*), and K13 (*Establishing an arterial catheter or CVC during the operation*) (Table 3).

Adverse Events

During the chart review period, 53 different AEs were identified in 39 (32.5%) of the 120 records. The percentage of admissions with at least one AE was 20.0% (8/40) for GS1, 35.0% (14/40) for GS2, and 42.5% (17/40) for NS. Table 1 shows the AE rate per 1000 patient-days and per 100 admissions for each department. The AE severities for each department are shown in Table 5. The highest number of different AEs found in a single record was four.

Challenges in Implementing the GTT

We experienced several challenges when implementing the GTT process. One challenge was that hospital managers and reviewers had limited awareness of the GTT before the study. We also found that a one-off instructional session for using the GTT is not sufficient. A further challenge was that the German translation of the GTT had to be adapted to the respective departments

TABLE 4. Identified Triggers

	GS1	GS2	NS
Total identified triggers (total reviewed records)	116 (40)	71 (40)	201 (40)
Identified triggers in patient records without an AE (total no. records without AE)	62 (32)	9 (26)	102 (23)
Identified triggers in patient records with at least one AE (total no. records with at least one trigger)	54 (8)	62 (14)	99 (17)

GS1, first department of general surgery; GS2, second department of general surgery; NS, Department of Neurosurgery.

before the review. Another challenge was the homogeneous structure and quality of the patient records included. Some records were paper based, others were electronic, and thus, the structure of the records was different. Often, information and documents were missing from the records. Further challenges to implementing the GTT were data protection requirements and approval of the ethics committees or staff representations.

DISCUSSION

This is the first publication to investigate AEs in German hospitals using the IHI GTT. The study demonstrates that after adapting it to the local context of the department, the GTT is a useful instrument for measuring triggers and AEs, and therefore it can be used in different departments of German-speaking hospitals.

The findings of this study showed 25.5 and 36.3 AEs per 1000 patient-days and 25.0 and 47.5 AEs per 100 admissions in the two general surgery departments. These results were similar to those published of a previous Austrian study reporting 21.1 to 42.8 AEs per 1000 patient-days and 43.7 to 80.0 AEs per 100 admissions.[24]

The only previous study applying the GTT in neurosurgery exclusively investigated the incidence of triggers for different patient groups.[20] Our study also calculated AE rates of 72.1 AEs per 1000 patient-days and 60.0 AEs per 100 admissions were identified. This adds to the current knowledge.

We examined only patient records in university hospitals. Thus, AE rates in this study might be influenced by a higher proportion of critically ill patients in this setting and by the specific surgical disciplines involved.[25] In principle, the AE rate is used exclusively to obtain an overview of the number of patient injuries in the respective department. However, calculating the AE rate alone is not enough to identify the causes of AEs and to reduce them sustainably.

Of the 53 patient records with AEs, 71.7% were assigned to the lowest category E and 26.4% to category F. This is similar to other studies identifying most AEs in category E.[17,24] This has implications for the learning potential of our findings as well as on the kinds of practice improvement strategies based on such analyses. We identified significant differences in the occurrence of individual triggers and of triggers in a patient record with an AE between the departments illustrating the heterogeneous sensitivity of the triggers depending on the department. Our findings indicate variations in practice. The trigger K8 (*Intraop epinephrine, norepinephrine, naloxone, or romazicon*) was most frequently identified in GS1 and NS. In GS2, the trigger was not named among the three most common triggers. This can be explained by the fact that the medications mentioned in the trigger are administered routinely for prevention hypotension in GS1 and NS. The trigger might therefore seem too sensitive for two of the three departments by highlighting triggers that were dismissed during the decision whether or not the trigger was related to an AE. However, this should not lead to the
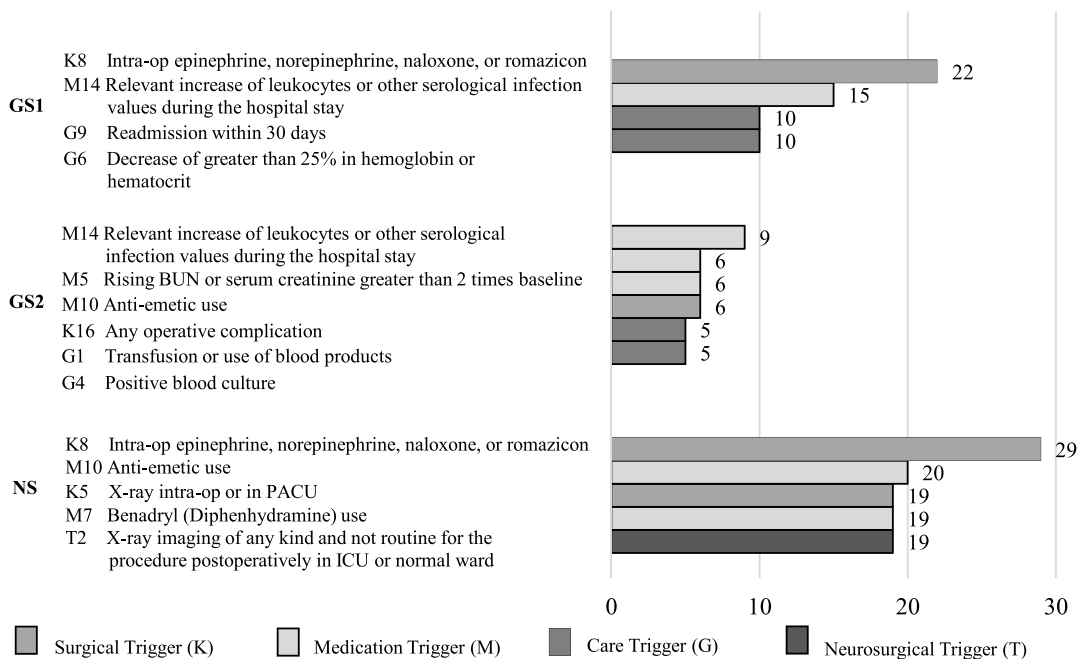
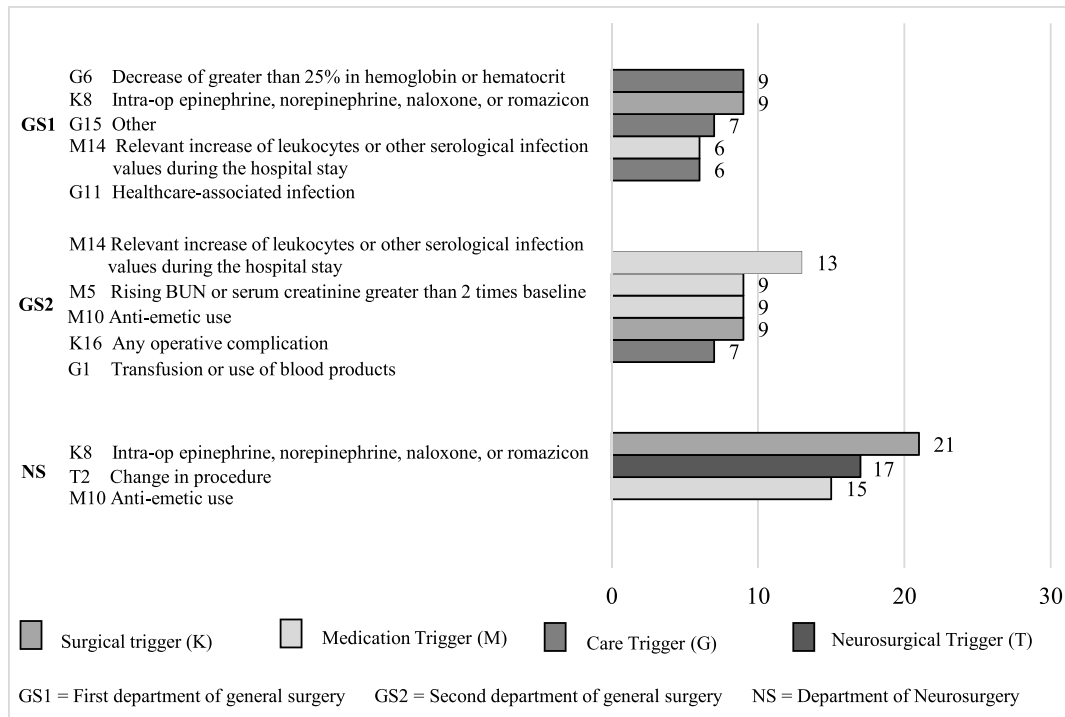**FIGURE 1.** Most frequently detected triggers per department.

FIGURE 2. Most frequently detected triggers in records with an AE.

exclusion of this trigger, because the trigger was also most frequently identified occurring in the records with an AE in GS1 and NS. Furthermore, the triggers M10 and M14 seem to be very sensitive, because these three triggers were most frequently identified in a record with an AE in two hospitals. The trigger G6 was also evaluated as very sensitive in one of the two surgical departments, especially because the trigger was the third most frequently identified but most frequently found in records with AEs. In all departments the trigger G15 "*Other*" was identified 14 times. This illustrates the need to add further new triggers to the instrument. As already emphasized in other studies,[26,27] the clinical relevance, benefit, and feasibility must be considered when creating new triggers. It is also important that clinicians are directly involved in this process to contribute their specific target criteria for patient safety. Eleven triggers were not identified at all. Thus, these triggers should be tested for their sensitivity and relevance for the respective department during long-term use.

The present study showed substantial agreement on the presence of a trigger between primary reviewers, as previously shown.[2,28] However, large differences in AE detection and categorization of their severity can exist between reviewer teams from different departments and hospitals.[18] Bjørn et al.[29] achieved other results that showed that experienced reviewer teams could not reproduce harm rates from previous screening processes. Therefore, the reliability of GTT should be considered critically and further investigations on reliability are necessary.

Results from different GTT studies should be compared with caution.[30] Studies use different definitions for triggers and AEs, different methods, and classifications. The GTT studies are characterized by a great methodological heterogeneity because before implementation, the GTT is typically adapted to the local context[2,31] by removing modules,[32–34] adding triggers and specific definitions,[35] or adding new modules.[36] In addition, the participating departments have different medical specializations with

TABLE 5. Identified AEs and Their Severity

	E, n (%)	F, n (%)	G, n (%)	H, n (%)	I, n (%)	Total AEs
GS1	6 (60.0%)	4 (40.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	10 (100%)
GS2	10 (52.6%)	9 (47.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	19 (100%)
NS	22 (91.7%)	1 (4.2%)	1 (4.2%)	0 (0.0%)	0 (0.0%)	24 (100%)

National Coordination Council for Medication Error Reporting and Prevention Index[22]:

Category E: Temporary harm to the patient and required intervention.

Category F: Temporary harm to the patient and required initial or prolonged hospitalization.

Category G: Permanent patient harm.

Category H: Intervention required to sustain life.

Category I: Patient death.

GS1, first department of general surgery; GS2, second department of general surgery; NS, Department of Neurosurgery.

different disease related groups of patients and clinical presentations. Furthermore, the different types of patient records (e.g., electronic, paper based) in each department may influence the results of the review.[37] Another factor is the variation of the reviewers in terms of their profession, experience and handling of records. The departments participating in our study had different access to physicians or nurses as primary reviews. However, we trained all reviewers in the same way to ensure consistent review.

Considering the various challenges in implementing the GTT, it became apparent that awareness of the GTT needs to be raised. One way to increase this would be the integration and guidance of the GTT in the training of medical students and nursing staff. Students could review records and share this experience in specialist areas of their studies or education.[38] This would promote individual learning by providing students with insights into factors potentially contributing to patient harm. In this context, it is important to distinguish between instruments that identify potential risks, such as the GTT or Critical Incident Reporting Systems, and instruments that support a systematic analysis of high-risk processes that allow for targeted improvement such as the Failure Mode and Effects Analysis. Detections of trigger with the GTT can be a valuable addition to proactive analyses of high-risk processes but cannot substitute them. Another challenge was the heterogenous structure and quality of the records. Like Najjar et al.[39] mentioned, incomplete and imprecise information in records makes the screening process more difficult. Further challenges to apply the GTT were the approval of record screening and reviewer access to records within the framework of data protection and ethical guidelines. These challenges make large-scale implementation of the GTT difficult, especially in Germany. A national deployment such as in Sweden and Norway is therefore not yet conceivable.[13]

Strengths and Limitations

The study was limited to three departments and only present AEs identified among hospitalized surgical and neurosurgical patients. These findings cannot be generalized to all German hospitals and their different departments. Because of procedural differences in data collection, our analysis of IRR was limited to two of the three departments. However, the reviewers of all participating departments received the same training. The IRR between primary and secondary reviewers could not be calculated because of nontransparent documentation because only the consensus for the identification of the AEs was documented. Furthermore, the effects of subjective attitudes on the identification of triggers and AEs or the level of cooperation between reviewers during the review process were not explored. The main limitation associated with GTT methodology is that results depend on the quality of documentation in the patient records, because the reviewer can only identify documented AEs. Therefore, the real number of AEs may be higher.[13] Finally, there are no studies proving the concurrent validity of the GTT.[28]

CONCLUSIONS

With a few adaptations specific to the department, GTT is a feasible and effective assessment tool to get an overview of AEs in hospitals. The instrument is easy to implement in the clinical environment and enables detection of warning signals. Many incidents are identified that may be regarded as commonplace by hospital staff and are therefore not recorded elsewhere. This lays an important foundation for further, targeted risk-preventive measures to increase patient safety. It is important not to use the results of the tool for comparing different departments, but rather, to use the tool for quality purposes. In the future, the results of the GTT

can be used as a basis and valuable addition for proactive analyses of high-risk processes. The linking of analyses with the GTT and further analyses to identify causes that may be hidden in the system should be part of additional studies.

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