Global variation in injury patterns, interventions, and post-operative outcomes for children and adolescents undergoing trauma laparotomy: an international cohort study

*Riaz Aziz, Michael F Bath, Sarah M Abdelmohsen, Isaac Chukwu, Raoof Saleh, Eder Cáceres, Carlos M Nuño-Guzmán, Joachim Amoako, Shobhana Nagraj, Daphne K Karusoke, Laura Hobbs, Brandon G Smith, Katharina Kohler, Timothy C Hardcastle, Zane B Perkins, Thomas G Weiser, Kokila Lakhoo, Tom Bashford, on behalf of the GOAL-Trauma Collaborative**

Summary

Background Trauma is the leading cause of death and disability in children and adolescents worldwide; however, paediatric trauma care is often neglected during health system development. We aimed to understand current global standards of laparotomy care for paediatric patients with blunt or penetrating traumatic injury and variation in patient injury patterns, intervention, and post-operative outcomes.

Methods This is a planned post-hoc analysis of the international, multicentre, prospective, observational cohort from the Global Outcomes After Laparotomy for Trauma (GOAL-Trauma) Study, which was conducted between April 1 and Dec 31, 2024. Patients aged 18 years or younger with a blunt or penetrating traumatic injury who underwent a laparotomy within 5 days of presentation were eligible. Countries were stratified by the Human Development Index (HDI), and the primary outcome was post-operative in-hospital 30-day mortality. Adjusted mortality risk was calculated using least absolute shrinkage and selection operator regression analysis. The study was registered with ClinicalTrials.gov (NCT06180668).

Findings 237 paediatric patients who underwent a trauma laparotomy were recruited from 85 hospitals in 32 countries, with the highest proportion of patients living in countries in the lower HDI tertile (110 [20%] of 563 cases overall). The median age among paediatric cases was 16·0 years (IQR 12·0–18·0), and most patients were male (195 [82%] of 237 patients) and had sustained a blunt injury (135 [57%] patients). The median time globally from injury to operation was 7·4 h (IQR 3·5–18·8; n=235), with longer times observed across the patient pathway for patients in the lower and middle HDI tertiles than for those in the upper HDI tertile (p=0·0008). The overall 30-day in-hospital crude mortality rate was 8% (19 of 237 patients); however, after adjustment, patients in the lower HDI tertile were nearly six times more likely to die post-operatively than those in the upper HDI tertile (odds ratio 5·69 [95% CI 1·58–20·44], p=0·0079).

Interpretation Proportionally more children undergo trauma laparotomy in lower-resource settings than in higher-resource settings; however, their mortality risk is substantially higher. Marked variation exists in paediatric pathways globally, and policy makers and health-care leaders should prioritise the development of paediatric trauma care worldwide.

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*Collaborators are listed in the appendix (pp 2–12)

International Health Systems Group, Department of Engineering, University of Cambridge, Cambridge, UK (R Aziz FFICM, M F Bath MRCS, D K Karusoke MBChB, L Hobbs FRCA, B G Smith PhD, K Kohler PhD, T Bashford PhD); **Department of Surgery, Aswan University, Aswan, Egypt** (S M Abdelmohsen MD); **Department of Surgery, Federal Medical Centre, Umuahia, Nigeria** (I Chukwu FWACS); **Médicins Sans Frontières Medical Unit, Berlin, Germany** (R Saleh FRCS); **Critical Care Department, Clínica Universidad de la Sabana, Chía, Cundinamarca, Colombia** (E Cáceres PhD); **Hospital Civil de Guadalajara Fray Antonio Alcalde, Guadalajara, Jalisco, Mexico** (C M Nuño-Guzmán MD); **Centro Universitario de Ciencias de la Salud, Universidad de Guadalajara, Guadalajara, Jalisco, Mexico** (C M Nuño-Guzmán); **University of Ghana Medical School, Accra, Ghana** (J Amoako FWACS); **Department of Surgery, Korle Bu Teaching Hospital, Accra, Ghana** (J Amoako); **Department of Public Health and Primary Care, University of Cambridge, Cambridge, UK** (S Nagraj DPhil); **Department of Anaesthesia, Kampala Hospital, Kololo, Kampala, Uganda** (D K Karusoke); **Department of Anaesthesia, East & North Hertfordshire NHS Trust, UK** (L Hobbs); **NIHR Global Health**

Introduction

Traumatic injuries have been the leading contributor to disability-adjusted life-years among adolescents and young adults for the past two decades.[1] Alongside the significant mortality rates associated with trauma that occurs globally,[2] injuries to children and adolescents also affect economic growth through reduced workforce potential and increased health-care costs, as well as the individual's future psychological and mental wellbeing. As a result, improvement of paediatric trauma care standards must be seen as a global health-care priority.

Trauma care pathways are known to vary substantially across the world.[3,4] Formalised trauma systems and specialised care pathways remain limited to the more resource-rich nations,[5–14] and this is also true for paediatric trauma. Globally, the vast majority of children with traumatic injuries do not receive care in dedicated paediatric centres,[15] and sizeable disparities in care have been reported even in countries with formalised trauma systems.[16] Specialisation is known to improve paediatric outcomes in other clinical specialities,[17] and the absence of specialised paediatric trauma pathways is likely to have a substantial effect on the quality of care received.

Trauma represents a complex and multifactorial process,[18,19] particularly in the paediatric population in

Research Group on Acquired Brain and Spine Injury, Cambridge, UK (L Hobbs, T Bashford); Department of Anaesthesia, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK (K Kohler, T Bashford); Trauma and Burns Unit, Inkosi Albert Luthuli Central Hospital, KwaZulu-Natal Department of Health, Durban, South Africa (Prof T C Hardcastle PhD); Department of Surgical Sciences, Nelson R Mandela School of Clinical Medicine, University of KwaZulu-Natal, Durban, South Africa (Prof T C Hardcastle); Major Trauma Service, Royal London Hospital, Barts Health NHS Trust, London, UK (Z B Perkins PhD); Centre for Trauma Sciences, Blizard Institute, Queen Mary University of London, London, UK (Z B Perkins); Department of Surgery, Stanford University, Palo Alto, CA, USA (Prof T G Weiser MD); Department of Paediatric Surgery, University of Oxford, Oxford, UK (Prof K Lakhoo PhD)

Correspondence to: Dr Michael F Bath, International Health Systems Group, Department of Engineering, University of Cambridge, Cambridge, UK mb2583@cam.ac.uk

See Online for appendix

Research in context

Evidence before this study

We searched PubMed for all articles published in English from Jan 1, 2000, to Oct 31, 2025, using the search terms "trauma", "laparotomy", "mortality", and "paediatric". We found no multicentre prospective international studies that compared patient factors, interventions, and post-operative outcomes for paediatric cases undergoing a trauma laparotomy. Most studies were single centre, retrospective in nature, or not procedure specific. The Global Outcomes After Laparotomy for Trauma (GOAL-Trauma) Study reported significant variation in care provided for patients of all ages globally who underwent a trauma laparotomy. However, paediatric care is often neglected within trauma research, and there is a growing call for improved paediatric-specific research in this field.

Added value of the study

In this study, injury patterns, interventions, and post-operative outcomes are reported for paediatric patients globally who underwent trauma laparotomy. We found a higher proportion of children overall undergoing laparotomy following traumatic injuries in lower-resource settings than in higher-resource settings, as well as higher numbers of laparotomies performed in rural hospitals and by surgeons who were not consultants or attending general surgeons. Longer delays in both reaching the hospital and proceeding to definitive intervention were observed in lower-resource settings than in higher-resource settings, with these delays more pronounced than those observed in the overall GOAL-Trauma cohort. Higher proportions of tranexamic acid, CT imaging, and blood products were used for paediatric patients in higher-resource settings than in lower-resource settings. The overall adjusted 30-day in-hospital mortality risk was almost six times higher in lower-resource settings than in higher-resource settings.

Implications of all the available evidence

Significant inequity and mortality risk in paediatric trauma care are apparent worldwide. The evidence calls for an urgent need to design paediatric-specific trauma systems to address structural and resource disparities worldwide.

which age-dependent anatomical, physiological, and developmental variability adds further challenges. Optimal management for paediatric trauma requires a coordinated systemic approach that addresses every component of the trauma care continuum and is specifically adapted to meet the unique needs of injured children. Indeed, there is a growing call for further research into paediatric trauma care so that the required systems and pathways can be developed,[20] avoiding the long-term health effects on children, adolescents, and their respective families. Although benchmarking metrics from adult cohorts are often used as surrogate indicators of paediatric trauma care quality, these do not accurately reflect the paediatric cohort,[21] which has prompted an increasing need for paediatric-specific trauma research to better characterise the quality of care delivered, identify existing barriers, and inform the development of dedicated paediatric trauma pathways.[22]

The Global Outcomes After Laparotomy for Trauma (GOAL-Trauma) Study was an international, multicentre, prospective, observational, cohort study of patients undergoing trauma laparotomy.[3] During the design of the study, the Steering Committee explicitly chose to include paediatric patients to understand existing global trauma pathways for children and adolescents, and to allow direct comparison with adult patient pathways. We aimed to analyse the GOAL-Trauma Study dataset to map current paediatric trauma care pathways worldwide and to understand the variation in injury patterns, interventions, and post-operative outcomes for children and adolescents undergoing trauma laparotomy.

Methods

Study design

This was a planned post-hoc analysis of the GOAL-Trauma Study, the methodology of which is described elsewhere.[23] Any health-care facility worldwide that could perform and manage a patient undergoing a trauma laparotomy was eligible to enrol. Patients were recruited between April 1 and Dec 31, 2024, during pre-selected 30-day periods and followed up until discharge, death, or 30 days post-operatively (if still hospitalised), whichever came first. Data were collected prospectively by local investigators for all eligible patients throughout pre-selected 30-day periods; each recruiting centre required a lead investigator (termed the local lead; appendix pp 2–12), who was asked to complete a site survey to provide further details and contextualise their respective clinical setting.

Ethical approval was granted by the Cambridge Psychology Research Ethics Committee (PRE.2023119), and the study was prospectively registered on ClinicalTrials.gov (NCT06180668). Written confirmation of appropriate local approval was provided by each contributing hospital before enrolment into the study, according to respective local regulations. In some participating hospitals, informed patient consent was obtained, whereas in other hospitals, this was deemed not to be necessary, at the discretion of the local team.

Procedures

To maintain consistency across hospitals, we defined a paediatric case as any patient aged 18 years or younger (irrespective of the local paediatric service designation). Patients who presented with a blunt or penetrating injury

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and underwent a laparotomy within 5 days (120 h) of presentation to the treating hospital were eligible for inclusion in the study. Patients were excluded if they were undergoing a repeat laparotomy at the recruiting hospital (often termed a relook laparotomy) within 30 days of the index procedure, or had been recently discharged from any hospital (including for non-trauma-related admissions) and had presented within 30 days of discharge. Given the known variation in minimally invasive surgery seen worldwide,[24] we excluded a priori patients undergoing a laparoscopic (including laparoscopic converted to open), robotic, or image-guided procedures. Fluid and blood product use was collected only in the pre-operative period to assess resuscitation practices in trauma. We deemed fluid and blood product use in the intra-operative and post-operative period might instead reflect rates of complication or failure to rescue, which was beyond the remit of the study.

Injury severity was calculated for each body region using the Abbreviated Injury Scale, with the overall degree of injury quantified through the summative Injury Severity Score (ISS),[25] a score that has been specifically used previously for paediatric injuries.[26,27] Patient comorbidity was quantified through the American Society of Anesthesiologists (ASA) score. An adapted National Early Warning Score (for those aged >16 years)[28] or Paediatric Early Warning System (for those aged ≤16 years)[29] value was calculated as a summative marker of patient physiology on arrival. Time to presentation was calculated from the documented time of injury to the time the patient presented to the hospital where the index operation was performed, time to decision was taken as the time from injury to the point the formal decision to proceed to a trauma laparotomy was made, and time to operation was the time to the first incision for the operation. Organ support was defined as any organ support performed in the post-operative period, within 30 days of the operation; to ensure comparisons across settings, this did not presuppose the clinical location of the patient to receive such care, only that the function of organ support provision was given. Cardiovascular support was defined as receiving vasopressor or inotropic agents, or mechanical support (extra-corporeal membrane oxygenation or cardiac bypass), and respiratory support was defined as receiving non-invasive positive pressure support or intubation and ventilation.

Submitted data were checked centrally and, where potential missing or inaccurate data were identified, local investigators were contacted and asked to check or complete the record. Any patient record with less than 70% of data points completed was excluded from the study. Hospital-level and patient-level data were uploaded centrally onto REDCap cloud,[30,31] a secure web-based system hosted by the University of Cambridge (Cambridge, UK). This study has been reported according to STROBE guidelines (appendix pp 13–14).[32]

Outcomes
The primary outcome measure for the study was post-operative in-hospital mortality, measured to 30 days. The secondary outcome measures were patient discharge destination and any return to theatre.

Statistical analysis
Patient-level data are reported as descriptive statistics. Contributing hospitals were stratified by their national Human Development Index (HDI), which was categorised into lower, middle, and upper tertiles. Continuous variables are reported as median with IQR or mean with SD, with statistical analysis performed using the Kruskal–Wallis test or ANOVA testing, where necessary. Categorical variables are presented as frequencies and percentages and compared using the Pearson's χ^2 test.

For the **Human Development Index** see https://hdr.undp.org/data-center

Selection of covariates for the regression model was guided by a directed acyclic graph (DAG), which was determined through a combination of literature review and expert consensus (appendix p 15). Variables were scaled appropriately before analyses, including rank transformation for ordinal variables (ASA grade), one hot encoding for categorical variables (HDI tertile, mechanism of injury, surgeon grade, and anaesthetist grade), and factor analysis for dependent ordinal data (resource availability); resource availability was used as a surrogate for overall hospital function, represented as a latent composite outcome measure derived using data from a structured centre assessment tool,[33] combining the availability of intensive care, CT scanning, pathology services, and blood products using factor analysis. Mortality rates were then analysed using a least absolute shrinkage and selection operator (LASSO) regression.[34] Factors identified from the DAG were paired to appropriate data points in the GOAL-Trauma dataset: patient age, arrival systolic blood pressure, time to operation, ASA score, ISS, mechanism of injury, resource availability, surgeon grade, anaesthetist grade, and HDI tertile. LASSO regression was performed to select the optimal parameters for subsequent logistic regression analysis. Adjusted risk is reported as odds ratios with 95% CIs.

Statistical tests were two sided, and we considered p values less than 0·05 to show a significant difference. All analysis was done using R Studio (version 4.4.1), using tableone, tidyverse, fastDummies, psych, bestNormalize, glmnet, broom, pROC, and cowplot packages.

Role of the funding source
The funders had no involvement in data collection, analysis, interpretation, writing of the manuscript, or decision to submit.

Results
Paediatric cases were submitted to the GOAL-Trauma dataset by 85 hospitals across 32 countries: 14 from the lower HDI tertile, nine from the middle HDI tertile, and

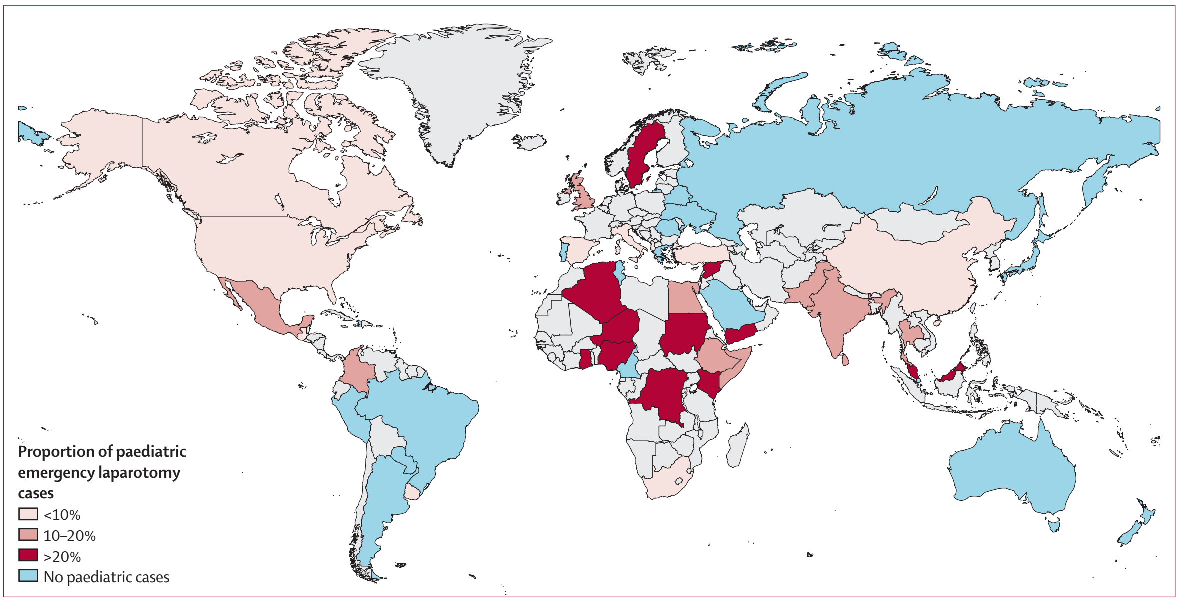

Figure 1: **Proportion of paediatric emergency laparotomy cases by country, relative to the overall GOAL-Trauma Study dataset**
GOAL-Trauma=Global Outcomes After Laparotomy for Trauma.

nine from the upper HDI tertile. 237 (13·4%) paediatric patients met the inclusion criteria from the overall GOAL-Trauma Study dataset.[3] 110 paediatric cases were from the lower HDI tertile (representing 20% of the total 563 cases in the lower HDI tertile, p<0·0001), 89 were from the middle HDI tertile (13% of total 714 cases in the middle HDI tertile), and 38 were from the upper HDI tertile (8% of total 492 cases in the upper HDI tertile;[3] figure 1).

Most hospitals submitting paediatric cases were located in urban settings (80 [94%] of 85), with the majority of rural hospitals being from the lower HDI tertile, equating to 15 (14%) of 110 patients being operated on in rural settings in the lower HDI tertile, compared with one (1%) of 89 patients in the middle HDI tertile and none in the upper HDI tertile (p<0·0001). Most hospitals in this analysis were tertiary-level hospitals (63 [74%] of 85).

The age of included patients ranged from 1 year to 18 years, with a median age of 16·0 years (IQR 12·0–18·0; table 1), and 85 (36%) of 237 patients aged 12 years or younger. Patients in the lower HDI tertile had a younger median age than those in the middle and upper HDI tertiles. The distribution of blunt and penetrating injuries was similar across HDI tertiles; however, the finding that blunt injuries were the most common mechanism of injury among paediatric patients (135 [57%] of 237) stands in contrast to that of the overall GOAL-Trauma population, where most patients presented with penetrating injuries (955 [54%] of 1769 patients). However, penetrating injuries became increasingly prevalent with increasing age.

Patterns of hospital presentation varied across HDI tertiles (p<0·0001), with transfer by land ambulance being the most common in the upper HDI tertile (30 [79%] of 38), and private vehicle being the most common in the lower HDI tertile (51 [46%] of 110). 153 (35%) of 237 patients went to another hospital before arriving at the treating centre, with this proportion highest in the middle HDI tertile, in which more than half of patients went to another hospital before arriving at the treating centre (46 [52%] of 110), compared with 28 (25%) of 110 in the lower HDI tertile and ten (26%) of 38 in the upper HDI tertile.

Globally, the median time recorded was 2·0 h (IQR 0·9–7·0) between injury and presentation, 5·2 h (2·3–14·2) between injury and decision to operate, and 7·4 h (3·5–18·8) between injury to operation (table 1). Times were shorter in the upper HDI tertile than in the middle and lower HDI tertiles across time to presentation (p=0·0004), time to decision (p<0·0001), and time to operation (p=0·0008), with most variance occurring in the pre-hospital setting (figure 2). Arrival physiology scores were equivalent across HDI tertiles; however, overall injury severity was higher in the upper HDI tertile than in the middle HDI tertile and lower HDI tertile (table 1). A higher proportion of ASA grades 3–5 was apparent in the upper HDI tertile than in the middle HDI and lower HDI tertiles, albeit not statistically significant. There was a suggestion of a higher median admission serum lactate concentration in the upper HDI tertile than in the middle HDI tertile and the lower HDI tertile; however, there was a high degree of missing data (114 [48%] of 237) that prevented direct analysis.

Pre-operatively, there was a significant difference in the number of patients who received intravenous fluids and blood products across settings (table 2); the highest proportion of patients receiving intravenous fluids across tertiles was in the middle and lower HDI cohorts, whereas

	Lower HDI (n=110)	Middle HDI (n=89)	Upper HDI (n=38)	Total (n=237)	p value
Age, years	14·5 (12·0–17·0)	16·0 (12·0–18·0)	17·0 (16·0– 18·0)	16·0 (12·0–18·0)	<0·0001
Sex	..	..	..	..	0·71
Male	89 (81%)	73 (82%)	33 (87%)	195 (82%)	..
Female	21 (19%)	16 (18%)	5 (13%)	42 (18%)	..
Mechanism	..	..	..	..	0·44
Blunt	58 (53%)	53 (60%)	24 (63%)	135 (57%)	..
Penetrating	52 (47%)	36 (40%)	14 (37%)	102 (43%)	..
NEWS-2 value (on arrival)	5 (2–8; n=34)	6 (5–8; n=42)	7 (4–10; n=27)	6 (4–9; n=103)	0·34
PEWS value (on arrival)	2 (1–5; n=76)	3 (2–6; n=47)	3 (2–9; n=62)	3 (1–5; n=185)	0·38
Time from injury to presentation, h	2·1 (1·0–8·3)	2·7 (1·0–6·5)	1·0 (0·7–1·7; n=37)	2·0 (0·9–7·0; n=236)	0·0004
Time from injury to decision to operate, h	6·0 (2·5–21·7; n=107)	6·1 (3·3–13·0)	2·3 (1·3–4·3; n=37)	5·2 (2·3–14·2; n=233)	<0·0001
Time from injury to operation, h	7·8 (3·5–25·9; n=108)	9·8 (5·0–17·0)	4·1 (1·9–7·8)	7·4 (3·5–18·8; n=235)	0·0008
Abdominal abbreviated injury scale	3 (2–3)	3 (2–4)	3 (2–4)	3 (2–3)	0·15
Injury severity score	9 (4–15)	13 (4–24)	25 (9–32)	9 (4–20)	<0·0001
ASA score	..	..	..	..	0·066
1	68 (62%)	41 (46%)	18 (47%)	127 (54%)	..
2	14 (13%)	20 (22%)	6 (16%)	40 (17%)	..
3	15 (14%)	15 (17%)	1 (3%)	31 (13%)	..
4	5 (5%)	3 (3%)	7 (18%)	15 (6%)	..
5	8 (7%)	10 (11%)	6 (16%)	24 (10%)	..
Haemoglobin (on arrival), g/L	107 (29; n=102)	107 (35; n=81)	126 (29; n=37)	110 (32; n=220)	0·0003
Lactate (on arrival), mmol/L	1·2 (0·6; n=22)	3·4 (3·1; n=59)	3·9 (3·3; n=33)	3·2 (3·0; n=123)	..
Pre-operative ultrasound scan performed	82 (75%)	56 (63%)	18 (47%)	156 (66%)	0·0074
Pre-operative plain film radiograph performed	63 (57%)	49 (55%)	14 (37%)	126 (53%)	0·085
Pre-operative CT performed	35 (32%)	44 (49%)	28 (74%)	107 (45%)	<0·0001

Data are median (IQR), n (%), or mean (SD), unless otherwise stated. Percentages might not sum to 100 as a result of rounding. p values represent comparisons across all three tertiles. ASA=American Society of Anesthesiologists. HDI=Human Development Index. NEWS=National Early Warning Score. PEWS=Paediatric Early Warning System.

Table 1: **Patient characteristics and injury factors**

the highest proportions of patients receiving blood products across tertiles was in the upper HDI cohort. Tranexamic acid was given to 62 (26%) of 237 patients, with a higher rate observed in the upper HDI tertile than in the lower HDI tertile and middle HDI tertile. For diagnostics, patients in the lower HDI tertile centres had a higher proportion of patients undergoing an ultrasound scan or plain film radiograph pre-operatively than the middle HDI tertile and upper HDI tertile, whereas those in upper HDI tertile centres had a higher proportion of patients undergoing CT imaging than those in the lower HDI tertile and middle HDI tertile (appendix p 16).

The most common organs injured across all tertiles were the small bowel, stomach, and spleen, and the most common procedures performed were upper gastrointestinal procedures, splenectomy, and small-bowel procedures; negative laparotomies were present in 16 (7%) patients (table 2). Concurrent non-abdominal procedures during the same period of anaesthesia were performed in 44 (19%) patients, with the highest proportion seen in the upper HDI tertile. An open abdomen occurred in 26 (11%) of 237 patients and were most common in the upper HDI tertile. The most senior surgical and anaesthetic providers present in theatre overall were consultant or attending; however, a higher proportion of registrars or residents were present in the lower HDI setting for both surgical providers and anaesthetic providers.

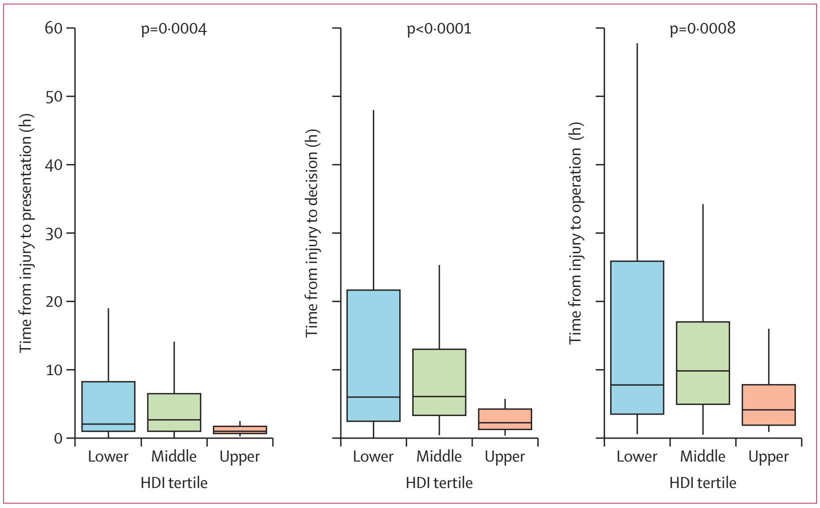

Figure 2: **Differences in timings across patient pathways, as represented by boxplots across each HDI tertile**
The median is the central line, the IQR is the bounds of the box, and the whiskers extend to the furthest values within the non-outlier range. HDI=Human Development Index.

	Lower HDI (n=110)	Middle HDI (n=89)	Upper HDI (n=38)	Total (n=237)	p value
Received pre-operative intravenous fluids	96 (87%)	87 (98%)	18 (47%)	201 (84%)	<0·0001
Received pre-operative blood products	42 (38%)	42 (47%)	24 (63%)	108 (46%)	0·027
Received pre-operative tranexamic acid	22 (20%)	15 (17%)	25 (66%)	62 (26%)	<0·0001
Procedures performed	..	..	..	..	..
Upper gastrointestinal procedure	14 (13%)	14 (16%)	7 (18%)	35 (15%)	..
Small bowel procedure	31 (28%)	15 (17%)	7 (18%)	53 (22%)	..
Lower gastrointestinal procedure	14 (13%)	11 (12%)	5 (13%)	30 (13%)	..
Primary vascular procedure	9 (8%)	12 (14%)	2 (5%)	23 (10%)	..
Splenectomy	11 (10%)	17 (19%)	9 (24%)	37 (16%)	..
Hepatorrhaphy or hepatectomy	7 (6%)	7 (8%)	1 (3%)	15 (6%)	..
Nephrectomy	4 (4%)	4 (4%)	0	8 (3%)	..
Diaphragmatic repair	3 (3%)	3 (3%)	1 (3%)	7 (3%)	..
Bladder repair	5 (5%)	2 (2%)	0	7 (3%)	..
Pancreatectomy	0	4 (4%)	1 (3%)	5 (2%)	..
Negative laparotomy*	9 (8%)	6 (7%)	1 (3%)	16 (7%)	..
Non-therapeutic laparotomy†	5 (5%)	4 (5%)	4 (11%)	13 (6%)	..
Concurrent procedures performed	15 (14%)	17 (19%)	12 (32%)	44 (19%)	0·049
Open abdomen	8 (7%)	9 (10%)	9 (24%)	26 (11%)	0·019
Intra-operative blood loss, mL	500 (163–800; n=105)	650 (200–1500; n=85)	800 (250–1950; n=34)	500 (200–1000; n=224)	0·0031
Most senior surgeon present	..	..	..	..	<0·0001
Consultant or attending general surgeon	65 (59%)	69 (78%)	37 (97%)	171 (72%)	..
Registrar or resident general surgeon	44 (40%)	16 (18%)	1 (3%)	61 (26%)	..
Other surgeon	1 (1%)	2 (2%)	0	3 (1%)	..
Medically qualified but not in surgical training	0	1 (1%)	0	1 (<1%)	..
Not medically qualified surgical provider	0	1 (1%)	0	1 (<1%)	..
Most senior anaesthetic provider present	..	..	..	..	<0·0001
Consultant or attending anaesthetist	38 (35%)	55 (62%)	36 (95%)	129 (54%)	..
Registrar or resident anaesthetist	51 (46%)	32 (36%)	2 (5%)	85 (36%)	..
Not medically qualified anaesthesia provider	21 (19%)	2 (2%)	0	23 (10%)	..

Data are n (%) or median (IQR), unless otherwise stated. Percentages might not sum to 100 as a result of rounding. p values represent comparisons across all three tertiles. HDI=Human Development Index. *Negative laparotomy was defined as no intra-abdominal injuries identified during the operation. †Non-therapeutic laparotomy was defined as intra-abdominal injuries identified that did not require operative intervention.

Table 2: **Pre-operative and intra-operative factors**

The overall 30-day in-hospital crude mortality rate was 8% (19 of 237 patients), which was equivalent across HDI tertiles (p=0·53; table 3). Of the 19 patients who died, four died intra-operatively. LASSO regression identified ASA score, lower HDI tertile, ISS, systolic blood pressure, and anaesthetic provider seniority as factors for inclusion in the logistic regression; following logistic regression of the LASSO-selected variables, the significant predictors for mortality were lower HDI tertile (odds ratio 5·69 [relative to upper HDI tertile], 95% CI 1·58–20·44, p=0·0079) and ASA score (37·39 [per ordinal increase of ASA score], 4·00–349·43, p=0·0013; figure 3).

Organ support was most frequently provided in the upper HDI tertile, alongside higher rates of return to theatre than in the lower HDI tertile and middle HDI tertile (table 3). For the 174 patients discharged to their usual place of residence, the median length of post-operative hospital stay was 6 days (IQR 4–10). A higher proportion of patients were either transferred to a rehabilitation unit or remained in hospital in the upper HDI tertile than in the middle HDI tertile and lower HDI tertile. 125 (74%) of 174 patients who were discharged to their usual place of residence were discharged back to the same level of care before the injury.

Discussion

We report on one of the largest published datasets of paediatric trauma patients undergoing laparotomy, covering 237 patients from 85 hospitals across 32 countries. The data suggest that there is a higher proportion of paediatric patients overall undergoing a trauma laparotomy in lower-resource settings than in higher-resource settings, with more procedures in these settings being performed in rural hospitals and by non-consultant surgeons. Longer delays in time to presentation, to decision, and to operation were observed among patients in lower-resource settings than in higher-resource settings, which were more pronounced than in the overall study cohort,[3] along with sizeable differences in the provision of infrastructure, resources, and staffing across the patient pathway. Although overall crude 30-day post-operative mortality globally was 8%, this inequity in care culminated in an adjusted mortality risk nearly six times higher for patients undergoing a trauma laparotomy in the lower-resource settings compared with those undergoing the procedure in higher-resource settings. These findings show that clear discrepancies remain in all aspects of patient care in paediatric trauma, more so than observed in adult-orientated trauma pathways, and substantial work is still required to strengthen paediatric trauma pathways worldwide.

Of the 5 billion people globally who do not have access to safe and affordable surgical care,[35] nearly half are children.[36] Trauma is no exception, with traumatic injuries being a major contributor to emergency presentations of children to hospitals worldwide, especially in lower-resource settings.[37–39] Our findings suggest that the proportion of paediatric trauma laparotomies being performed is three times higher in lower-resource settings than in higher-resource settings, despite reduced resource availability. This higher burden of paediatric trauma might reflect a younger average age of the general population in these settings or a varying degree of injuries that would warrant operative intervention; however, it might also indicate a greater underlying burden of trauma among children, as region-specific work laws, exposure to occupational hazards, or road-safety infrastructure will all contribute to a greater risk of traumatic injury,[40,41] with road traffic injuries alone known to be the leading cause of death for children and adolescents.[42,43] Differences in clinical decision making might also contribute to this observation; in higher-resource settings, greater diagnostic, human, and clinical resources can enable a watch-and-wait strategy, either through conservative management or non-operative intervention (eg, interventional radiology), resulting in only select severely unwell patients being operated upon. Such an approach might not be feasible in lower-resource settings, where limited infrastructure, diagnostic capacity, specialist paediatric clinicians, and access to suitable critical care services might necessitate earlier operative intervention—a rationale supported by the higher rates of negative laparotomies observed in the lower-resource settings. Patients recruited from lower-resource settings were also less injured, which could also suggest a survival bias whereby those more severely injured patients in lower-resource settings succumbed to their injuries before ever arriving at hospital.

There have been growing calls for improvement in paediatric surgical care services, across infrastructure, service delivery, training, and research.[44] However, optimal trauma care is not just confined to the operating theatre; rather it relies on injury prevention and ongoing interactions between health-care services and professionals within a pre-existing health-care system, from the time of injury to eventual rehabilitation. Although we observed mortality rates nearly six times higher in lower-resource settings, we also observed discrepancies in care across the inpatient trauma pathway; paediatric cases in the lower HDI tertile were significantly less likely to receive tranexamic acid or blood products, undergo a CT scan, or receive post-operative organ support than those in middle and upper HDI tertiles. Moreover, lower proportions of consultant-led care were observed in the lower-resource settings, similar to the overall cohort.[3] Discrepancies in care globally have previously been shown in paediatric surgery for congenital conditions,[45] and this work demonstrates that these discrepancies extend beyond the theatre setting to pre-operative and post-operative care. Even if a hospital can manage adult trauma patients appropriately, a scarcity of age-specific equipment, staffing, pathways, and infrastructure can limit the hospital's ability to manage a paediatric trauma

	Lower HDI (n=110)	Middle HDI (n=89)	Upper HDI (n=38)	Total (n=237)	p value
In-hospital 30-day mortality	11 (10%)	5 (6%)	3 (8%)	19 (8%)	0·53
Post-operative organ support (any)	26 (24%)	40 (45%)	21 (55%)	87 (37%)	<0·0001
Post-operative cardiovascular support	17 (15%)	26 (29%)	13 (34%)	56 (24%)	0·019
Post-operative respiratory support	13 (12%)	30 (34%)	17 (45%)	60 (25%)	<0·0001
Return to theatre*	8 (7%)	8 (9%)	11 (29%)	27 (11%)	0·0009
Discharge destination	..	..	..	..	<0·0001
Usual place of residence	86 (78%)	67 (75%)	21 (55%)	174 (73%)	..
Transfer to another hospital	4 (4%)	8 (9%)	0	12 (5%)	..
Transfer to rehabilitation unit	0	1 (1%)	4 (11%)	5 (2%)	..
Remains in hospital	8 (7%)	8 (9%)	10 (26%)	26 (11%)	..
Absconded	1 (1%)	0	0	1 (<1%)	..
Discharged to usual place of residence with same level of care†	57/86 (66%)	52/67 (78%)	16/21 (76%)	125/174 (72%)	0·27

Data are n (%) or n/N (%), unless otherwise stated. p values represent comparisons across all three tertiles. HDI=Human Development Index. *Of patients who survived the index operation. †Of patients who were discharged to their usual place of residence, the number for whom the level of care was reported.

Table 3: **30-day in-hospital post-operative outcomes**

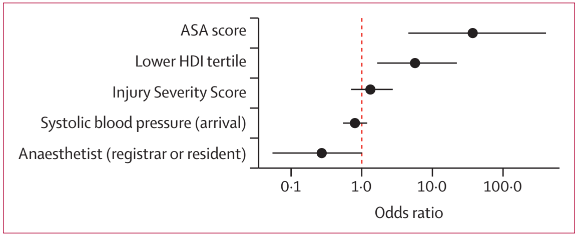

Figure 3: **Post-operative mortality in the post-LASSO logistic regression model**
Error bars in the forest plots represent 95% CIs. ASA=American Society of Anesthesiologists. LASSO=least absolute shrinkage and selection operator.

population. Beyond the burden of mortality, further increased costs for the health-care system derive from higher complication rates and ongoing care burden.

The vast majority of current formalised trauma care services have largely been designed with adult populations in mind.[46] However, paediatric populations have distinct physiological characteristics and care requirements that necessitate a dedicated and tailored management pathway to ensure optimal outcomes.[47] Indeed, the physiological and anatomical differences in children, alongside the likely differences in mechanism of injury, rehabilitation burden, and social care needs mean that best-practice adult trauma care does not necessarily translate into optimal trauma care for children. In the overall GOAL-Trauma dataset,[3] discrepancies in care were also observed across the patient pathway; however, many of these seemed much more pronounced in the paediatric population. For example, significantly longer delays were demonstrated in the lower HDI tertile than in the middle or higher HDI tertiles for the time taken from injury for arrival to hospital, a decision made to operate, and the start of the procedure, suggesting a more limited system functioning in these settings. Delays to treatment might also reflect the varying mechanisms of injury, specific injuries sustained, and eventual procedures performed across the settings. Such system limitations were further demonstrated by sizable differences in the rates of returning to theatre and use of rehabilitation hospitals across settings, suggesting generally weaker health-care systems in lower-resource settings. According to the UN World Population Prospects 2024, children account for almost half the population in many parts of the world, and have to date been neglected from health service design.[48,49] A systematic and integrated approach that explicitly incorporates all such elements into a dedicated paediatric trauma pathway, alongside improvements to training, equipment, and staffing, has the potential to substantially enhance the quality, timeliness, and equity of care for this vulnerable patient population.

For the **UN World Population Prospects 2024** see https://population.un.org/wpp/

This dataset is one of the largest on global paediatric trauma surgery, providing clear targets for improvement across the trauma pathway for paediatric patients across all income settings. However, as an observational study, we have been cautious not to infer direct causality from our findings, given the complexity that lies with trauma care and that causal chains might be non-linear.[18] Similarly, as with all observational studies, selection bias and unmeasured confounders will influence these findings, and further caution is advised in the interpretation of the results; in attempt to address this, we ensured the use of a consensus-derived directed acyclic graph in data analysis to ensure appropriate representation of all relevant variables and adjustment for patient-level and system-level factors. A high proportion of our centres were both tertiary hospitals and located in urban areas, a common issue with global observational studies on emergency care,[50] which limits the applicability of these study findings in more rural settings. Categorisation of certain variables, such as staff grade, allowed for comparison across settings, but does result in a loss of nuance within these categories. Due to the data collection being focused around the in-hospital setting, mortality events that occurred pre-hospital were not recorded, leading to a possible survival bias, while any death occurring post-discharge that was not included might lead to a potential under-estimation of the true 30-day mortality rates. Finally, as a post-hoc analysis of the GOAL-Trauma Study,[3] the study might not be sufficiently powered to detect variation and risks type 2 error.

In this global multicentre prospective observational study, we demonstrate significant inequity across global trauma paediatric care and a sizeable variation in mortality risk across resource settings. This work produces a clear call for the planning and implementation of paediatric-specific trauma pathways and systems worldwide if global standards of care for children are to be improved. The provision of age-specific equipment, implementation of appropriate paediatric referral pathways, and training of staff are core to this cause. Currently, with clear differences in infrastructure, resources, and staffing across resource settings in paediatric trauma care, a system approach is vital if such apparent inequities are to be addressed.

Contributors
MFB and TB contributed to study design, data collection, data analysis, data interpretation, and writing. JA, ZBP, and TCH contributed to study design, data collection, data interpretation, and writing. LH, BGS, KK, and TGW contributed to study design, data analysis, data interpretation, and writing. RA contributed to data analysis, data interpretation, and writing. SMA, IC, RS, EC, and CMN-G contributed to data collection, data interpretation, and writing. SN, DKK, and KL contributed to data interpretation and writing. RA, MFB, and TB accessed and verified the data. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declarations of interests
We declare no competing interests.

Data sharing
Data are available to any researcher who provides a methodologically sound study proposal that is approved by the Global Outcomes After Laparotomy for Trauma (GOAL-Trauma) steering committee. Proposals can be submitted to the International Health Systems Group at the University of Cambridge. Individual patient or hospital data will not be identifiable in any released data and all appropriate information governance protocols will be followed.

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