

Supplementary material [web extra material]

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Methods S1: Injury severity scores

Major trauma patients may have one or many injuries and the Injury Severity Score (ISS) is an anatomical score that measures the overall severity of injured patients¹ and is used to predict survival after injury². For an individual patient, all of their injuries are assigned an Abbreviated Injury Scale (AIS)³ code and score from an internationally recognised dictionary that describes over 2000 injuries ranging from 1 (minor injury) to 6 (an injury that is thought to be 'incompatible with life'). Patients with multiple injuries are scored by adding together the squares of the three highest AIS scores in three predetermined regions of the body. This is the ISS, which can range from 1 to 75. By convention, a patient with an AIS code of 6 in one body region is given an ISS of 75.

The ISS has some limitations in the assessment of multiple injuries located in the same body compartment. For example, in a patient with multiple bone fractures, the ISS will only include the most severe bone injury and may underestimate the overall severity by ignoring other significant skeletal injuries. Therefore, a New Injury Severity Score (NISS) has been developed⁴ to include the three most severe AIS values, irrespective of body region, with the aim of taking better account of multiple injuries in the same body region. However, there is no high-quality evidence that NISS is a better predictor of outcome than ISS in major trauma^{5,6}. In this manuscript, therefore, ISS and NISS are reported together.

National major trauma audit is undertaken by the Trauma Audit and Research Network (TARN) on behalf of NHS England. The assignment of AIS codes and scores for the TARN registry are undertaken by trained coders within a quality assurance programme. AIS, ISS and NISS are all reported, with major injury in any one body compartment defined as AIS ≥ 3 .

Figure S1: Greater Manchester Major Trauma System Network

Figure S1 represents the geographical distribution of the Greater Manchester Major Trauma System Network (GMMTSN) operational during the Manchester Arena bombing incident. Central Manchester NHS Foundation Trust (CMFT), Salford Royal NHS Foundation Trust (SRFT) and the University Hospital of South Manchester NHS Foundation Trust (UHSM), blue circles, were designated as major trauma centers (MTC) and function collaboratively as a Level-1 Trauma Centre. The Royal Manchester Children's Hospital, red circle, is the Paediatric Major Trauma Centre (P-MTC). The Royal Albert and Edward Infirmary Wigan (RAEI), the Royal Oldham Hospital and Stepping Hill Hospital Stockport, orange circles, are designated Trauma Units (TU) and each is equivalent to a Level-2 Trauma Centre. Local Emergency Hospitals (LEH) include Bolton, Fairfield Bury, North Manchester and Tameside – green circles – and function as Level-3 Trauma Centres. The location of the Manchester Arena bombing incident is indicated in yellow.

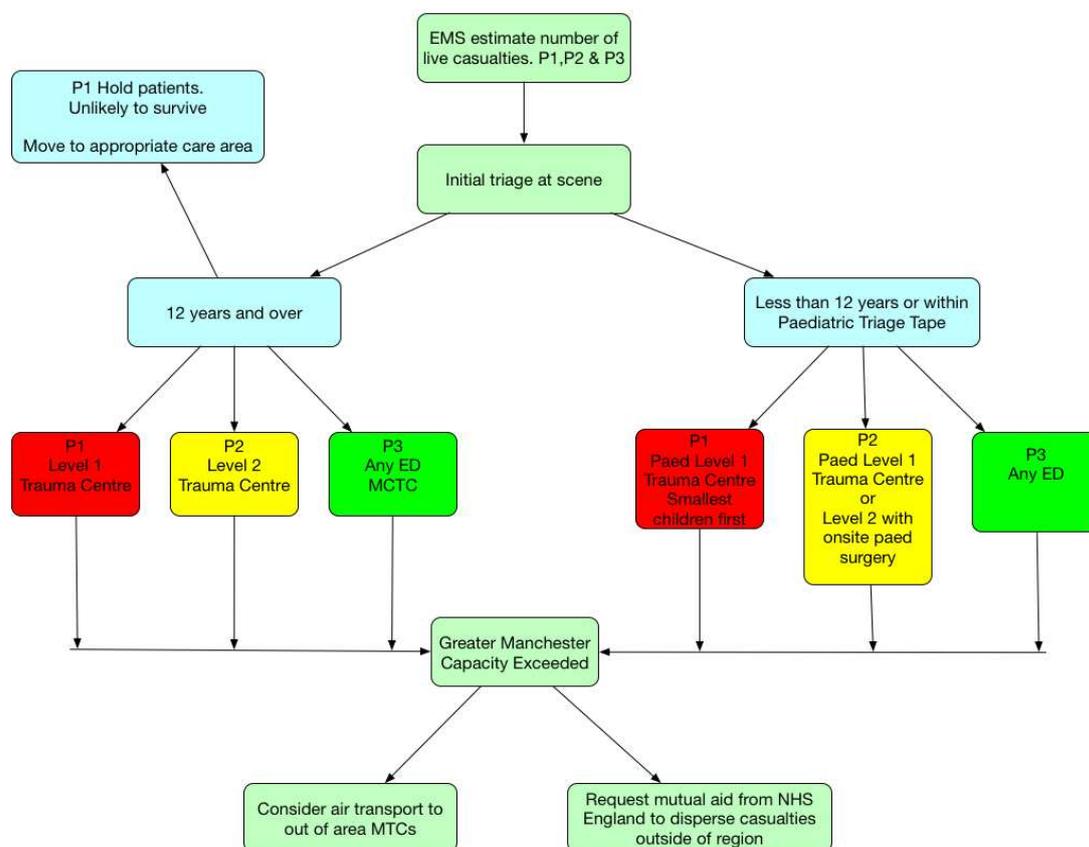
Figure S2: Greater Manchester Major Incident Plan Patient Dispersal Framework

Figure S2 summarises Greater Manchester Major Trauma System Network's Major Incident Plan Patient Dispersal Framework operational in May 2017. The plan resulted from a detailed review of healthcare capabilities across Greater Manchester (GM). The plan was agreed at each hospital in advance of an incident and had been rehearsed at a regional level in March 2017⁷. Three hospitals were designated as Major Trauma Centres (MTC) for seriously injured adult patients assessed at the scene by the Emergency Medical Service (EMS) with a P1 priority sort code (patients who require immediate life-saving treatment), and a single MTC for paediatric patients. Designated trauma units (Level-2 Trauma Centres) receive patients with a P2 priority sort code (patients who require treatment within 6 hours) and other Local Emergency Hospitals (Level-3 Trauma Centres) receive the least seriously injured P3 priority code patients (less serious cases who require treatment but not within a set time). At scene, the EMS selects destinations for P1 patients to ensure that (i) patient flows at each MTC does not exceed its pre-determined capacity of 10 patients per hour and (ii) to transfer patients to MTCs with specializations that patients are likely to need such as neuro-injury at one of the MTC hospitals. The EMS divert patients from unrelated emergencies from the MTCs to the other hospitals to release capacity and the total regional capacity was pre-determined as 300 incident patients in the first 2 hours.

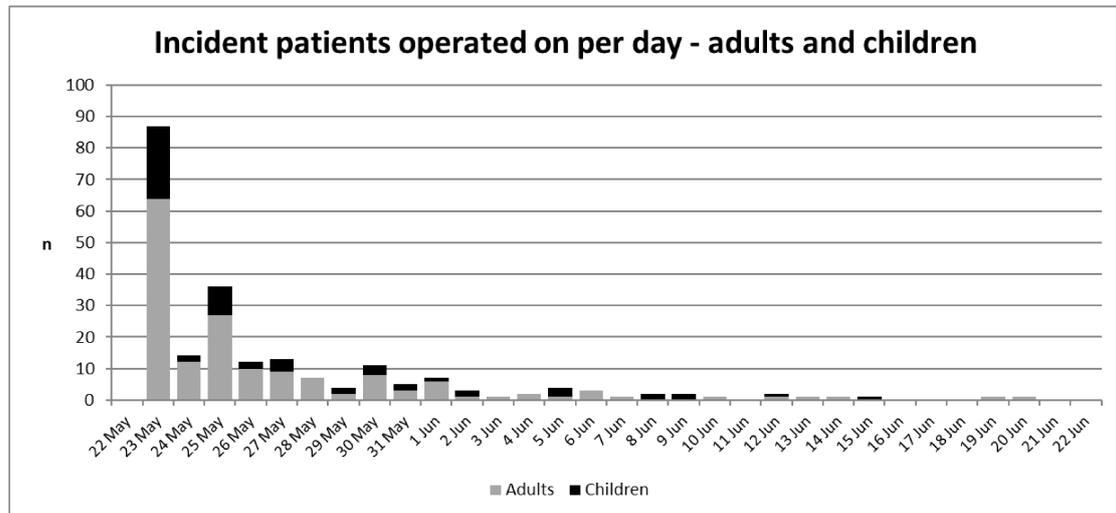
Figure S3: Incident patient operations per day to 30-days

Figure S3 displays daily data for surgical operations performed on incident patients in the first 30-days following the Arena bombing. Data are shown for adults and children. These data provide evidence for a so-called long surgical tail.

Figure S4: Patient attendances at Greater Manchester Major Trauma System Network emergency departments (ED)

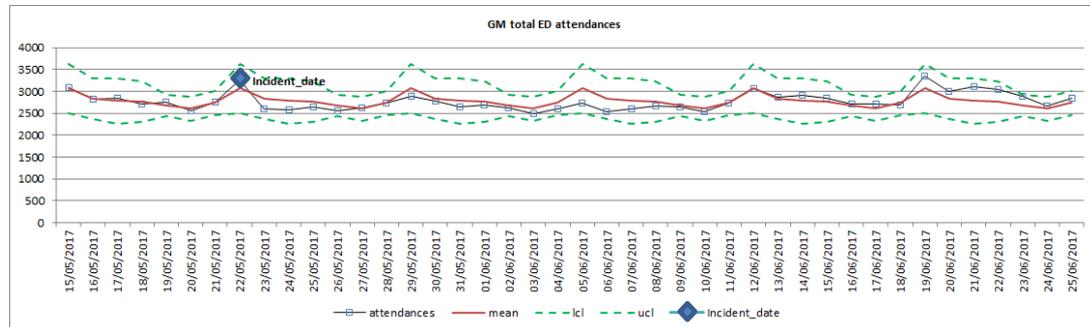


Figure S4 is the Shewhart chart showing patient (adult and children) data for total daily ambulance arrivals at EDs over six consecutive weeks for NHS hospitals across Greater Manchester (GM). Note that Monday 29th May 2017 was a national holiday in England. ED attendances were higher than the predicted mean on the day of the incident. Thereafter, an immediate reduction in ED attendances is apparent for Greater Manchester hospitals, with evidence of sustained reductions (> 7 days).

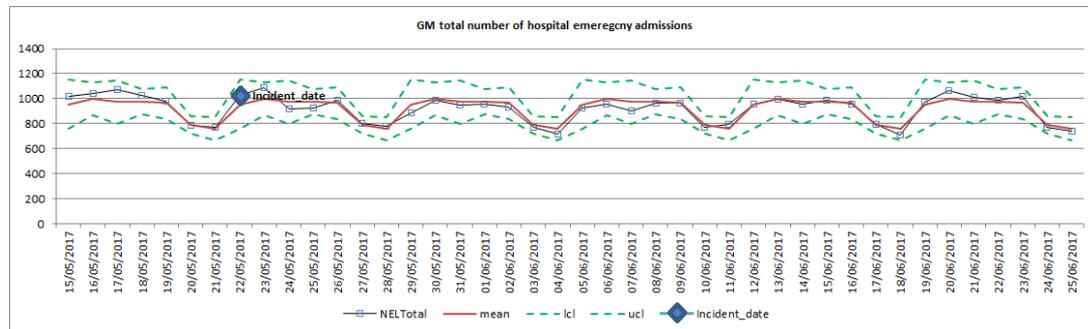
Figure S5: Emergency admissions at Greater Manchester Major Trauma System Network hospitals

Figure S5 is the Shewhart chart showing patient (adult and children) data for total daily emergency hospital admissions over six consecutive weeks for NHS hospitals across Greater Manchester (GM). Note that Monday 29th May 2017 was a national holiday in England. Emergency hospital admissions were higher than their predicated mean on the day of the incident. Thereafter, an immediate further increase in emergency hospital admissions is apparent for Greater Manchester hospitals (approaching the 99.7% upper confidence limit), which rapidly returns to predicated mean patterns.

Figure S6: Unplanned hospital discharges for Greater Manchester Major Trauma System Network hospitals

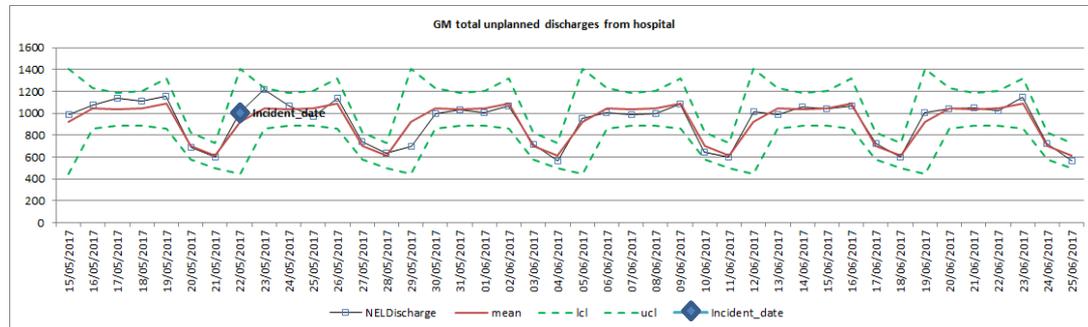


Figure S6 is the Shewhart chart showing patient (adult and children) data for total daily unplanned discharges from hospital to community care over six consecutive weeks for NHS hospitals across Greater Manchester (GM). Note that Monday 29th May 2017 was a national holiday in England. Immediately following the incident, there was a marked surge in unplanned patient discharges from Greater Manchester hospitals, which is at the 99.7% upper confidence limit the day after the incident, rapidly returning to predicated mean patterns thereafter.

Figure S7: Delays for transfer of patient care* from hospital to the community for Greater Manchester Major Trauma System Network compared with a control region

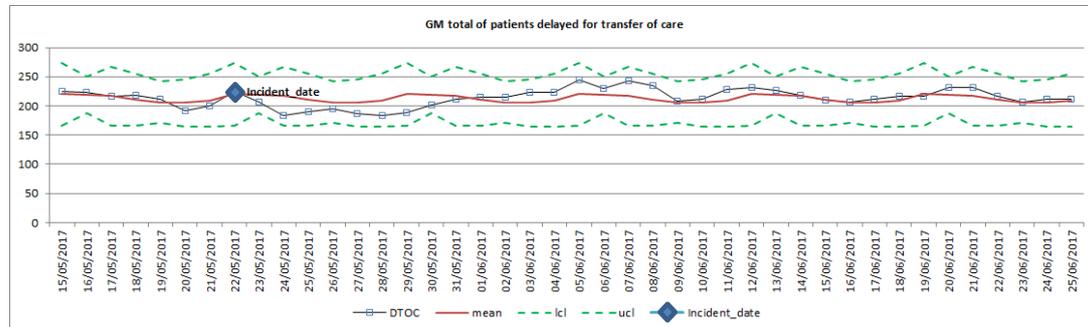


Figure S7 is the Shewhart chart showing patient (adult and children) data for total daily delayed discharges from hospital to community care over six consecutive weeks for NHS hospitals across Greater Manchester (GM). Note that Monday 29th May 2017 was a national holiday in England. Immediately following the incident, there was a sustained reduction (> 7 days) in delayed hospital discharges from Greater Manchester hospitals.

*NHS England defines patients as ready for care transfer when: a. A clinical decision has been made that the patient is ready for transfer AND b. A multi-disciplinary team decision has been made that the patient is ready for transfer AND c. The patient is safe to discharge/transfer. Patients who have been assessed as ready for care transfer and remain in hospital at midnight each day are recorded as delays to transfer of care in this figure.

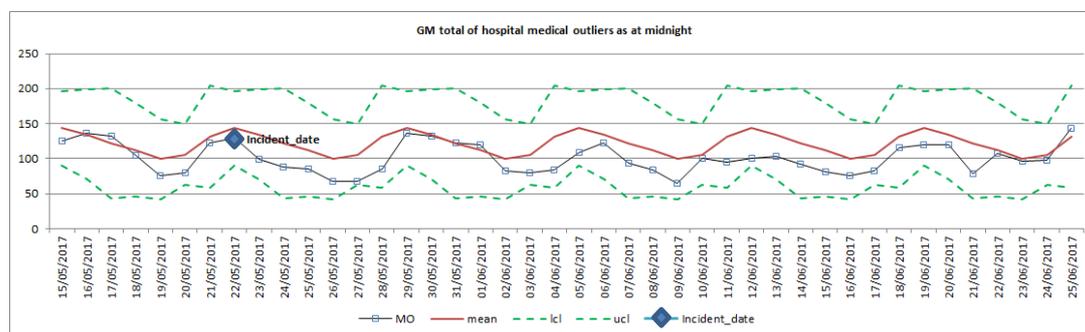
Figure S8: Medical outliers for Greater Manchester Major Trauma System Network**

Figure S8 is the Shewhart chart showing patient (adult and children) data on hospital bed utilization ('medical outliers') over six consecutive weeks for NHS hospitals across Greater Manchester (GM). Note that Monday 29th May 2017 was a national holiday in England. Immediately following the incident, there were sustained reductions in 'medical outliers' in Greater Manchester hospitals (> 7-days), approaching the 99.7% lower confidence limit at a nadir 5-days after the incident.

** Medical outliers are internal medicine patients counted at midnight who occupied hospital beds designated for non-internal medicine patients (e.g. surgical specialties).

Figure S9: Proportion of emergency department (ED) patients with care completion within 4-hours of attendance at Greater Manchester Major Trauma System Network EDs compared with a control region

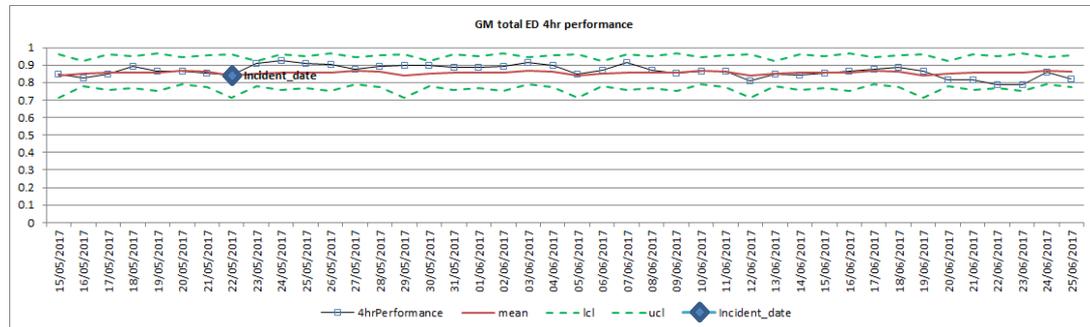


Figure S9 is the Shewhart chart showing patient (adult and children) data on care completion within 4 hours of ED attendance over six consecutive weeks for NHS hospitals across Greater Manchester (GM). Note that Monday 29th May 2017 was a national holiday in England. Immediately following the incident, there was a marked increase in the proportion of ED patients being treated within 4 hours in Greater Manchester hospitals, approaching the 99.7% upper confidence limits. This improvement was sustained (> 7-days) for emergency departments across Greater Manchester.

Table S1: Patient disposition at 30-days following hospital admission

Patient disposition at 30-days from hospital admission	All	Adults	Children
Home (own)	113	77	36
Acute hospital	36	29	7
Mortuary	3	2	1
No fixed abode	1	1	0
Rehabilitation facility	0	0	0
Total	153	109	44

Table S1 shows patient disposition recorded at 30-days following emergency hospital admission or death, whichever occurred first.

References

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