Assessing the capacity and equity of major trauma services for adult patients in the East of England Trauma Network a decade after its establishment (2013–2021)

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ABSTRACT

Background The number of trauma patients in the East of England Trauma Network has been steadily increasing since 2013, raising concerns about whether the existing design (one Major Trauma Centre (MTC) with 12 trauma units (TUs)) can effectively meet the region's trauma care needs. This study assessed service capacity and patient pathway utilisation and outcomes to determine if the existing design serves the TN's growing population and changing needs.

Methods We analysed 9 years (2013–2021) of Trauma Audit and Research Network data to evaluate bed occupancy trends, service outcomes (predicted and realised survival rates and Glasgow Outcome Scale scores), and patient pathway patterns (direct-to-MTC, transfer-to-MTC and direct-to-TU) by patient demographics (age, sex and index of multiple deprivation (IMD) 2019). We used Injury Severity Score (ISS) >15 to define major trauma.

Results MTC bed occupancy rose steadily, frequently exceeding the planned capacity of 75 beds since 2018. Notably, 61.8% of major trauma patients were managed entirely in TUs. Yet, the direct-to-TU pathway showed a lower mean of realised survival rates compared with predictions despite managing less severe cases compared with direct-to-MTC (mean ISS 21.2 vs 26.2). Significant disparities in access to the MTC (including transfer-to-MTC) were found for elderly patients (23.5% vs 51.3% for younger patients), women (31.4% vs 42.9% for males) and those residing in IMD deciles 1–2 (31.1% vs 39.1% for the rest).

Conclusion The current network design shows significant capacity demands and disparities in access and outcomes. This highlights the need for strategic service redesign, enhanced TU capabilities and targeted policies to ensure equitable access to specialised trauma care across the network.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The East of England Trauma Network (EoE TN), established in 2012 with a single Major Trauma Centre (MTC), experiences challenges in delivering specialised trauma care due to its large geographic catchment and increasing cases of major trauma, particularly among the elderly.

WHAT THIS STUDY ADDS

⇒ The MTC frequently operates at or beyond its planned capacity, while a substantial proportion of patients with Injury Severity Score >15 (major trauma) are managed entirely by trauma units (TUs), which observe lower survival rates than predicted, despite handling less severe cases.

⇒ Disparities in access to MTC services are found in vulnerable populations, particularly for elderly patients, women and those from deprived areas.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study demonstrates the urgent need for a strategic reassessment of the EoE TN's configuration and resource allocation, while identifying demographic groups requiring targeted interventions to improve equity of access and outcomes.

⇒ As such, it may inform trauma care—especially in regions with dispersed populations served by a single MTC—by supporting the advocacy of improved triage protocols, enhanced TU resources and age-specific trauma care strategies to address systemic inequities and potential demographic shifts.

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INTRODUCTION

Major trauma poses a significant burden on healthcare systems globally with an estimated 22 000 UK patients requiring complex care delivery annually.[1] Delivering timely, high-quality care is crucial for improving survival and recovery outcomes given the time-sensitive nature of severe injuries.[2–4] Trauma systems worldwide are struggling to balance the centralisation of resources and expertise against geographical access, particularly as older adults comprise an increasing proportion of major trauma patients.[5]

Regional trauma networks (TNs) were established across the UK in 2012, aimed at creating an inclusive system to minimise death and disability from trauma. These networks operate a tiered model with Major Trauma Centres (MTCs) providing comprehensive care for complex injuries supported by local trauma units (TUs) that manage less severe trauma cases and stabilise patients requiring transfer to an MTC. Prehospital teams triage patients based on physiological and clinical findings, and whether an MTC can be reached within a critical time frame (45 min for East of England (EoE)).[6] Patients may transition to a TU for further care and rehabilitation after discharge from an MTC.

The EoE TN serves a population of 6.6 million residents with a single MTC at Addenbrooke's Hospital (Cambridge University Hospital Trust), supported by 12 TUs.[7] This configuration, and the MTC's capacity of 75 beds, was designed for a population of 5.7 million based on modelling completed in 2010.[8] However, significant demographic change has occurred in the region, with older adults comprising over 50% of cases with an Injury Severity Score (ISS) >15 in 2021 compared with 37% in 2012.[9] This presents unique challenges as major trauma in older adults is often overlooked due to age-related physiological differences and the limitations of standard triage criteria.[10–12]

Geographic challenges further complicate trauma care delivery, with only 20% of historic EoE ISS >15 patients residing within the catchment area of its single MTC.[13] Secondary transfers, while necessary in geographically dispersed regions, are associated with delayed imaging, surgery and higher crude mortality.[14] Despite these growing demands and demographic shifts, the EoE TN's capacity and design have not been systematically reassessed since its inception.

This study evaluates three aspects of network performance: (1) trends in MTC capacity to understand resource constraints; (2) patient outcomes across treatment pathways and (3) disparities in access to MTC services. Through this analysis, we aim to provide evidence-based insights for optimising trauma care delivery and ensuring equitable access across the network.

METHODS

Design and study population

We employed a retrospective analysis of trauma services in the EoE TN, focussing on three key metrics: bed occupancy, admission pathway outcomes and access patterns. We utilised 9 years (2013–2021) of data from the Trauma Audit and Research Network (TARN). TARN served as the national clinical audit for TNs in England and Wales and was replaced by the National Major Trauma Registry in 2024.

Each TARN data entry (submission) represents a single patient admission to a hospital. We constructed unique patient-incident pairings as individual patient journeys (hospital spells, ie, a chain of hospital stays) by matching patient identifiers (anonymised patient ID number, age, sex, incident date, arrival date at the hospital) and transfer patterns (transfer, previous hospital, next hospital). Only adult patients (≥18 years old) in the TARN data were included (figure 1) as the variability in paediatric injury patterns requires separate analysis. 'Trauma beds' refers to any inpatient bed occupied by a TARN-eligible patient, regardless of ward location. The planned capacity of 75 beds refers to the ability of the MTC to manage 75 patient admissions based on the expected availability of resources that operational capacities allow including staff and operating theatre capacities.

The ISS determines the severity of injury on a scale from 1 to 75, with a higher score indicating worse severity. ISS >15 is commonly used to define potential major trauma in research and clinical contexts and has demonstrated moderate sensitivity in predicting mortality from common causes of injury in patients.[15] While ISS is a proxy measure rather than an absolute determinant of clinical need, it enables standardised comparisons of trauma populations across healthcare systems.[16] Therefore,

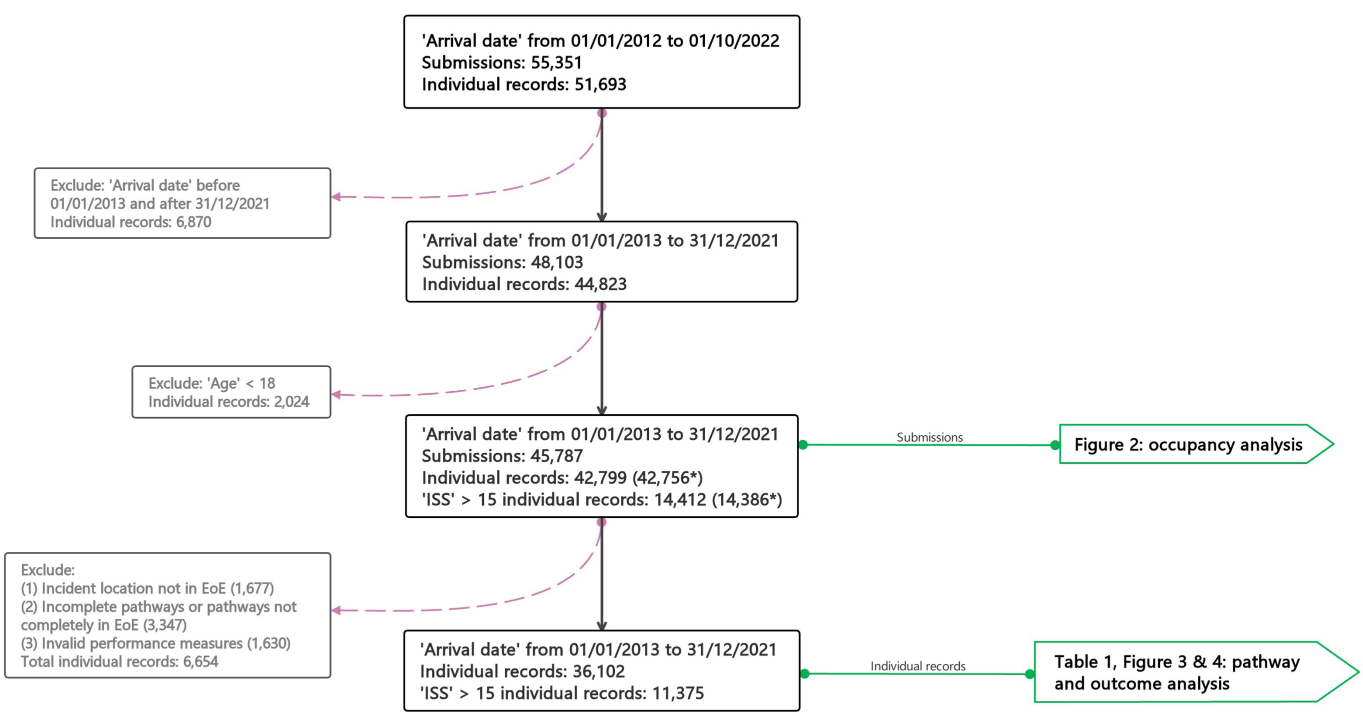

Figure 1 Data inclusion/exclusion criteria. For the incomplete, inaccurate or missing TARN incident postcode data we used the 'Postcodes.io' API (a UK Postcode & Geolocation API) to attempt auto-completion. If that failed (likely representing incorrect or missing data, approximately 21%), we used the patient's home postcode as a proxy for the incident postcode. *In addition to the pathway build and exclusion criteria that we used, we performed a manual check of data and further aggregated the same-incident–same-patient submissions to individual records, which affected <45 individual records (0.1% of the whole individual records). The selections afterwards are based on the samples after this manual check. EoE, East of England; ISS, Injury Severity Score; TARN, Trauma Audit and Research Network.

in our analysis, we define ISS >15 as patients with potential major trauma and an ISS of 9–15 as moderately severe trauma. NHS England service specification recommends potential major trauma patients ('candidate' major trauma patients) for treatment at an MTC where travel times allow.[17]

Measures

We chose three quality indicators specified by TARN to evaluate the treatment outcome of ISS >15 patients: probability of survival 'Ps' (patient-specific survival probabilities estimated by TARN retrospectively before hospital treatment), outcome at 30 days (1: 'alive', 0: 'dead') and the Glasgow Outcome Scale (GOS) score. We calculated 'predicted survival rates' as the monthly average of Ps and the 'realised survival rates' as the monthly average of the outcome at 30 days field in TARN data for the last submission for each case. We reported the GOS at the last hospital admission ('unadjusted') or the most recent available GOS submission for each pathway ('imputed' as last observation carried forward), sorted by 'arrival date'. If there are no GOS submitted for a patient, we report it as 'not available'.

We used three broad pathway categories based on whether MTC has been part of the patient's care: in direct-to-MTC, patients are directly admitted to the MTC; in direct-to-TU, patients are admitted to a TU and receive their treatment in one or multiple TUs; and in transfer-to-MTC, patients are initially taken to a TU, but then transferred to MTC. Each pathway may experience multiple hospitals. Therefore, instead of using TARN's case-mix standardised outcomes (Ws), which are hospital specific, we reported the crude realised survival rates.

We explored inequalities in MTC pathway admission by patient demographics, including area-based deprivation deciles, using the index of multiple deprivation (IMD) 2019,[18] measured at the scale of Lower Super Output Areas (LSOAs) across England linked to patients' home postcodes.

Analysis

We aggregated hospital submissions (45 787 entries) to daily bed occupancy (ie, the number of patients in the hospital on a given day) from 1 January 2013 to 31 December 2021. To understand the daily time series data dynamics, we decomposed (ie, broke down) the bed occupancy into three components ('trend', 'day of the week' seasonality and 'day of the year' seasonality), and an error term that captures the idiosyncratic changes that these three components do not capture with an additive regression model using Facebook Prophet, an open-source time-series forecasting tool.[19] Facebook Prophet has recently been adopted to study the healthcare time series patterns such as daily emergency department visits and COVID-19 cases.[20 21] For the decomposition, we did not include the data during the COVID-19 pandemic (1 January 2020 to 31 December 2021) when the demand and service patterns and clinical processes may have changed temporarily in order not to confound the analysis.

For the continuous variables (predicted and realised survival rates), we reported mean, median, IQR, whiskers and CIs (in the

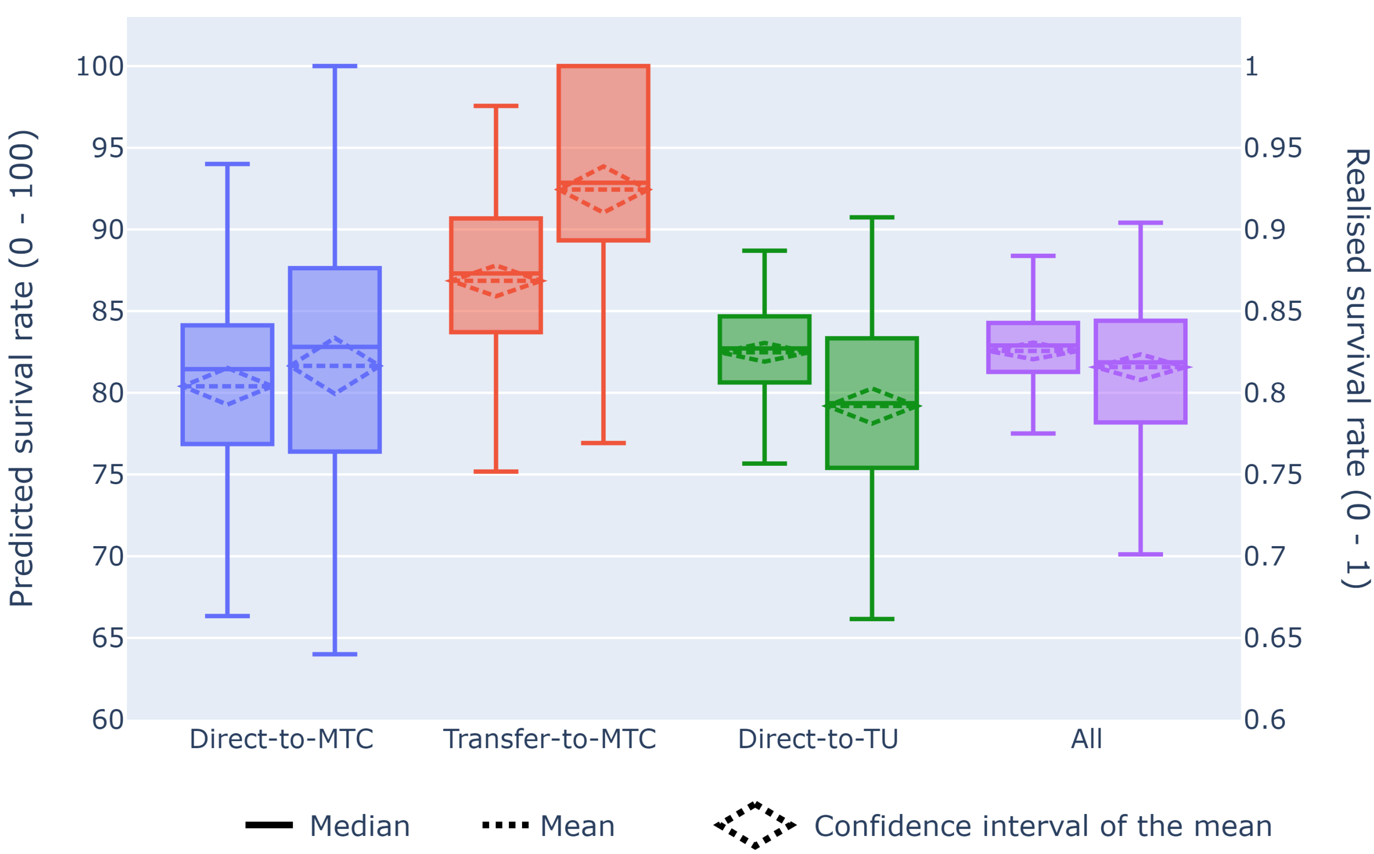

Figure 2 Outcome box plots (2013–2021 data). In the box plots, the box covers the 25%–75% quantiles, including the median (solid horizontal line), for each outcome measure. The whiskers are determined by the 1.5 IQR. The means are plotted as dashed lines, and the 95% CIs for the means are plotted as dashed diamonds. For each pathway, the first box plot represents the predicted survival rate (left y-axis), and the second box plot represents the realised survival rate (right y-axis). Extended box plots show both means with confidence intervals and medians with quantiles/IQR, enabling detailed comparisons of central tendency and variability. MTC, Major Trauma Centre; TUs, Trauma Units.

Outcome differences in pathways in the EoE Trauma Network section, figure 2) to offer a comprehensive visualisation of data. We performed t-tests to compare means. In the Pathway patterns in the EoE trauma network section, we used one-tailed χ^2 tests to compare the proportions of specific pathway choices (direct-to-MTC and direct-to-TU) between two groups, focusing on differences in a specific direction (greater or less than).

In the Outcome differences in pathways in the EoE Trauma Network section, one-tailed χ^2 tests were conducted to evaluate directional differences (greater or less than) in GOS outcome category proportions between two pathways, while a two-tailed χ^2 test was used for a non-directional comparison. Additionally, in in the Outcome differences in pathways in the EoE Trauma Network section, one-tailed t-tests were employed to compare the means of predicted and realised survival rates, considering directional differences (greater or less than).

For patients with ISS>15, we performed a further breakdown of the ISS. Although ISS=25 is often considered as a cut-off for identifying very severely injured patients, existing literature provides little guidance for stratifying patients within the ISS 16–24 range. Lacking specific clinical directives, we employed a statistical approach to balance the sample, stratifying patients into four ISS groups: 16–17, 18–21, 22–26 and 27–75. These ranges' upper bounds were selected to approximate the 25th, 50th, 75th and 100th percentiles of our dataset's ISS distribution.

Patient and public involvement statement

This research employed secondary data analysis of clinical audit data for capacity needs assessment. There was no patient or public involvement in the conception or design of this study.

RESULTS

Trends in bed occupancy in the EoE Trauma Network

Both the TN and MTC experienced rising daily bed occupancy over time (figure 3g, h). The TN's average daily occupancy climbed from 158 beds in 2013 to 212 in 2021, while the MTC occupancy rose from 42 to 76 beds. ISS>15 patients constituted the majority of daily MTC bed occupancy, and their growth (from 27 to 48 beds, an over 75% increase) significantly contributed to the overall rise. In TUs, ISS 9–15 patients were the most frequent occupants, but ISS >15 cases also showed a gradual increase, rising from an average daily occupancy of 27 beds in 2013 to 37 (a 37% increase) in 2021.

In figure 3, we displayed the daily bed occupancy in MTC (figure 3g) and TUs (figure 3h) and analysed the underlying components of daily bed occupancy in MTC (figure 3a, c and e) and TUs (figure 3b, d and f) for all trauma cases. We decomposed daily occupancy (using 2013–2019 data) into 'trend', and 'day of the week' and 'day of the year' seasonality. For the MTC, the decomposition revealed an overall upward 'trend' from 2013 to 2018 (figure 3a), followed by a plateau reached in mid-2018, with occupancy maintained around the low 70s. Around the same time in 2018, TUs occupancy exhibited a turning point, where a previously downward 'trend' shifted to an upward one (figure 3b). The MTC and TUs displayed a 'day of the week' seasonality

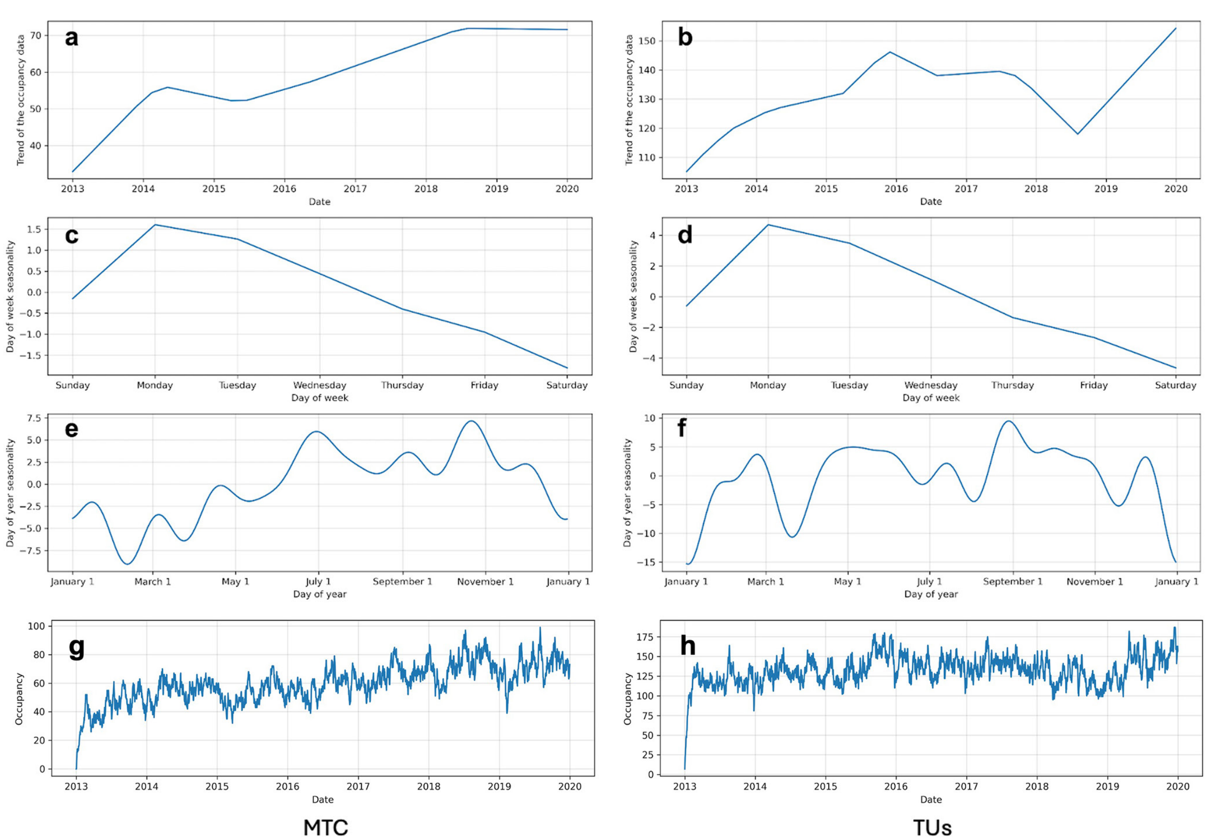

Figure 3 Decomposition of daily bed occupancy (all trauma cases, 2013–2019) in the MTC (a, c and e) and TUs (b, d and f). Panels a and b display the 'trend', c and d the 'day of the week' seasonality, and e and f the 'day of the year' seasonality. Panels g and h display the total bed occupancy for MTC and TUs, respectively. MTC, Major Trauma Centre; TUs, Trauma Units.

Table 1 Pathway statistics for ISS>15 patients (2013–2021 data) with 95% CIs

Cohort	Population		Mean ISS	Direct-to-MTC	Transfer-to-MTC	Direct-to-TU
	All	11 375		24.7% (23.9%, 25.5%)	13.5% (12.9%, 14.1%)	61.8% (60.9%, 62.7%)
	Mean ISS		23.1 (23.0, 23.3)	26.2 (25.8, 26.5)	26.5 (26.1, 26.9)	21.2 (21.0, 21.3)
ISS	16–17	3994	16.4 (16.4, 16.4)	17.2% (16.0%, 18.4%)	5.7% (5.0%, 6.4%)	77.1% (75.8%, 78.4%)
	18–21	1704	19.6 (19.6, 19.7)	23.9% (21.9%, 26.0%)	8.5% (7.2%, 9.8%)	67.5% (65.3%, 69.8%)
	22–26	3640	25.0 (24.9, 25.0)	21.9% (20.5%, 23.2%)	19.2% (17.9%, 20.5%)	58.9% (57.3%, 60.5%)
	27–75	2037	35.8 (35.5, 36.2)	45.1% (43.0%, 47.3%)	22.9% (21.1%, 24.8%)	32.0% (29.9%, 34.0%)
Age	<75 years old	6014	24.5 (24.3, 24.7)	31.8% (30.6%, 33.0%)	19.5% (18.5%, 20.5%)	48.7% (47.4%, 49.9%)
	≥75 years old	5361	21.6 (21.4, 21.7)	16.7% (15.7%, 17.7%)	6.8% (6.1%, 7.5%)	76.5% (75.3%, 77.6%)
Sex	Male	6759	23.7 (23.5, 23.9)	27.5% (26.4%, 28.5%)	15.4% (14.6%, 16.3%)	57.1% (55.9%, 58.3%)
	Female	4616	22.3 (22.1, 22.5)	20.7% (19.5%, 21.9%)	10.7% (9.8%, 11.6%)	68.6% (67.2%, 69.9%)
Mechanism of injury	Fall less than 2 m	6363	21.2 (21.0, 21.3)	16.8% (15.9%, 17.7%)	9.3% (8.6%, 10.1%)	73.9% (72.8%, 74.9%)
	Vehicle incident/ collusion	2655	26.8 (26.4, 27.2)	42.7% (40.8%, 44.6%)	18.9% (17.4%, 20.4%)	38.4% (36.6%, 40.3%)
	Fall more than 2 m	1476	24.8 (24.3, 25.2)	26.7% (24.4%, 28.9%)	17.7% (15.7%, 19.6%)	55.6% (53.1%, 58.2%)
	Blow(s) without weapon	432	22.3 (21.7, 22.9)	22.9% (18.9%, 26.9%)	32.4% (28.0%, 36.8%)	44.7% (40.0%, 49.4%)
	Stabbing	121	22.0 (20.4, 23.7)	21.5% (14.1%, 28.9%)	16.5% (9.8%, 23.2%)	62.0% (53.2%, 70.8%)
	Others	328	25.2 (24.4, 26.1)	26.8% (22.0%, 31.6%)	6.4% (3.7%, 9.1%)	66.8% (61.6%, 71.9%)
IMD decile*	1–2	1207	23.5 (23.0, 23.9)	12.3% (10.5%, 14.2%)	18.7% (16.5%, 20.9%)	68.9% (66.3%, 71.5%)
	3–4	2066	23.3 (22.9, 23.6)	16.9% (15.3%, 18.6%)	15.4% (13.8%, 17.0%)	67.7% (65.6%, 69.7%)
	5–6	3016	23.2 (22.9, 23.5)	23.7% (22.2%, 25.2%)	12.5% (11.3%, 13.7%)	63.8% (62.1%, 65.5%)
	7–8	2529	22.8 (22.5, 23.1)	28.9% (27.1%, 30.7%)	12.7% (11.4%, 14.0%)	58.4% (56.5%, 60.3%)
	9–10	2455	22.9 (22.6, 23.2)	34.1% (32.2%, 35.9%)	10.9% (9.6%, 12.1%)	55.1% (53.1%, 57.0%)

*We do not have the IMD decile for 102 patients (<1% of the data).
ISS, Injury Severity Score; MTC, Major Trauma Centre; TUs, Trauma Units.

(figure 3c, d) with higher occupancy Mondays through Wednesdays. Additionally, a ‘day of the year’ seasonality (figure 3e, f) was observed, with higher occupancy during the summer and autumn months.

Pathway patterns in the EoE Trauma Network

From 2013 to 2021, there were a total of 11 375 ISS >15 patients; 2811 (24.7%) of those were in the direct-to-MTC pathway, 1537 (13.5%) were in the transfer-to-MTC pathway and 7027 (61.8%) were in the direct-to-TU pathway (table 1). The mean ISS was 26.2, 26.5 and 21.2 for these pathways, respectively. The mean ISS for direct-to-TU was lower than direct-to-MTC (21.2 vs 26.2, $p<0.0001$).

There are multiple areas of interest in table 1; however, we only highlight the notable results including ISS, age, sex and the common mechanisms of injury. Increasing ISS is associated with a greater likelihood of MTC care, whether via direct admission or transfer. Outside the most severely injured subgroup (ISS 27–75), the majority of patients were managed entirely within TUs. Even within the highest ISS subgroup, a substantial proportion (32%) still received their entire care within TUs. Elderly patients (≥75 years old) were less likely to be treated at the MTC (including transfer-to-MTC) (23.5% compared with 51.3% for patients aged 18–74 years old, $p<0.001$) and women showed lower MTC access (31.4% including transfer-to-MTC) compared with men (42.9% including transfer-to-MTC) ($p<0.001$). Patients with low falls were less likely to be treated at the MTC (26.1%, including transfer-to-MTC) compared with those involved in vehicle incidents/collisions (61.6%, including transfer-to-MTC) ($p<0.001$). More than half of the patients with high falls (55.6%) and stabbing (62%) were treated in TUs. For patients with blows without weapons, this percentage was lower (44.7%), mostly due to transfers to MTC. Finally, 31.1% of patients residing in the most deprived areas (IMD deciles 1 and 2) had access to MTC (including transfer-to-MTC), lower than the rest (39.1% (not reported in table 1) for IMD deciles 3–10) (p<0.001). Although the neighbouring deciles are not necessarily statistically different in table 1, direct-to-MTC access has a decreasing trend with increasing patient deprivation.

To further examine the patterns in ISS, we replicated the analysis from table 1 for the ISS subgroups 16–17, 18–21, 22–26 and 27–75 (online supplemental tables S1a–S1d in the supplemental file). Within each ISS subgroup, we consistently observed a higher proportion of elderly patients receiving their entire care within TUs. For instance, in the lowest ISS group (ISS 16–17; online supplemental table S1a), 69.1% of patients aged 18–74 years old were treated in TUs compared with 83.3% of elderly patients. This pattern persisted across higher ISS subgroups; even in the most severely injured group (ISS 27–75; online supplemental table S1d), a clear difference remained (22.6% for patients aged 18–74 years old compared with 60.3% for elderly patients). Similarly, online supplemental tables S1a–S1d also reveal disparities in MTC access across sex, mechanism of injury and IMD deciles within each ISS subgroup, suggesting that these gaps persist even after accounting for injury severity.

Outcome differences in pathways in the EoE Trauma Network

Figure 2 displays the statistics of predicted and realised survival rates in different pathways. The whiskers (IQR) show variation in the monthly outcomes. The mean of predicted survival rates for direct-to-TU was 82.5%, higher than 80.4% for direct-to-MTC (p=0.0007), while the mean of realised survival rates for direct-to-TU was 79.2%, lower than 81.6% for direct-to-MTC (p=0.0085).

Figure 4 displays GOS outcomes in different pathways. In direct-to-MTC, transfer-to-MTC and direct-to-TU, 3.3%, 10.5% and 28.9% of pathways did not have a GOS record; therefore, we also included the percentages based on the imputed GOS. Imputing the missing GOS values does not considerably alter the results except for '(iv) moderate disability' in the transfer-to-MTC pathway.

In contrast to a lower GOS death rate (8.1% vs 18.9%, p<0.001), the transfer-to-MTC pathway displayed a higher percentage (32.1% unadjusted, 38.5% imputed) of patients recovering with disabilities (categories ii–iv) compared with the direct-to-MTC pathway (25.8% unadjusted, 27% imputed) (p<0.001 for unadjusted and imputed). Severe disabilities to deaths (categories i–iii) were not significantly different (23.8% vs 22.9% unadjusted, p=0.349) in the direct-to-MTC and direct-to-TU pathways.

DISCUSSION

Our analysis of 9 years of TARN data reveals interconnected challenges facing the EoE TN including (1) capacity constraints impacting service delivery; (2) outcome disparities across treatment pathways and (3) inequitable access across demographic groups. These findings suggest that the current network design, established a decade ago, requires strategic adaptation to meet evolving population needs.

Capacity constraints at the MTC

Bed occupancy levels in the EoE TN have been steadily increasing, especially at the MTC for patients with an ISS >15, exceeding planned capacity in recent years. Our decomposition analysis shows that MTC bed occupancy reached a plateau at around 72 beds since 2018, suggesting the capacity is saturated. This coincides with an inflection point in TU occupancy, suggesting spillover cases are being diverted to TUs within the network as limited MTC bed availability may delay or prevent transfers.

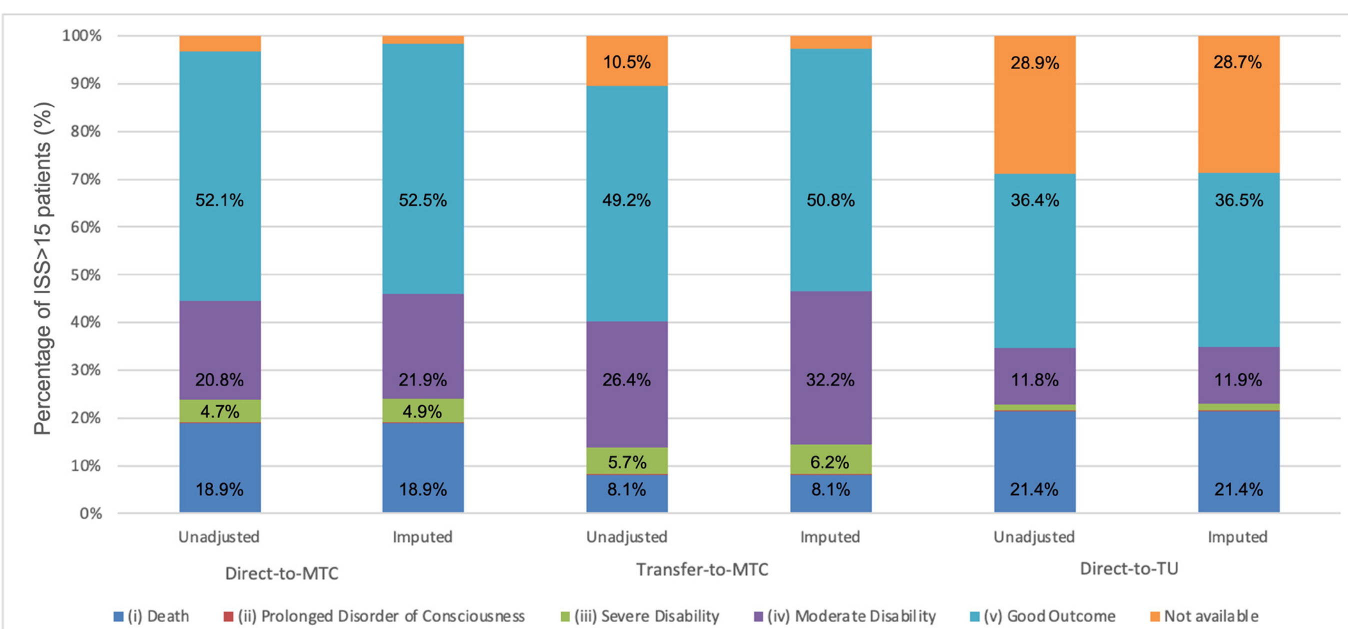

Figure 4 GOS outcomes by patient pathway (2013–2021). GOS is a scale that categorises the recovery of patients with brain damage in five categories: (i) death, (ii) prolonged disorder of consciousness, (iii) severe disability, (iv) moderate disability and (v) good recovery. GOS data are not available for all submissions and are recorded as 'not available' for the missing ones. GOS is recorded at each stage of the patient pathway and may change; we reported both the GOS at the last hospital ('unadjusted') and the last non-'not available' GOS submission for each patient pathway (last observation carried forward) sorted by 'arrival date' of the submissions ('imputed'). If all submissions in a pathway reported 'not available' GOS, we reported the GOS of the pathway as 'not available'. GOS, Glasgow Outcome Scale; MTC, Major Trauma Centre; TUs, Trauma Units.

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The concurrent rise in ISS >15 occupancy at TUs (37% increase from 2013 to 2021) supports this interpretation.

This outcome has significant implications for TNs throughout England, which have shown similar increases in MTC admissions by moderately severe and major trauma patients over time.[22] Additionally, our analysis revealed higher bed occupancy on weekdays (Monday–Wednesday) and during summer and autumn months, consistent with previous research.[23 24] This suggests that, in addition to expanding capacity, the EoE TN may need to adapt capacity and service allocation strategies to account for seasonal demand variations.

Outcome disparities across pathways

Our findings show, contrary to NHS England specification for major trauma care[17]; less than 40% of ISS >15 cases were treated at the regional MTC, substantially lower than the 75% observed for the single MTC of the South West London and Surrey TN in 2014.[25] While focused on a specific region, our outcomes offer a more detailed perspective that complements a national study of England TN, which reported 60% of trauma patients (all ISS) were treated entirely within TUs.[26]

While direct-to-TU had a lower mean of ISS (21.2 vs 26.2) and a higher mean of predicted survival rates compared with patients treated in the MTC (direct-to-MTC), there were disparities in actual crude 30-day realised survival rates. The direct-to-MTC pathway exceeded the mean of predicted survival rates by 1.2% (80.4% vs 81.6%). Conversely, the direct-to-TU pathway's mean of realised survival rates was 3.3% lower than the mean of predicted survival rates (82.5% vs 79.2%). Combining death and severe disability for GOS scores across both pathways indicates comparable outcomes, with no significant difference in the incidence of the worst GOS scores (severe disabilities to deaths; 23.8% vs 22.9% for GOS i–iii). Although the transfer-to-MTC pathway displayed a lower GOS death rate, a higher percentage of patients recovered with disabilities (categories ii–iv) in this pathway compared with the direct-to-MTC.

Inequity of access to the MTC

Our analysis revealed that there were systemic disparities in access to the MTC by patient demographics. Elderly patients (≥75 years old) were significantly less likely to be treated at the MTC (including transfer-to-MTC) compared with younger patients (23.5% vs 51.3%). These age disparities have been reported across national TN analysis and support the evidence for improvement in elderly triage.[26] While initial disparities in MTC access between age groups may appear attributable to differences in injury severity, our stratified analysis by ISS subgroups reveals that elderly patients are consistently less likely to access MTC care across all severity brackets. This suggests an age-related disparity in MTC access independent of injury severity, though the potential for residual confounding remains. In addition, women showed lower MTC access (including transfer-to-MTC) compared with men (31.4% vs 42.9%). Certain injury mechanisms such as 'falls less than 2 m' which are more prevalent in older and female patients, and 'stabbing' (despite their low occurrence) are associated with lower MTC admission rates. Patients residing in the most deprived areas (IMD deciles 1 and 2) were more likely to be treated in TUs emphasising the need to address geographic barriers to equitable trauma care. These disparities may raise concerns of healthcare inequity and call for a scrutiny of prehospital triage. An improved prehospital triage can modulate patient pathways and decrease access disparities.

Limitations

While our analysis provides robust evidence for system-level challenges, there are limitations. While data completeness has improved substantially over time, particularly for the MTC which has had over 100% ascertainment since 2018/2019, some TUs may have underreported to TARN, leading to a conservative estimate of capacity needs. Additionally, trauma calls may not be included due to TARN submission criteria, which exclude pre-hospital deaths and admissions shorter than 72 hours.[27]

Our choice to use prepandemic data (2013–2019) for our decomposition analyses may limit our understanding of recent system adaptations. We found nearly 30% of direct-to-TU patients had missing GOS outcomes without any clear pattern for exclusion, which limited our ability to impute and analyse disability outcomes across pathways of this measurement effectively. Over 60% of missing GOS submissions had severe head injuries (Abbreviated Injury Scale 3 and above), suggesting the missing data were not due to a GOS measurement not being warranted.

ISS>15 is a validated measure of major trauma for comparing patient injury across systems internationally.[28] We recognise that ISS alone does not determine the need for MTC care and that some patients may be appropriately treated in a TU if their injury does not require specialist intervention, while others with moderately severe trauma may benefit from expedited MTC care. Future studies should endeavour to include more specific injury patterns and interventions to better determine patients who would benefit most from MTC care.[29] Further details on the reasons for direct versus secondary transfer would also provide useful context on clinical need as factors on clinical judgement, frailty and bed availability are not available in TARN. We were unable to determine the impact of delayed repatriation on MTC capacity, although such patients contributed less than 10% of our patient cohort.

While our study demonstrates a persistent association between age and access to MTC, even after stratifying by ISS, we acknowledge that residual confounding by other factors may influence these findings. Specifically, differences in mechanism of injury, pre-existing comorbidities, variations in patient frailty and geographical access to MTC care were not fully accounted for in our analysis and could contribute to the observed disparities in MTC access. Further causal analysis is encouraged to identify the underlying drivers of these inequalities in MTC access and to provide practical recommendations for improving equity in trauma care triage.

Implications

Our findings have significant implications for TNs facing comparable demographic and geographic challenges, particularly regional networks operating with a single MTC, serving rural or fragmented populations with significant travel times to specialist care, and regions experiencing rapid demographic shifts towards an ageing population. For example, the Dutch trauma system has similar MTC access issues for major trauma patients with further geographical distance, particularly for older patients.[30] Our findings also alert nations to potential challenges associated with regional restructuring such as the networks found in Ireland and Japan.[31 32]

First, the constraints on MTC capacity and pathway utilisation patterns suggest a need to reassess the single MTC model for the region's evolving population needs. This suggests strategic capacity expansion or redistribution based on demand patterns, particularly considering the interconnected nature of capacity across the MTC and TU resource availability.

Second, the outcome disparities across MTC and TU care indicate a need for enhanced support across the network, ensuring that TUs and MTCs are equipped with the clinical capabilities and capacities for their patients. This may involve enhanced support and resources for TUs managing major trauma cases.

Third, the observed inequity of access suggests the need for targeted policy interventions that address both geographic barriers to access and differences in pathway utilisation across demographic groups. In particular, there should be a focus on improving specialised care for elderly patients who represent an increasing proportion of major trauma cases but lower MTC access rates. The NHS England's legal duty, as outlined in the Health and Social Care Act 2012 and Trauma Network Service Specification, mandates the reduction of healthcare access inequalities, which ensures individuals receive equal treatment when seeking specialised trauma care and its timely provision.

Last, we note that limitations in data collection at TUs impeded our ability to perform effective pathway analysis and we suggest TUs are compensated similarly to the MTC best practice tariff to encourage timely and valid submissions. Further research is warranted to understand patient characteristics and geolocations on differential access to explore equity of care, a core dimension of quality and support necessary policy decisions on improving major TNs.

Conclusion

Our analysis of the EoE TN highlights critical challenges in its current trauma care model that may resonate with regional TNs internationally. Capacity constraints at the MTC have increased reliance on TUs, with significant observed outcome disparities. Systemic inequities in MTC access disproportionately affect elderly patients, women and persons from deprived areas. These findings emphasise the urgent need for strategic service redesign to alleviate MTC capacity constraints, enhance TU capabilities and promote equitable access to specialised trauma care, potentially through improved prehospital triage. Without such measures, the current model risks failing to meet the needs of an increasing and ageing population.

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Contributors EK proposed the initial research. MT and CP provided the clinical context of major trauma care and the historical context of the EoE TN. ZL, LR, HJ, FE and EK designed the research questions. ZL prepared the data under LR's and EK's guidance and performed the analyses under FE's and HJ's guidance. ZL, LR, HJ, FE interpreted the results and prepared the initial draft. All authors contributed to revisions and approved the final manuscript. ZL acted as guarantor.

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Ethics approval TARN has Health Research Authority approval (Patient Information Advisory Group (PIAG) Section 251) for research on the anonymised data it holds from NHS Trusts. A formal data transfer agreement was completed between Cambridge Judge Business School and the East of England Trauma Network/TARN. Patient consent and ethical approval were not required as the research presented in this manuscript comprises a secondary analysis of routinely collected clinical audit data. We obtained departmental approval (reference: 23-25) from the Cambridge Judge Business School's Departmental Ethics Review Group.

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