

Major trauma critical pathway: preliminary results from the monitoring system in the regional network and in a hub center in Rome metropolitan area

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Abstract. – OBJECTIVE: The aim of this study is to collect the two years' data regarding the Integrated Trauma Management System (SIAT) by capturing the activity of its three Hubs in the Italian Lazio Region and test the performance of one of the Hubs' (Fondazione Policlinico Universitario A. Gemelli – IRCCS, FPG –IRCCS) Major Trauma Clinical Pathway's (MTCP) monitoring system, introducing the preliminary results through volume, process and outcome indicators.

MATERIALS AND METHODS: A retrospective analysis on SIAT was conducted on years 2016 to 2018, by collecting outcome and timeliness indicators through the Lazio Informative System whereas the MTCP was monitored through set of indicators from the FPG – IRCCS Informative System belonging to randomly selected clinical records of the established period.

RESULTS: Hubs managed 11.3% of the 998,240 patients admitted in SIAT. All patients eligible for MTCP were "Flagged", and 83% underwent a CT within 2 hours; intra-hospital mortality was 13% whereas readmission rates 16.9%.

CONCLUSIONS: SIAT converges the most severe patients to its Hubs. The MTCP monitoring system was able to measure a total of 9 out of 13 indicators from the original panel. This research may serve as a departing point to conduct a pre-post analysis on the performance of the MTCP.

Key Words:

Critical pathway, Emergency department, Patient centred care, Patient outcome assessments, Trauma network.

Introduction

Trauma injuries represent one of the worldwide leading causes of death and morbidity¹⁻⁴, constituting a burdensome issue for Public Health that is predicted to increase globally in the next ten years due to war, violence, and car accidents^{5,6}. Major Trauma is a time-dependent pathology in which key performance determinants are promptness, appropriateness and quality of the diagnostic, the therapeutic and the rehabilitative management of the patient.

According to the "Berlin Definition"⁷, Major Trauma patients are those who meet at least one of the following criteria:

- Two injuries that are greater or equal to three on the Abbreviated Injury Scale (AIS) and one or more additional diagnosis
- Hypotension (systolic blood pressure < 90 mm Hg)

- Unconsciousness (GCS score < 8)
- Acidosis (base deficit < -6.0)
- Coagulopathy (PTT > 40 seconds or INR > 1.4)
- Age above 70
- Injury Severity Score (ISS) > 15 (calculated after clinical, radiological and laboratory evaluations including autopsy in fatal cases).

In Italy, trauma is the first cause of death for under 35-year-olds and the fourth if we include all ages. Most trauma patients, and their relatives, are affected both physically and financially due to no or partial reintegration of health⁸.

However, survival and outcomes in severely injured patients have shown improvements when patients turn to specialized Major Trauma Centres (MTCs) that are part of formalised systems and treat a sufficient number of cases with a coordinated multidisciplinary team that receives, resuscitates, and provides definitive treatment⁹⁻¹¹.

Nowadays, the Major Trauma Network's organizational model, which was first implemented in the USA, has been broadly adopted around the world as the method for managing this burden, although with some differences between each country and the lack of agreements on a patients' volume-threshold¹².

In Italy, an integrated system was activated in the form of regional Major Trauma networks, by means of the Ministerial Decree (DM) 70/2015¹³ and, in the Lazio Region, this network is known as SIAT and it covers about 5.8 million inhabitants. SIAT functions by connecting physicians, structures, services provided by medical facilities, socio-sanitary services of different typology and levels of specialisation in a formalised and coordinated way, to guarantee the continuity of care and both clinical and organisational appropriateness¹⁴. Medical facilities within the SIAT are organised as follows:

- *Emergency Departments for Trauma* (EDT): twenty-seven small facilities spread out more or less all over the Region, in charge of immediate treatment for cardio-respiratory instability; they provide prompt assessment, resuscitation, surgery, intensive care, stabilization of injured patients and emergency operations and they also prepare patients for transfers to higher levels of care when needed.
- *Area Trauma Centers* (ATC): six 24-hour facilities, gathered in the central area of the Lazio Region, destined to treat all trauma injuries except for those that require highest specialization; they are able to initiate definitive treatment for all injured patients and pre-

pare patients for transfers to higher levels of care when needed.

- *Highly Specialised Trauma Centres* (HSTC): three Hubs with highly specialized facilities, gathered mostly in the Central and Southern area of Lazio, capable of treating the most complex cases and equipped with Intensive Care Units (ICUs).

The three HSTCs are two teaching hospitals (i.e., Policlinico Umberto I and Fondazione Policlinico Universitario Agostino Gemelli – IRCCS (hereafter FPG – IRCCS)) and another third level hospital (i.e., Azienda Ospedaliera S. Camillo-Forlanini) and they constitute the referential centres for the ATCs and EDTs that make up the subsidiary facilities, referred to as Spokes.

The FPG – IRCCS is the second largest hospital in Italy and first in its region. In 2014, it treated 364 patients with Major Trauma of whom 90 were paediatric. Recognizing its pivotal role as one of the three Hubs in Lazio Region, it decided to improve the quality of its service by establishing a Major Trauma Clinical Pathway (MTCP) in January 2016, with the intent of granting continuum of effective care from the patients' admission to the ED right up to their discharge and rehabilitation. One of the most useful organizational solutions offered by the MTCP implementation is the support provided to operational managers and medical staff by the deliberately designed monitoring system which also consents the receipt, at any time, of information on patients' conditions, procedures and exams by recurring to the Hospital Informative System (HIS). The FPG – IRCCS has set up a system known as "Flagging", designed to track each patient into the critical pathway: once a Major Trauma patient's data is introduced into the HIS, he or she is connected to the clinical pathway most suitable to his or her health status. After being *Flagged*, all the patient's information is available on the HIS and is accessible to authorized staff, for evaluating the appropriateness of examinations and procedures, and monitoring patient's conditions and care episodes horizontally and in time.

In the interest of this, our study captures the activity of the three Hubs of the Major Trauma Network of the Lazio Region, through retrospectively collected data belonging to the years 2016 to 2018 on the network's performance. Subsequently, we introduce the preliminary results of FPG – IRCCS's newly implemented monitoring system of the MTCP through process and outcome indicators.

Materials and Methods

SIAT Data Collection

A cohort of Major Trauma patients (International Classification of Diseases - ICD-9-CM: 800-959.9 - except those from 940 to 949, as they are related to burn, therefore not suitable for our analysis¹⁵) was retrospectively analysed by collecting data from the Lazio Region Informative System, referred to the three HSTCs in the period between the 1st May 2016 to the 30th April 2018.

More specifically, we included just those admitted to the ED with a Red Code. Colour codes are assigned through the “*triage system*”, an operative scale of urgency to summarise the severity of each patient’s clinical profile:

- Red: urgent, non-deferrable
- Yellow: critical but not in immediate danger of death
- Green: deferrable
- White: not appropriate for the Emergency Department (ED)¹⁶.

ED information was then extracted for the three HSTCs and for the network as a whole for the following indicators:

- a) Total admissions
- b) Admissions with Red Code
- c) Total admissions from ambulance callers (hereafter referred to as *Admissions “from 118”* as it is the Italian emergency dial code)
- d) Total Red Code admissions “from 118”
- e) Hospitalizations with Red Code
- f) Hospitalization Rate (E/B%)
- g) Deaths with Red Code
- h) Mortality Rate (G/B%)

In addition, for the year 2017 it was possible to obtain ED waiting times and the number of secondary transfers, intended as those patients who first access an ATCs or an EDTs and then are sent to an HSTC, due to the severity of their conditions¹⁴. We developed a One-Sample *t*-test ($\alpha=0.05$), using SPSS Statistical Analysis Program (SPSS Inc., Chicago IL), to assess if there were statistically significant differences between the values observed in the three HSTCs.

The MTCP Monitoring System

To test the operational performance of the MTCP’s monitoring system, we conducted a retrospective analysis on patients admitted to the ED of FPG – IRCCS between the 1st May 2016 and the 30th April 2018 by investigating ICD Codes obtained through the HIS.

We identified Major Trauma patients and constructed our sample by randomly selecting 10% of patients, mirroring the guidelines provided by the Italian Ministry of Health regarding the ideal sample size for clinical audits^{11,15}. Following these directives allows to choose a sample big enough to represent the issue of interest, but not too large to compromise feasibility of analysis¹¹. The patient inclusion criteria were kept the same as for the SIAT data collection phase of this study. Despite the necessity to gather data from a unique database, we were tied to collecting it from two different sources as hospital and regional health data on trauma are separated in our Region of interest. The data was, in fact, downloaded from the HIS and then confronted with GIPSE, the Regional Informative system specific for EDs, and DIGISTAT, FPG – IRCCS’s HIS specific for Critical Pathways, making sure that system errors were not present.

First of all, we reported the demographic characteristics of the studied patients. Subsequently, we selected a set of indicators from the MTCP monitoring system and calculated them on our sample of patients (Table I).

Moving on to secondary transfers data, results reported in the first three columns of Table III show the amount of time spent in the EDs, by patients awaiting the secondary transfer to their assigned HSTC.

When looking at the last three columns of Table III, we observe a large variety in the number of patients arriving from secondary transfers, spacing from a minimum of 4 transfers to San Camillo-Forlanini and a maximum of 22 transfers to Policlinico Umberto I with an average and median values of secondary transfers for the three HSTCs of 12 for the entire year.

The MTCP Monitoring System

According to the Regional data shown in Table II above, the FPG – IRCCS registered 1,857 Red Code patients and not 826 declared by the number of ambulance callers. Of these 1,857 patients who were admitted to the ED, 984 were then hospitalized. All patients are classified according to the ISS and the recovery ward. For our study we selected 710 patients with an ISS higher than 15.

Patients’ demographic characteristics, reported in Table IV, were described according to:

- a) Age: paediatric patients (17-year-olds or younger); young adults (between 18 and 35); adults (between 36 and 64) and geriatric patients aged 65 years or older;
- b) Gender: 39 males and 32 females;

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Table I. Set of indicators and phase of detection of the MCTP monitoring system.

Type of indicator	Indicator	Definition	Pre-Hospitalization in a Spoke of the ReTra	ED of the Hub	Surgical Intervention and ICU post ED discharge	Acute/Sub-Acute treatment after ED treatment	Rehabilitation after hospital discharge
Volume	Volumes of Major Trauma patients according to ICD-9	According to ICD-9 codes, number of Major Trauma patients admitted to the ED	x	x	x	x	x
Process	Number of Major Trauma patients flagged	Number of Major Trauma patients flagged by the HIS		x	x	x	
Process	CT time	Time interval between the ED admittance and the CT scan		x			
Process	LOS	LOS over 30 days	x	x	x	x	
Outcome	Readmission rate	Readmission rate within 30 days		x	x	x	x
Outcome	Mortality rate	In-hospital mortality rate		x	x	x	x
Process	Patients transferred from ICU to other wards	Number of patients transferred from ICU to other wards and length of stay			x	x	
Process	Ward transfers	Number of wards changed by patient		x	x	x	
Process	Patients in Rehabilitation	Number of patients following the Internal Rehabilitation programme					x
Process	First surgical intervention or embolization procedure	Time interval between admittance to ED and first surgical intervention or embolization procedure		x	x	x	
Process	% of interventions within 1 day for patients with spine fracture	Percentage of patients with fracture in the spinal column who received the intervention in 1 day		x	x	x	

Table continued

Table I. (Continued). Set of indicators and phase of detection of the MCTP monitoring system.

Type of indicator	Indicator	Definition	Pre-Hospitalization in a Spoke of the ReTra	ED of the Hub	Surgical Intervention and ICU post ED discharge	Acute/Sub-Acute treatment after ED treatment	Rehabilitation after hospital discharge
Process	% of interventions within 3 days for patients with fracture in the spine	Percentage of patients with fracture in the spinal column who received the intervention in 3 days		x	x	x	
Process	Craniotomy procedure	Time interval between the ED admittance and craniotomy intervention		x	x		

Table II. Description of the three HSTCs and of the whole SIAT activity.

ED volume indicators	San Camillo-Forlanini	FPG – IRCCS	Policlinico Umberto I	One-Sample Test	SIAT (total)	Percentage (HUBs/SIAT%)
A) Total Admissions	37,562	25,030	50,076	0.035	998,240	11.29%
B) Admissions with Red Code	1,612	1,857	1,184	0.016	14,016	33.20%
C) Admissions from 118	2,006	1,892	1,602	0.004	37,310	14.74%
D) Admissions from 118 with Red Code	586	826	558	0.016	6,224	31.65%
E) Hospitalizations with Red Code	763	984	852	0.005	6,494	40.02%
F) Hospitalization Rate (E/B %)	47.30%	53.00%	72.00%	//	46.30%	//
G) Deaths with Red Code	27	17	47	0.075	258	35.27%
H) Mortality Rate (G/B %)	1.70%	0.90%	4.00%	//	0.03%	//

c) Geographical origin: among the five provinces of the Region (Rome, Viterbo, Rieti, Latina and Frascati), Rome resulted as the most represented province with 71.8% of cases (51 patients).

Outcomes of the MTCP monitoring system are reported in Table V. As we can see, the implemented monitoring system allowed us to calculate 9 out of the 13 indicators we had previously intended to investigate. We grouped the obtained measures into Emergency activities and Post-Emergency activities.

Within the Emergency activities, it appears that:

- The Flagging procedure: 100% of patients admitted with an ICD-9 referable to Major Trauma patients were flagged as MTCP patients.
- CT scans: 83% of patients were scanned within two hours from admission to the ED. 11% of patients arrived at the FPG – IRCCS ED with a CT scan from another structure. Among these, 26% had had an RX procedure

Table III. Waiting time in ED and number of secondary transfers.

HSTC	Time (in hours and minutes) spent in ED			N° of secondarily transferred patients		
	Average	Median	Min-Max	Total	Median	Min-Max
Policlinico Umberto I	0.21	0	00:24-42:06	190	17	44,774
FPG – IRCCS	0.24	0	00:06-68:00	133	11	43,221
San Camillo-Forlanini	0.21	0	00:18-62:30	112	9.5	41,365

Table IV. Patients' demographic characteristics.

Characteristics	Number of patients (n=71)
Sex	
Male	39
Female	32
Age groups	
0-18	17
19-34	9
35-64	22
>65	23
Provenience	
RM	51
VT	10
RI	5
FR	1
LT	4

and only 1 patient had undergone a surgical intervention/embolization before the CT scan

- Surgical interventions: 56.3% of patients underwent at least one surgical intervention with an average waiting time of 23.27 days between the surgical intervention and the admission.

The total number of surgeries performed on Major Trauma patients was 69, among which only 5 were Craniotomies (7.2% of cases).

No surgical intervention for spine fracture was performed within 3 days from admission (the percentage of surgical interventions was lower than 1%).

As for the post-Emergency activities:

- Type of discharge: to specifically analyse the effectiveness of coordination and continuum of care after discharge in Major Trauma patients between the FPG – IRCCS and its intermediate care network of reference, we investigated the type of discharge (Table VI).
- Readmission and mortality rates: 16.9% and 13%, respectively.
- Rehabilitation: 9.9% of patients was sent to the Internal Rehabilitation Department.
- Length of stay (LOS): 24% of patients reported a LOS above 30 days, with a Relative Risk

of being readmitted of 1.88 if compared to patients discharged in less than 30 days (respectively 2.63% and 1.4). The average LOS was 22.63 days per patient.

- Patients transferred from the Intensive Care Unit (ICU): 90% of patients switched from the ICU, or from the Paediatric ICU, to other wards, with a total of 160 ward changes (average of 2.38 changes per patient).

Discussion

We analysed the activity of the three HSTCs of Lazio Region's Major Trauma Network: Policlinico Umberto I, FPG – IRCCS and Azienda Ospedaliera San Camillo-Forlanini. Subsequently, we tested the monitoring system of the MTCP of the FPG – IRCCS, by investigating data from 2016 to 2018.

Table II shows that the DM 70/2015 directives towards a more appropriate and timely treatment in Hub centres are being followed. The greater the severity, the more likely it is to be treated in the three Hubs. In fact, as the severity increases (from total admissions, to Red Code admissions, to Red Code hospitalizations), so does the amount of cases treated in the Hubs (11.29% < 33.2% < 40.02% respectively).

What's more, is that increases in volumes seem to guarantee better quality of care in Trauma cases. Each Hub's overall volume exceeds the threshold introduced in 1999 by the American College of Surgeons Trauma Committee of 1200 yearly admissions¹⁰ both considering total amount of admissions and those with "118" Red Code^{10,17}.

Higher mortality rates in all three EDs of the Hubs above the SIAT's average, are a natural consequence of the higher severity of cases treated in these specialized centers. Among the three Hubs, Policlinico Umberto I reports the highest mortality rates. Although analyzing the reasons goes beyond the purpose of our study, we can make

one preliminary assumption: the rate between ambulance admissions and total admissions is the lowest among the Hubs (respectively 5.3% for San Camillo-Forlanini, 7.56% for FPG – IRCCS and 3.20% for Policlinico Umberto I). In addition, Policlinico Umberto I is the only HSTC lacking a helicopter 24h emergency service. These two factors, which imply a generally more complex access to the center, may constitute a significant burden in time-dependent cases. This would be further aggravated by the higher incidence of secondary transfers, as reported in Table III.

The discrepancy between Red-Code admissions to the ED and 118 Red-Code admissions, is worthy of concern. Red-Code admissions are, in fact, much higher and this issue, known as “*over-triage*”¹⁸. On one hand, we have registered statistically significant differences between all four typologies of ED admission codes and also for the hospitalizations with Red Code; on the other, deaths with Red Code did not reveal statistically significant differences in EDs of the three HSTCs.

In all the three Hubs, the median values of waiting times are slightly higher than the two-hour threshold identified by the Ministry of Health guidelines¹⁴.

As quality of care in the Hubs has shown to be linked not only to the level of specialization, but also to volume of treated cases, the network has also activated a regional teleconsultation system which enables remote interactions between facilities with the intent of providing counselling and evaluating whether a secondary transfer from the Spokes to the Hubs is necessary. This allows multidisciplinary collaborative therapy, necessary for patients with severe multiple trauma and leads

to a decrease in length of stay and a reduction in unnecessary treatment and costs¹⁹.

The second aim was to present the monitoring system of the MTCP of the FPG – IRCCS, which evaluates the performance of the network through process and outcome indicators. The establishment of the “Trauma Team” is a crucial step in the implementation of the MTCP, as the “Team leader” covers a key organizational role and is the coordinator of a multidisciplinary approach known as the “Team Approach”. In addition, Rotter’s review on the benefits of Critical Pathways (CPs) highlights how the components that make a CP effectively able to improve professional practice, outcomes, LOS and costs are guaranteed, among other factors, by the incorporation of systems to allow audit and feedback on implementation, which is the aim of the construction of FPG – IRCCS’s MTCP monitoring system²⁰.

As shown in Table V, our monitoring system was able to measure a total of 9 out of 13 indicators from the original panel of the CP indicators, notwithstanding the Flagging method. This may be due to the relative scarce capacity of our actual informative system to track continuity of care and other procedures that are not actually included in the monitoring system. Currently, in fact, the Policlinic is working to refining horizontal tracking methods towards a more effective Enterprise Resource Planning (ERP) Informative System.

During the analyzed period, 25,030 patients were admitted to the FPG – IRCCS’s ED, of whom 1,857 with a Red Code (7%). Red Code Major Trauma patients with an ISS >15 admitted to FPG – IRCCS’s ED in the investigated period, identified through the DIGISTAT, constitute

Table V. MTCP outcomes.

Indicator	Outcome
Volumes of Major Trauma patients according to ICD-9	25,030
Number of Major Trauma patients flagged	25,030
CT within 2 hours from admission	83.00%
LOS	24.00%
Readmission rate	16.90%
Mortality rate	13.00%
Patients transferred from ICU to other wards	90.00%
Ward transfers	N/D
Patients in Rehabilitation	N/D
First surgical intervention or embolization procedure	N/D
% of interventions within 1 day for patients with spine fracture	0%
% of interventions within 3 days for patients with fracture in the spine	0%
Craniotomy procedures	N/D

Table VI. Type of discharge for MTCP's patients of FPG – IRCCS.

Type of discharge	Percentage
Home	48%
Transfer to other structure	18%
Death	13%
Transfer to other kind of assistance	13%
Home, waiting for external pathway	8%

38.2% (710 patients) of Red-Code admissions. In most cases, these patients need to be treated in ICU. This percentage differs greatly from the value obtained in an Australian study²¹, which counts only 16.6%. Once again, we can identify the root of this difference in the tendency to over triage, as discussed for the SIAT.

As for timely diagnosis, considered as key factor of a good outcome in major injuries such as Maxillofacial Fracture²², the implementation of the MTCP shows that there are only three cases (83%) without a CT scan procedure within 2 hours.

Outcome measures available for this study were limited to inpatient mortality and hospital LOS. Expansion of the trauma registry to include longer term outcomes would be beneficial but would require appropriate resourcing. Ogilvie et al²³ suggest that linking National Coroners Information System and ambulance records to trauma data would provide more accurate information suitable to build local injury prevention strategies and plan trauma systems. Our results are consistent with other evidence available in the literature, on the relationship between the Major Trauma Centre implementation through MTCP and outcome indicators²⁴⁻²⁶.

Although our study is not the first to examine the management of trauma through the implementation of a network between different actors of a macro-area^{11,27,28} or to monitor the functioning of a single trauma center^{22,29}, it is one of the first to connect this “macro” dimension to a “micro” one, as we believe that the smooth functioning of the MTCP within one center can positively affect all the rest of the centers in the Region due to the interconnectedness of the entire service delivery.

Our study is subject to some limitations. Due to the absence of a formalized monitoring system before the implementation of the MTCP, it was not possible to conduct a pre-post impact assessment to evaluate the effectiveness of the CP, making this research a potential starting point for future impact evaluations. We also declare some limitations in the data gathering phase. Lit-

tle demographic information could be collected, and the population sample showed broad heterogeneity. The lack of availability of data on other dimensions of quality, e.g., according to the patients' perspective, is likely to depend on the administrative nature of our dataset. In addition, we were not able to determine direct causation between “exposure” to the CP and “effects” on single patient's health.

Conclusions

In the two years that were analyzed, nearly 1 million patients were admitted in the ED of the whole SIAT. From our analysis it is possible to highlight how the most severe Major Trauma cases (Red Codes) were treated within each Hub, as planned. Time spent in secondary transfer constitutes the most relevant weakness in SIAT nowadays. According to our study, the largest demographic groups affected by major trauma are people aged between 36 and 64 and over-65 year-olds. The focus on injury prevention in the macro-area of FPG – IRCCS should remain on road trauma, however there were also high proportions of domestic falls and injuries of paediatric and geriatric patients, confirming literature findings that show how, especially in the case of multiple trauma, most cases have been caused by car accidents or falls¹⁹. As for the Hub Centre FPG – IRCCS, we selected and measured a set of indicators which is likely to describe all the main phases of the critical pathway. Nevertheless, a pre-post analysis of the whole impact of the Major Trauma both in Lazio Region and in the FPG – IRCCS was not available, as the “before implementation” data had not previously been collected. This research may serve as a departing point to conduct a pre-post analysis on the performance of the MTCP by using the specifically designed monitoring system, in order to assess the impact of the implementation of the pathway on FPG – IRCCS's outcomes on Major Trauma patients. Enlarging the percentage of patients ran-

domly selected in our research could ensure a better representation of the reference population.

Examining the cumulative percentage of in-patient bed days and the cumulative percentage of trauma activations as a function of the ISS, as investigated in other studies²⁷, could be useful to better look into our volume of activity.

The focus of our analysis is on one of the three HSTCs of the Trauma Network in the entire Lazio Region. A comparative study among the three Hubs could provide useful insight into the function of the SIAT and likely increase overall performance. To gain deeper knowledge on the different causes of variability in the timing of secondary transfers, it would be of great value to understand if a Regional organizational policy could be useful to increase the appropriate functioning of the SIAT.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Ethical standards

All procedures performed in studies involving human participants were by the ethical standards of the Institutional and/or National Research Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Formal consent

This is a retrospective study without sensible data. Formal consent was waived.

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