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RISK-BASED REDUCTION OF THE OVER-TRIAGE OF GREATER MILAN'S EMERGENCY SANITARY SYSTEM: THE NIGUARDA MAJOR TRAUMA CENTRE USE CASE

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ABSTRACT

In the urban area of Milan, the Niguarda Trauma centre has a key role in the management and treatment of major trauma. Niguarda Trauma Centre receives a high number of patients not afflicted by a major trauma. This number is translated into a percentage, called over-triage. The reduction of this percentage would lead to a more effective utilization of this resource. However, the patient sorting within the hospital present on the territory is performed by AREU, i.e. regional company for emergency assistance. This company manages all the sanitary emergency of the territory, assigning them to the correct hospital typology. The process is composed by three phases, conducted respectively by three different teams: SOP1, collection of the first information about the patient through a telephone interview, SOP2, management of the vehicles available on the territory, and SOP3, collection of medical information, evaluation and selection of destination hospital. The analysis of patient's evaluating process was performed with ALBA, i.e. Artificial Logic Bayesian Algorithm, a program able to represent all the universe of possible alternatives of a complex process, both considering stochastic and logical constrains present in the system. Another important tool was the Niguarda Trauma Centre database, containing data about circa three -thousand cases collected in the last six years. The analysis of the system and of the available data allows identifying the critical components of the system and the typology of events more involved in the generation of the over-triage. The analysis of some resolution approach lead to the theorization of another evaluation medical filter, able to support the SOP3 personnel in its decisional process, including also those contextual parameters linked especially to road accident traumas. The analysis of those parameters has also been useful for a modification of the SOP1 interview process. The insertion and the modification of some contextual parameters can potentially reduce the percentage of red codes of the

twenty percent in the first phase. Globally, the proposed resolution approaches can effectively reduce the over-triage.

ABSTRACT

Il Trauma Centre dell’ospedale di Milano è una struttura di riferimento nel trattamento dei traumi maggiori che si verificano nell’area urbana che circonda Milano. Il Trauma Centre riceve però un alto numero di pazienti non afflitti da traumi maggiori: questa percentuale viene detta over-triage. La riduzione di questa percentuale permetterebbe un migliore sfruttamento di questa struttura. Lo smistamento dei pazienti è però a carico di AREU, l’azienda regionale che si occupa della gestione delle emergenze sanitarie, che si occupa della valutazione dei singoli casi e li assegna alle varie strutture presenti sul territorio. Il processo di valutazione passa da tre fasi, gestite da tre differenti team: SOP1, raccolta delle prime informazioni attraverso un’intervista, SOP2, gestione dei veicoli presenti sul territorio, e SOP3, raccolta d’informazioni mediche, valutazione del paziente e scelta dell’ospedale di destinazione. L’analisi del processo di valutazione del paziente è stata condotta con ALBA, Artificial Logic Bayesian Algorithm, un programma in grado di rappresentare l’universo di possibili alternative presenti in un processo complesso, considerando i vincoli logici e stocastici presenti nella realtà. Un altro importante mezzo di supporto è stato il database creato dal Trauma Centre, contenente le informazioni riguardanti circa tremila casi registrati negli ultimi sei anni. L’analisi del sistema e dei dati disponibili ha permesso di individuare le componenti critiche del processo e le tipologie di eventi più connessi alla generazione di over-triage. L’analisi di alcuni approcci risolutivi ha portato alla teorizzazione di un nuovo filtro valutativo, capace di supportare la SOP3 nel processo decisionale. Il filtro si baserebbe su aspetti medici, ma anche su alcuni parametri contestuali, soprattutto per quanto riguarda gli incidenti stradali. L’analisi di questi parametri è stata anche utile per modificare l’esistente fase di intervista di SOP1, portando ad una riduzione finale del venti percento dei codici rossi generati in

questa fase. Complessivamente, le modifiche proposte garantirebbero una riduzione dell'over-triage del sistema.

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ACRONYMS AND ABBREVIATIONS

ABCDE	Airway, Breathing, Circulation, Disability, Exposure
AIS	Abbreviated Injury Scale
ALS	Advance Life Support
ANS	Anaesthesiologist
AREU	Regional Company for Emergency and Urgency Assistance [Azienda Regionale Emergenza Urgenza]
AUX1	Auxiliary Personnel 1
AUX2	Auxiliary Personnel 2
BLS	Basic Life Support
CCDF	Complementary Cumulative Distribution Function
CFL	Critical Function List
CPR	Cardio Pulmonary Resuscitation
CT	Computerized Tomography
CTS	High Level Trauma Centre [Centro Traumi di Alta Specializzazione]
CTZ	Medium Level Trauma Centre [Centro Traumi di Zona]

DEA	Emergency and Reception Department [Dipartimento Emergenza Accettazione]
E-FAST	Extended Focused Abdominal Sonography for Trauma
EM.S	Emergency Surgeon
GCS	Glasgow Coma Scale
HR	Heart Rate
ILS	Intermediate Life Support
ISS	Injury Severity Score
N1	Nurse 1
N2	Nurse 2
NMR	Nuclear Magnetic Resonance
OT	Over-triage
PST	Low Level Trauma Centre [Pronto Soccorso per Traumi]
RAD	Radiology Technician
RDF	Risk Distribution Function
RR	Respiratory Rate
RTS	Revised Trauma Score
SBP	Systolic Body Pressure
SIAT	Integrated System for Trauma's Assistance [Sistema Integrato dell'Assistenza al Trauma]
SOP1-2-3	Operating Room part 1-2-3 [Sala Operativa Parte 1-2-3]
SOREU	Regional Operative Room for Emergency and Urgency Assistance [Sala Operativa Regionale Emergenza Urgenza]
SpO2	Oxygen Saturation
STUD	Medicine's Student
TC	Trauma Centre
UT	Under-Triage

INTRODUCTION

This works focuses its attention on Niguarda’s trauma centre: the objective is to improve the efficiency of this complex system, in particular to reduce the percentage of over triage, in order to optimize the use of this resource on the territory. In fact, in Milan’s urban area Niguarda is the most important structure for the cure of major trauma. A major trauma is a trauma caused by a high energy impact that can happen due to a road accident, a fall or other violent mechanism: this energy can lead to important consequences inside our bodies that should be analysed and solved in the most effective and fastest way possible.

In order to do this, and hospital has to be correctly prepared, in terms of spaces, personnel and resources: not all the hospital of the analysed urban area has the possibility to guarantee this kind of assistance to the population. Lombardy region has compiled a classification of hospital for the management of the emergency: this operation allows optimizing resources on the territory by splitting competences and resources within the hospitals.

This classification leads to three kinds of hospitals, as will be explained in the following chapters.

Even tough each hospital has a given role, Niguarda has still got the problem of over-triage: during his five years of work the trauma team has received a lot of patients that doesn't necessary need to be nursed in a trauma centre. In the last year this percentage has reached the value of 66%, this means that this resource was mostly used for not major trauma. It's important to consider that the trauma centre has the capability to receive one major trauma per time: if the shock room is occupied by a yellow code, i.e. someone whose conditioned are not so severe to be necessary treat in a high specialized hospital, the trauma team has no possibility to receive a major trauma. Consequently the hypothetical severe patient has to be hospitalised in a lower level structure.

Another consideration is that the percentage of over-triage should not be completely removed, but it should be reduced to circa30-35%: in this area of interest it's better to be conservative, because, on the other hand, a high percentage of under-triage in unacceptable. Under-triage is the amount of patient for which the symptoms where underestimate, so they are sent to a hospital that can't face all kind of major trauma, because of its limited resources.

After this observation, it's necessary to extend the considered process and to introduce another important variable: the emergency number.

The steps that go from the emergency call to the arrival in the trauma centre involve a series of different stations, each one with a specific role in the classification of the patient. The classification of the patient is performed using a triage code: each patient during the process is associated to a red, yellow, green or white code, which is the most important characteristic for the assignment of the destination hospital.

The emergency telephone exchange manages every day NUMERO of emergency call. For each call they have to collect information from the person on the scene by filling up a filter, which generates the triage code.

They also have to decide which vehicle has to intervene on the scene, mainly depending on the seriousness of the trauma and on the distance between vehicle and patient: time is an important variable for major trauma, but severe cases require also a medical assistance available only on some kind vehicles, the medical cars.

At last they had to decide in which hospital the patient should be received, after they collection of other medical information about the patient from the personnel on the scene: also in this phase there are several variables in addition to the seriousness of the injuries, such as the availability of hospitals resources dedicated to the treatment of major trauma.

In this work we focus our attention in the description and in a macro-analysis of the whole process, in order to underline its criticalities, which lead to the existence of a high percentage of over-triage. The main objective is to reduce this percentage by improving the available resources of the trauma centre, but also of the emergency chain preceding the choice of the destination hospital. This work will also propose some possible solutions to these criticalities, especially for what concerns the indicator variables of a major trauma.

In fact there are some characteristics in the mechanisms of traumas that seem to be directly linked with the over-estimation of patient injuries.

In the following chapters this relation will be underlined and analysed especially in the first phases of the emergency chain.

Chapter 1.
TRAUMA CENTRE PRESENTATION

1.1 Role of Niguarda Trauma Centre in Lombardy's sanitary structure

Niguarda Trauma Centre was born in 2009. This structure is part of Niguarda Hospital, which is one of the main hospitals of Milan.

The trauma centre can be considered CTS, i.e. high specialized traumatic centre, as part of a classification of the emergency and urgency Italian system.

A classification of the Emergency hospitals was issued in Lombardy in 2012 with a decree of the general health management [V]. This classification was necessary in order to improve the SIAT, Sistema Integrato di Assistenza Territoriale, i.e. Integrated Territory Assistance System, as was codified from the Italian board of health in 2004 [I].

According to this decree, hospitals are divided in:

- CTS (Centro Traumi di Alta Specializzazione), i.e. high specialized trauma centre, which is a structure able to identify and to treat every kind of major or multiple trauma. All kind of resources are available twenty-four hours a day in these hospitals, so they are always able to guarantee a high level of cure.

- CTZ (Centro Traumi di Zona), i.e. specialized trauma centre, is a hospital which has the resources to identify and treat all kind of trauma, except for those one that requires a high specialization not available in this kind of structure. These structure can be classified in two more categories:
    - With neurosurgery,
    - Without neurosurgery,

On the base of the presence of a neurosurgical ward in the hospital.

- PTS (Pronto Soccorso per Traumi), i.e. low specialized trauma centre, is able to guarantee an cardiorespiratory stabilization of the patient, also with a surgical intervention, but cannot definitely treat a trauma: for this reason the patient, once is emo-dinamicaly stable, needs to be transferred to a CTS or CTZ.

In order to maintain a balanced distribution of resources [Figure 1] is necessary to have at least one CTS or CTZ per two millions habitants. PTSs are strategically localized in function of the typology of territory and existing transports.

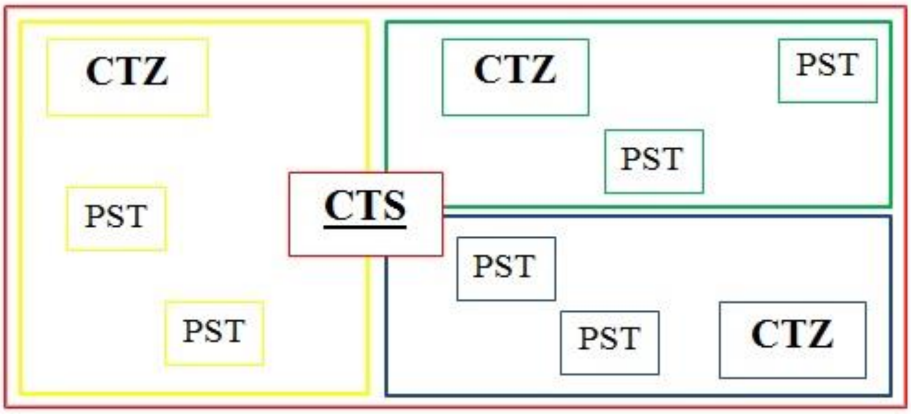


Figure 1:territorial competences for CTS, CTZ and PST

This new structure has the objective to treat patients as better as possible by sending them to the hospital with the adapt level of specialization: the more severe is a patient’s condition, the higher is the level of the destination hospital.

In this way, each structure as an assigned role in the urban healthcare: the main task is to create a system based on sharing resources and capabilities.

Furthermore, a collaboration with the single hospitals will allow the stabilization of severe cases in the nearest structure, with respect to the event scene, and then a transfer to CTS, if available [Table 2].

Niguarda hospital has been selected as CTS for the urban area of Milan [Figure 3], that counts circa three millions habitants; this number increases to four millions if also commuters are consider. The area covers 1440 square kilometres, including one hundred eighteen municipalities.

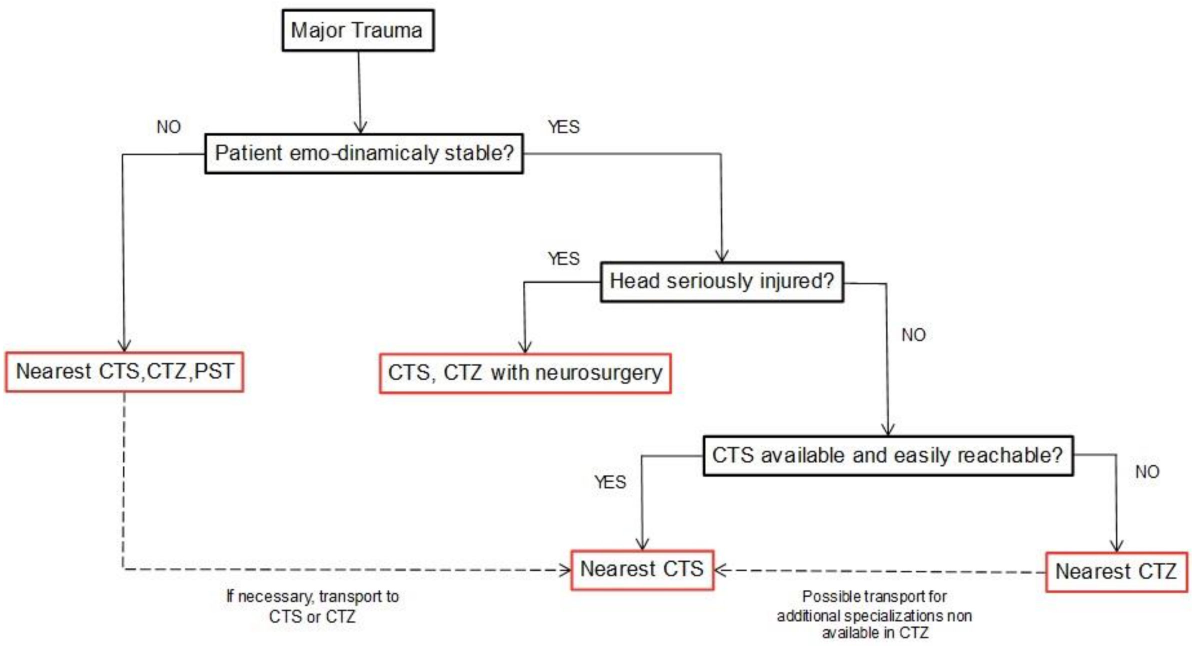


Figure 2: Algorithm showing the decisional mechanism between CTS, CTZ and PST and the consequent possible transitions.

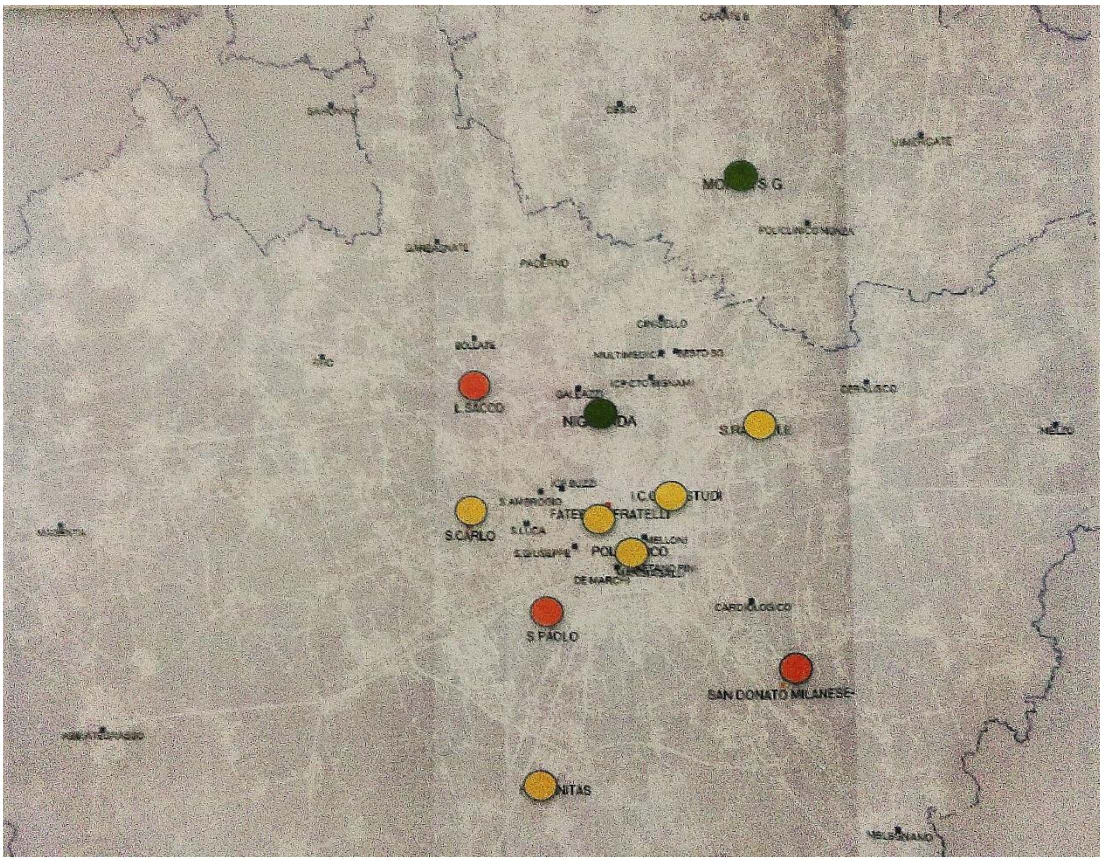


Figure 3: territory map and hospitals distribution. The green points are associated with CTs, the red one to the CTZ and the yellow one to the PST.

1.2 Structure of the Trauma Centre

The trauma centre is located in the DEA building inside Niguarda Hospital. DEA, Dipartimento di Emergenza e Accettazione, i.e. Emergency and Reception Department, is an independent structure for the treatment of traumatic patient. The DEA operates in order to offer a complete assistance to each patient, whatever its pathology is. The concept is that a wounded, who enters in DEA after an accident, will be dismissed at the end of the healing procedure, when he will be able to perform a rehabilitation path.

For this reason DEA has got several sub-departments and competences:

- Orthopaedics
- Neurosurgery
- Emergency Medicine

- Burn unit
- Anaesthesiology ICU
- Interventional radiology
- Hospital administration
- Nurse coordinator, which is the link between AREU and trauma team
- Two surgical room, so that one can always be available for emergency

This approach offers the patient a coherent and complete treatment along its healing path and makes also easier to the doctors to supervise all their patients, also if they are affected by different kind of injures.

1.2.1 The shock room: available instrumentation and primary evaluation of the patient

However, once the patient arrives to the DEA, he is not directly taken to a surgery room or to a specific department, but he is taken to a shock room: this medium dimensions room is reserved to the treatment of traumatic event, and is located at the first floor of the DEA. It is connected to the ambulance arrival and to the helicopter landing site trough an elevator.The shock room is a particular working space, where is possible to find all the primary required equipment to face a major trauma. Particularly this room allows the Trauma Team, i.e. a specialized èquipe working in the Trauma Centre, to perform a primary estimation of the condition of the patient, in order to stabilize his condition and to establish the necessary therapy.

A primary estimation includes five steps, known with the acronym ABCDE [Table 1] five passages are fundamental to identify and treat all the conditions that represent an immediate risk for the patient's life.

A	Airway -C spine	Airway control and rachis protection
B	Breathing	Ventilation control
C	Circulation	Circulation control (shock identification)
D	Disability	Summary neurological evaluation (GCS)
E	Exposure	Complete clothes removal and objective analysis of entire body

Table 1: Primary evaluation's steps

This primary evaluation lasts few minutes and can be followed by a secondary estimation if the patient is enough stable to tolerate further examinations. Usually the principal exams are:

- CT, i.e. Computerized Tomography, in order to evaluate potential internal injury in various corporal districts. This investigation is the most sizable and specific for the study of a traumatic patient.
- X-ray, which allows the identification of possible fractures, contusions and internal lesions.
- E-FAST, i.e. Extended Focused Abdominal Sonography for Trauma, which is a sonogram useful for the identification of a bleeding.
- NMR, i.e. Nuclear Magnetic Resonance, mainly used for patients with head injury which present discrepancies between the previous analysis and apparent conditions.

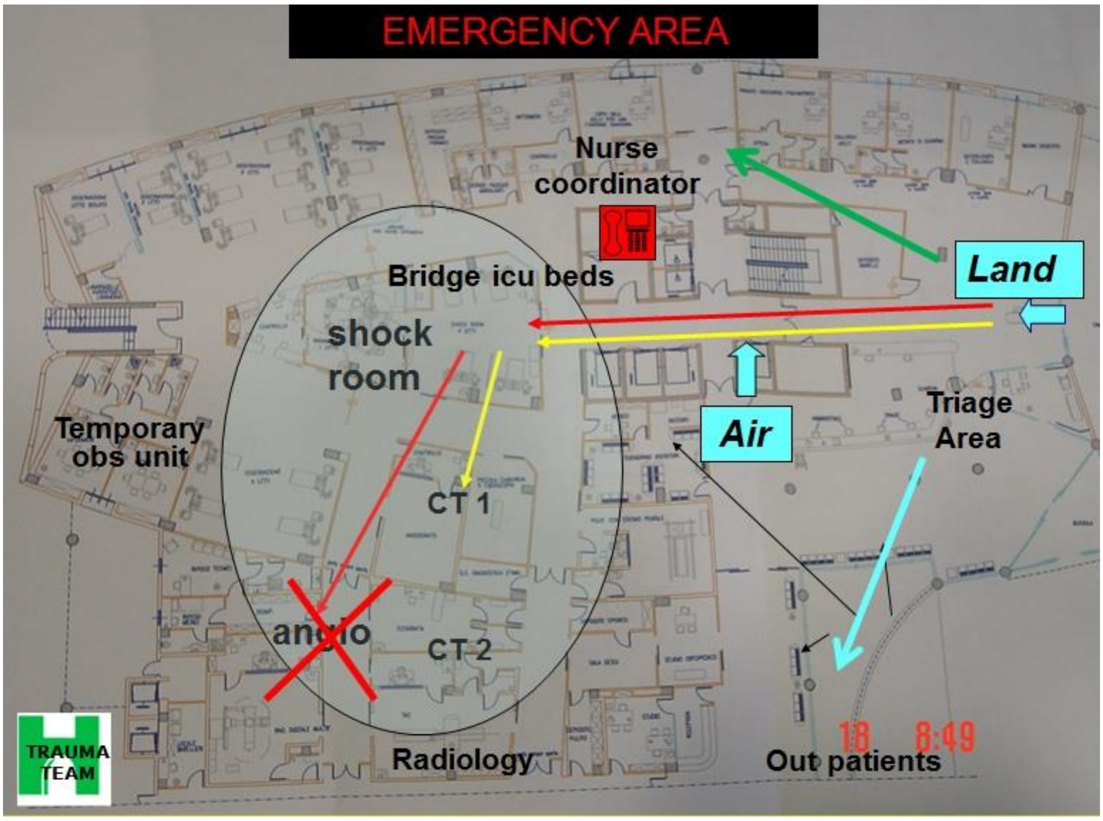


Figure 4: DEA floor plan. The plan underlines the two available entrances, specifying the direction followed by each triage code in function of its colour.

Obviously not all the necessary instrumentation is located into the shock room: some of them are positioned in other rooms easily accessible from the shock room, as represent in the images below [**Errore. L'origine riferimento non è stata trovata.**].

In the floor plan is also possible to see the accesses to the structure, one for patients carried by ambulances and one for the ones carried by the helicopter.

In the shock room [Figure 5], in addition to the medical instrumentation, is also possible to find a board, on which the team writes some parameters about the patient: the board allows each member of the team to be quickly informed about the case, without the necessity to ask to other colleagues.

The board has a key importance because it shows synthetically the severity of the incoming case, before it physically arrives in the trauma centre: the SOREU station, i.e. the telephone exchange of the emergency number, shares the information collected on the scene with the trauma centre, so that the team can be optimally prepared to face the situation.

The parameters involved are:

- Mechanism of trauma, e.g. road accident or pedestrian ran over,
- Emo-dynamics, i.e. stable or not stable,
- GCS, i.e. Glasgow Coma Scale,
- Possible evidence of thorax, abdomen, pelvis or other injuries,
- Gender,
- Age, if available,
- BP, i.e. Blood Pressure,
- HR, i.e. Heart Rate,
- SpO_2 ,i.e. oxygen saturation,
- Fluids dispensed before and after the arrival in trauma centre.

These parameters can be easily collected by the personnel on the scene and allows the team to build up a mental image of the arriving patient. This last passage is important because some medical personalities are not fixed member of the trauma team: in case of necessity they have to be alerted in time.

The board is filled in by the nurses of the team while their preparing the shock room from the arrival of a patient and it can be update with further information during this lapse of time. In fact the emergency vehicle can adjourn, through the SOREU, the trauma centre about the condition of the patient every time they worsen.

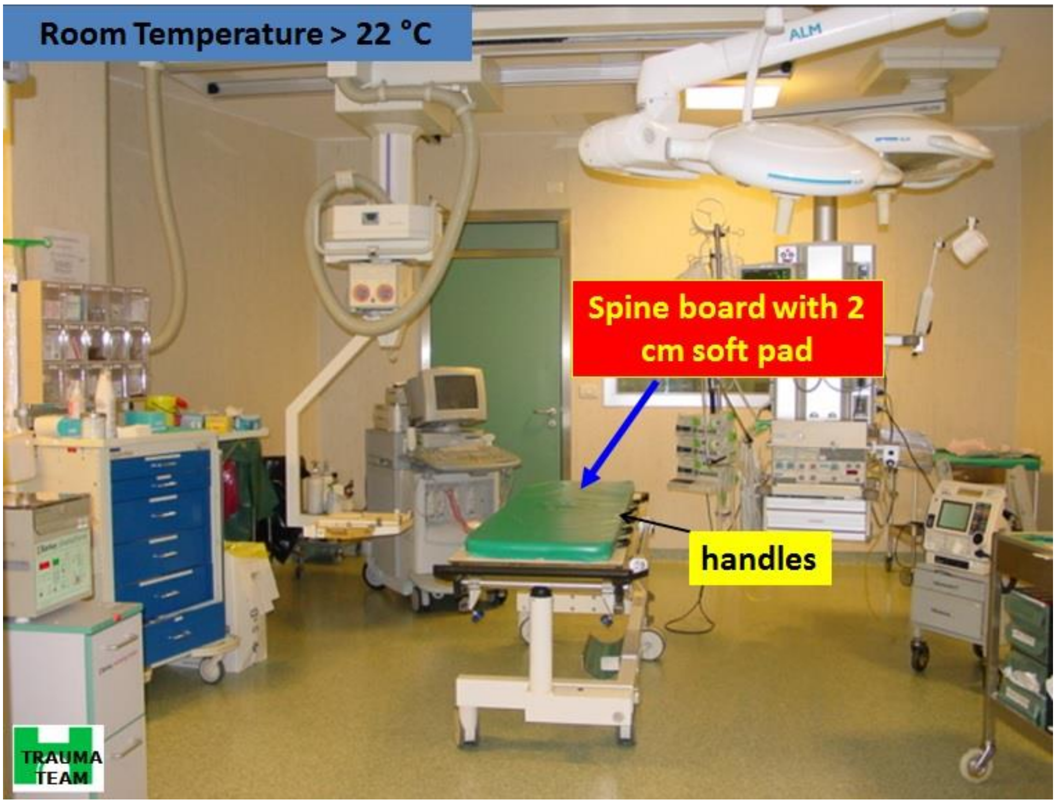


Figure 5: shock room

1.2.2 *Composition of the Trauma Team*

This high specialized structure needs a particular èquipe in order to be able to maintain the standards of CTS: the trauma team.

The trauma team is composed by nine personalities [Figure 6]:

- Team leader: is the most important member of the team because is the person with the higher level of knowledges for what concerns the major trauma. Usually he is a general or emergency surgeon, but sometimes this role is taken also by an anesthesiologist. He hasn’t an active role in the team; he supervises the entire team in the shock room.

- Emergency surgeon [EM.S]: in Italy this role is usually fulfilled by a general surgeon with a large experience in the management of emergency procedures. He is positioned on the patient's side and he has to perform the possible drainage, the surgical acquisition of airways or intravenous routes, the placement of urinary catheter and other medical practices. In the most severe cases he has to surgical intervene on the patient.
- Anaesthesiologist [ANS]: he works at the edge of the patient because he is responsible for the airway, he has to intubate the patient, if necessary, and he has to control the rachis during the evaluation. He also has to manage the anaesthesia in case of operation.
- Two nurses [N1-N2] that has to assist the anaesthesiologist and the surgeon in all the necessary procedures. They can also do some of them, e.g. insert the urinary catheter or medicate bleeding wounds.
- Radiology technician [RAD]: he has the role to perform the sonography and the x-rays exams during secondary evaluation.
- Auxiliary personnel [AUX1-AUX2]: they have to provide the team with all the necessary materials eventually not present in the shock room, e.g. additional blood sacks, and they have to assist the medical personnel and help during the transport between the several rooms of the trauma centre. They also have to psychologically support the parents of the wounded and to collect his personal effects.
- A doctor who cooperates with one of the surgeon [STUD], in order to acquire knowledges, and who registers all the data coming from the primary and secondary evaluation.

For the correct operation of the trauma team three more figures should be always available if the information about the incoming patient suggests the requirement of specific medical competences. These three figures are:

- Radiologist in order to perform directly in shock room the E-FAST, so that he can help the surgeon to evaluate the result of the exam and together they can decide the following investigation needed.

- Orthopaedist is fundamental when the incoming patient present severe pelvic fracture: he has the competences to stabilize this kind of injury that can cause strong haemorrhage. He can also supervise the stabilization of limbs fracture and propose particular secondary evaluation.
- Neurosurgeon: his presence is required in case of compromised consciousness, in case of side effects, e.g. vomit, bleeding or agitation, or in case of tetraplegia or paraplegia.

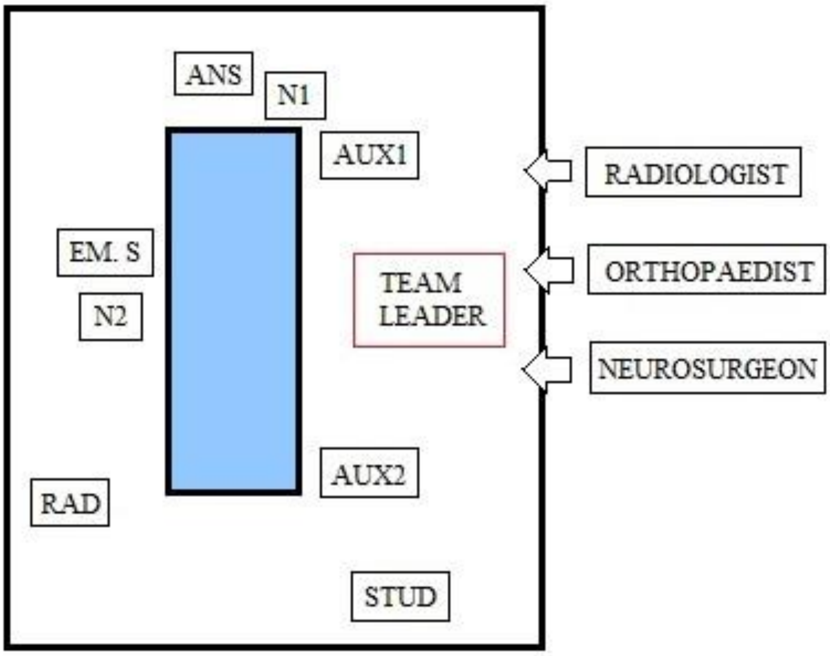


Figure 6: Trauma team's member disposition within shock room.

Other specialists that can be called in shock room are:

- Thoracic surgeon
- Cardiac surgeon
- Vascular surgeon
- Plastic surgeon
- Maxilla facial surgeon
- Gynaecologist
- Interventional radiologist
- Paediatric surgeon

- Transplantation surgeon
- Oculist
- Otolaryngologist

All these personalities must always be available, so is fundamental to arrange a list of turns within the trauma centre.

1.2.2.1 The role of the team leader

The team leader is responsible for the activation and the alert of all the members of the team, including the additional elements. He receives from the coordinator, i.e. a nurse of the trauma centre telephonically connected with the emergency number, the information about the incoming case and he has to decide whether to accept or not the patient.

The trauma centre has the capability to receive only one patient per time: there is only one trauma team and only a shock room, so the available resources do not allowed treating two or more patient contemporary. For this reason the emergency telephone exchange has to check the availability of the CTS before sending the patient to Niguarda.

The coordinator, whose role will be analysed in the following paragraphs, receives the call, but he is not involved in the decisional process. The team leader has the responsibility of decide to accept a patient: he knows if the team is ready to face a new case and if the required personalities are available. Furthermore, if there's already a patient in a surgical room with some members of the trauma team, he can decide to accept a patient if the timing of the operation allows the team to be ready in time for the arrival of the new wounded. In order to make it possible, the team leader has to know the ongoing operation, so that he could be able to estimate its ending time.

The team leader has other responsibilities within the trauma team [III]:

- Activation and composition of the trauma team before the arrival of the patient.
- Preparation of the shock room with all the necessary aids.

- Communication with the prehospital personnel, in order to collect information about the patient, useful for a better preparation of the team.
- Choice of diagnosis and treatments priority, with resulting communication of the strategies to the rest of the team.
- Execution and supervision of the primary and secondary evaluation and of the life-saving operations.
- Involvement of the specialist and coordination of the several procedures until the final hospitalization of the patient.
- Communication with the conscious patient, with his family and with the media.

In light of the previous considerations, the team leader is to be considered the chief of the structure in terms of command and control.

1.2.2.2 The role of the coordinator

The role of the coordinator is performed by a member of the trauma centre, usually a nurse. The coordinator should be always available, because he receives the emergency call for the acceptance of new cases.

As explained before, he has not any decisional power in critical situations, he is a communication key between AREU, i.e. the emergency telephone exchange, and the trauma team. With critical situation is to be considered those cases in which the trauma team is already busy: the team could be working in the shock room or in the operation room, but the coordinator is not able to decide for how long the resources would be unavailable. For this reason, the coordinator should consult the team leader before giving an answer to the AREU.

Another task of this particular figure is to take not of the availability of the single fixed or on call members of the team: for example, if the situation requires the presence of the neurosurgeon, the team leader must be sure that he is available in a suitable time before accepting the incoming patient. In order to make the decision process as easier as possible, each member has to communicate to the coordinator whether he is not available for a lapse of time. This process permits the team leader to always have a clear outline of the situation.

1.3 Study case

Now that the structure of trauma centre and his role in the regional health system have been explained, a description of the specific function of these resources is fundamental.

The trauma centre is a high specialized centre for traumatic patients; this means that they mostly should treat patients in severe conditions. The classification of the hospitals, as introduced in the previous paragraph, has the objective to create a hierarchy of the hospitals in order to improve the overall treatment of traumas on the territory: this means that Niguarda Hospital should receive all the major trauma of the urban area of Milan, in order to make this categorization functional.

1.3.1 Definition of major trauma

First of all, is important to define whether a trauma is to be considered a major trauma. There is a list of criteria that helps the operators, medical or not, to define the level of a trauma [Table 2].

Physiologic Criteria
GCS < 14
SBP < 90 [mmHg]
RR < 10 or RR > 32 [acts/min]
RTS < 11
Anatomy of Injury Criteria
Penetrating injuries of head, chest, abdomen, neck or limbs (proximal to elbows or knees)
Pelvic ring disruption
Fracture of two or more proximal long bones
Limb paralysis
Amputation proximal to ankle or wrist

Flail chest
Trauma combined with a second or third grade burnt
Crushing, pelting, mutilation or peripheral pulse absent

Table 2: primary major trauma criteria, divided into physiologic criteria and anatomy of injury criteria.

These physiologic criteria concern parameters calculable on the scene. The most important parameters are the GCS, i.e. Glasgow Coma Scale, which is a measure of possible neurological damages and the RTS, i.e. Revised Trauma Score, that is a general measure of the severity of a trauma.

The GCS index considers the consciousness, the verbal and motor response. Each one of these three fields is associated to a score, the sums of these numbers gives the GCS parameters: the lower is the obtained value, the more severe is the neurological damage.

The RTS index is depends on the sum of three different values: the GCS, the SBP, i.e. systolic body pressure, and RR, i.e. respiratory rate. The GCS is the parameter that influences more the global obtained measure. The lower is the value of the RTS, the higher is the severity of the trauma.

Mechanism of injury
Fall from more than own height
Presence of a dead in the same vehicle
Extrication time longer than 20 minutes
Deformation of the vehicle (more than 30 cm in the passengers compartment or more than 45 cm in other parts)
Rollover of the vehicle
Ejection from the vehicle
Impact between vehicles with high velocity (high risk of severe injuries)
Impact of a vehicle against pedestrian, cyclist (velocity higher than 32 km/h)
Motorcyclist crushes with velocity higher than 32 km/h

Table 3: secondary major trauma criteria

Together with these primary criteria, is possible to list a series of secondary parameters, linked to the mechanisms of trauma [Table 3: secondary major trauma criteria [Table 3]. These parameters are also known as high energy impact indicators: sometimes after a road crush the people involved seems to be unharmed, but in case of high energy dissipation at the impact, they can be affected by internal injuries, not evident immediately after the accident. This is the reason why is important to identify on the scene potential signs of high energy dissipation.

If a patient is affected by at least one of the listed parameters, ids to be considered as affected by a severe trauma. His condition leads to the transport to CTS, or to a PST for a primary stabilization. These are the kind of patient that the trauma centre should treat, for what concerns traumatic injuries.

Finally patient affected by known comorbidities or pregnant women are to be treated as major trauma, such as children younger than thirteen and adults older than sixty-four.

1.3.2 Triage code: what is it and how is correlated with major traumas?

In the latter paragraph we have explained how it’s possible to identify a major trauma. Now is fundamental to introduce the triage code: the triage code allows the medical personnel to easily communicate the severity of an injured.

A code is a common language to briefly communicate: if every part of the system knows this language, the communication process becomes easier and quicker.

The triage code classifies the traumas in three different categories: red, yellow and green codes. These codes are used in hospital but also in the assignment process before the hospitalization by the emergency call centre.

A major trauma characterized by at least one primary criterion is considered a red code: this code is the most severe one and it’s used for the emergency.

Patient affected by one or more secondary criteria are considered yellow codes. This second level comprehends cases attributable to the trauma centre, but also less severe injuries, that should be hospitalized in a CTZ. During the decisional process the emergency call centre as to discern yellow codes associated to a major trauma from the other one, by using the high energy impact indicators. Sometimes this separation process is not easy and can lead to some problems, that will be introduces later.

The last category, the green code, is associated to minor traumas, treatable by a CTZ but also by a PST.

1.3.3 Evaluation of data collected by Niguarda Hospital

After this description of major trauma and triage code we can go back to Niguarda Trauma Centre.

Since October 2010 up to December 2015 Niguarda trauma centre has received circa 2840 patients [VI]. Considering years between 2011 and 2015 the number of activation per year has progressively increased. The daily mean of incoming patient is around 1.83 patient/day.

Each patient that enters in the Trauma Centre has been scheduled into a database: in this database the team takes note of the injuries of the patient. This process allows a posteriori analysis of the cases arrived at Niguarda.

It is interesting to note that is possible to verify whether a case was a major trauma or not.

1.3.3.1 A posteriori Evaluation Parameters for major Traumas

This evaluation is possible with the use of some scoring, particularly with AIS and ISS. The AIS, i.e. Abbreviated Injury Scale, is a classification of injuries of each corporal district. The human body is divided into 3224 district, each one is analysed and associated to a number on the basis of the presence of injuries. The severity of the wounds is underlined with a number from one to six [Table 4]: the lower is the severity, the lower is the corresponding number. Each district is associated to a score, so, at the end, six different values are available for the evaluation of the patient's conditions.

The ISS, i.e. Injury Severity Score, is based on the AIS: it considers only the three higher AIS value, whatever are the districts involved. The final ISS is the sum of the squares of the three selected values.

$$ISS = a^2 + b^2 + c^2$$

When one district is associated with a score of 6, the ISS automatically takes its maximum value, 75.

If the ISS as a values bigger than fifteen, the trauma is to be considered as a major one. This evaluation is purely indicative because of the intrinsic nature of the ISS. In fact the ISS doesn't allow distinguishing between wounds associated to the same AIS, but located in different district: each district as a different impact on the probability of survival of the patient, e.g. the scores being equal a head injury is potentially more risky than a skin one. However the ISS is the most suitable mean for the analysis of past cases of the trauma centre.

Body Districts	AIS score per district	Associated severity
Head and neck	1	Minor
Face	2	Moderated
Chest	3	Severe, but not risky for life
Abdomen	4	Severe, potential risky for life
Pelvis and limbs	5	Critical
Skin	6	Not compatible with life

Table 4: AIS districts and scores

1.3.3.2 Over-triage and Under-triage: what they are and how they influenced Trauma Centre's Work

By performing an analysis of the available data [VI] is evident that most of cases where not domain of the Trauma. Only the 36.37 % of the incoming cases where major trauma according to their ISS. These values mean that 1809 patients over 2843, the 63.63%, should have been treated in lower level hospitals.

This percentage is called over-triage: this term indicates those wounded that has received a high specialized treatment in a CTS although they didn't need it, because their injuries weren't too severe to be necessarily cured by a trauma team.

The over-triage leads to an incorrect use of resources in the sanitary system: the trauma centre can receive only one person per time, simply because they have only one available shock room and obviously only one available trauma team. For this reason, if the shock room is occupied by a minor trauma, contemporary it could be not available for acceptance of a major trauma: this patient will be carried in an lower level hospital, probably a CTS, which is not equipped to face every typology of emergency.

The over-triage has not any direct consequence on the patient, because he is hospitalized in a higher level trauma centre and he receives all the necessary

Observation period	2010	2011	2012	2013	2014	2015	Total observed cases
Number of observed cases	104	429	508	574	616	612	2843
ISS>15	24	185	202	184	232	205	1032
Percentage of major traumas	23.08 %	43.12%	39.76%	32.55%	37.66%	33.50 %	36.30%
Percentage of over-triage	76.92 %	56.88%	60.24%	67.94%	62.34%	66.50 %	63.70%

Table 5: percentage of major traumas and over-triage from 2010 to 2015

treatment, but it results in excessive costs and burden of CTS.

However the over-triage is needed in order to be conservative in the cure of the patient: the ISS gives an immediate feedback about the severity of a trauma, but can only be calculated at posteriori, when all the patient's injuries have been found out and cured. When a patient arrived in the trauma centre is impossible exactly to predict his conditions: that's the reason why is better to maintain a safety margin in the assignation of the triage code, following a series of criteria, previously listed.

Another interesting confrontation can be made between the triage code assigned by the emergency number, the incoming triage code [Table 6] and the one evaluated by the trauma team at the arrival of the patient. Once the emergency vehicle arrives in the Trauma Centre, the èquipe performs a summary control of the conditions of the patient: at the end they assign to each case a triage code.

Sometimes the two triage codes are different, because the trauma team is trained to identify major traumas thanks of their experience in this setting.

Most of the patient arrived at Niguarda Hospital as yellow codes: obviously not all these cases are truly major trauma, as is confirmed by the analysis of the ISS numbers divided according to the incoming triage codes. This phenomenon leads to a high percentage of over-triage, especially for green and yellow incoming codes.

In order to understand this numbers, it's important to compare them with other trauma centre's results. According to the American College of Surgeon, i.e. a scientific and educational association of surgeons with the objective to improve the quality of care of the surgical patient, including those affected by a traumatic event, by setting high standards for surgical practice, the over-triage percentage must be between 25% and 50%, in order to protect the population from the under-triage.

Incoming Triage Code	Number of cases	Percentage
Green	25	0.88%
Yellow	2088	73.44%
Red	555	19.52%
None	175	6.15%

Table 6: incoming triage codes. The term "none" indicates the collected cases without any assigned incoming triage code.

The under-triage comes from the transportation of severely injured patient to a lower level trauma centre, such as a CTZ or a PST, which don't have the resources for facing these kinds of events. The under-triage is a problem for the health of the patient, so is really important to limit this phenomenon and to keep its percentage under 5%. The under-triage marked in the Trauma Centre is composed by the incoming green codes, that later resulted in more severe traumas. The obtained percentage is 0.88 % [**Errore. L'origine riferimento non è stata trovata.**].

Although the Niguarda Trauma Centre filled in a database, it's not possible to estimate the overall percentage of under-triage in the metropolitan area of Milan: in order to evaluate this number all the hospital involved in the trauma care system should take note of all their incoming cases.

This procedure would lead to the creation of a complete data set, that could be useful for the Lombardy's Sanitary System.

In this work the attention will be focused on the reduction of the over-triage, in order to optimize the territorial resources and to approach the standards suggested by the American College of Surgeon.

The choice of the American College of Surgeon as a landmark for the evaluation of the over-triage comes from the necessity to compare Niguarda Trauma Centre with the American and Canadian ones, whose results are collected and represented by this institution.

1.3.4 Where does the over-triage come from?

The trauma centre has no decisional power for the assignation of destination hospital after traumatic events: the team leader can refuse a patient only if the trauma team is unavailable. This means that the decisional process is performed outside the Trauma Centre.

		Incoming Triage Code							
		Green		Yellow		Red		None	
Trauma Centre's Triage Code and ISS	Green	0	0%	7	0.33%	1	0.18%	2	1.14%
	Yellow	25	100%	1800	86.21%	37	6.67%	115	65.71%
	Red	0	0%	281	13.46%	517	93.15%	58	33.14%
	ISS>15	5	20%	527	25.24%	419	75.49%	81	46.28%
	ISS<15	20	80%	1561	74.76%	136	24.50%	94	53.71%

Table 7: trauma team revaluation of the Incoming triage codes, both in terms of assignation of new triage code and ISS number evaluation.

The AREU has the responsibility of the assignation of destinations hospitals to each patient. AREU, i.e. Azienda Regionale Emergenza Urgenza, is the regional company appointed for the management of emergencies in Lombardy. In the metropolitan area of Milan they are represented by a SOREU, i.e. Sala Operativa

Regionale per Emergenza e Urgenza, an operations centre that follows each event from the incoming call to the choice of the destination hospital.

The structure of the SOREU will be analysed in the following chapter, in order to find out the human and technical problems that can have a role in the generation of the over-triage.

Previously is necessary to underline that the SOREU works following a list of standards and criteria for the identification of trauma: as listed beforehand, there are some parameters, coming from scientific literature, useful for the identification of high energy impact. If an impact causes the dissipation of a high energy amount against, for example, a vehicle, it means that also the human body has received the same amount of energy that can lead to severe wounds.

Nowadays the problems comes from the technological evolution, e.g. actual cars have got several airbags and other safety devices, or simply are built in order to absorb the energy coming from an impact, which limit the dissipation of energy against the human body. Unfortunately, the indicators parameters haven't been updated and sometimes this leads to an overestimation of the patient's injuries.

The road accident, in particular those ones that involve cars, should be the events that are majorly influenced by the use of old parameters, because of the security evolution happened in the last years. Table 9 represents the dismissed patients before a truly hospitalization: road accident is associated to the highest percentage, around 29%. This data means that all these cases where not major traumas: they didn't need to be hospitalized in a high level trauma centre.

Although the road accident represents the 67% of the events [Table 8], the over-triage cannot originate only by this category. Also fall and violent are frequent and for this reason they can lead to an over-triage.

For what concerns mortality, the percentage are really low and the 40% derives by patient with injuries not compatible with life, i.e. they were identify by an ISS equal to seventy-five.

The analysis of the database has underlined the problem of over-triage, but is not possible to completely comprehend from where this incorrect use of resources comes from.

In the following chapter the analysis of the AREU system will help us with the identification of the problems related to the over-triage. The prehospital process is fundamental to optimize the Trauma Centre system.

<table>
<tr><th><u>Typology of Event</u></th><th><u>Number of Cases</u></th><th><u>Percentage of Cases</u></th><th><u>Percentage of over-triage</u></th></tr>
<tr><td>Road Accident</td><td>1920</td><td>67.53%</td><td>35.94%</td></tr>
<tr><td>Fall</td><td>575</td><td>20.22%</td><td>44.35%</td></tr>
<tr><td>Violent Event (Beating, with Weapons or Self-Harm)</td><td>211</td><td>7.42%</td><td>21.33%</td></tr>
<tr><td>Accident (e.g. at Work, at Home, while Doing Sport)</td><td>121</td><td>4.26%</td><td>27.27%</td></tr>
<tr><td>Wounded by Animals</td><td>12</td><td>0.42%</td><td rowspan="3">25%</td></tr>
<tr><td>Major Event (e.g. Fire, Explosion)</td><td>2</td><td>0.07%</td></tr>
<tr><td>Not Known (e.g. Person Found on the Ground)</td><td>2</td><td>0.07%</td></tr>
</table>

Table 8: Typology of event and their percentage

	Mortality		Patient Dismissed without Hospitalization	
	Number of Deaths	Percentage	Number of Dismissed	Percentage
Overall	50	1.76%	832	29.26%
Road Accident	23	1.20%	604	31.46%
Fall	17	3.96%	136	23.65%
Violent Event (Beating or with Weapons)	7	3.32%	60	28.44%
Accident (e.g. at Work, at Home, while Doing Sport)	3	2.48%	30	24.79%
Wounded by Animals	0	0%	2	16.67%
Major Event (e.g. Fire, Explosion)	0	0%	0	0%
Not Known (e.g. Person Found on the Ground)	0	0%	0	0%

Table 9: Number of deaths and of dismissed patient. The first row's data regard all the registered events. The data related to each category of event can be seen in the other rows.

Chapter 2.

TERRITORIAL EMERGENCY SYSTEM: THE SOREU

In case of emergency, in Italy, a citizen should call the 112, i.e. the unique emergency number. This service splits up all the incoming call, so that every emergency can be faced by the correct department.

If the emergency concerns a medical event, such as an illness or a wounded due to a road accident, the incoming call is redirected to SOREU.

A SOREU (Sale Operative Regionali dell'Emergenza Urgenza) is a regional operating room that manages every kind of sanitary emergency, from the incoming call to the arrival at the appointed hospital.

The SOREUs are set up by AREU (Associazione Regionale Emergenza Urgenza) which is the regional body for the management of emergency and urgency in Lombardy.

The SOREU associated to the urban area of Milan and Monza Brianza, is located in Niguarda Hospital and it is the one that deals with the Trauma Centre. The

SOREU covers an area with the availability of two CTS, i.e. Niguarda Trauma Centre and San Gerardo Hospital in Monza.

In this area of 1855 square kilometres' live more than three million inhabitants; if also commuters are included, this number exceeds four millions. The SOREU must guarantee the health care in all this area and must be able to face every type of emergency as fast as possible. This task implicates a great organizational effort and a great amount of resources.

In order to optimize a limited number of resources in terms of personnel and vehicles, the SOREU has been improved during the years and now it works as a complex structure with defined procedures.

Actually the Niguarda Hospital's SOREU is divided in three main SOP, i.e. a part of the operative room Each SOP has a different role in the prehospital trauma care and a different typology of personnel involved.

The number of persons present physically present in SOREU, considering all its departments, is different between day and night: during the day twenty-two persons work in Niguarda office, while in the night hours they are thirteen.

The SOREU physically is organized in three different areas, so that each SOP1 can work separately. The SOPs are linked through common software that collects all the active events.

A case is considered active from the redirection of the medical incoming call made by the emergency number, to the arrival of the patient at the designated hospital, with consequent reallocation on the territory of the vehicles involved. Every SOP updates automatically the status of every single case according to its skills.

Thanks to this software is possible to share information also if the SOPs are not physically connected.

2.1 SOP1: management of emergency call and of ALS

In SOP1 fifteen persons work during the day: eight operators, i.e. seven working for the call centre and one responsible for the ALS, one doctor, two nurses and a coordinator.

SOP1 is the department that interacts with the citizen on field. The citizen that calls the emergency number is considered as layman, i.e. a person without any particular medical knowledge. The objective is to collect all the necessary information about the event and to associate a triage code to it and if necessary, to directly send on the scene an advance ore intermediate life support.

2.1.1 Phone Operators

The operators of the SOP1 have to interact with a layman, that can be stressed and frightened by the situation that he is facing. Consequently the information given by the citizen can be confused and not completely correct: this reflection underlines the necessity to use easy questions, so that the comprehension and the answer can be easy for every kind of person on the phone, independently of their medical knowledges.

In order to be more efficient and complete as possible, the operators conduces an interview following a particular filter.

This filter was projected by AREU and it is able to represent every kind of possible event using question with multiple answers. Each answer has a different weight and lead to a specific consequent question, following an algorithm that is able to calculate the triage code of the analysed event and to choose the correct sequence of questions step by step.

Thanks to the filter, the operator has a guideline during the interview, that allows to collect all the necessary information about the event, if they are available, e.g. the state of consciousness and the condition of the breathing of the patient. Little basic information is enough for the generation of a triage code, which is significant for the following SOPs.

2.1.2 Doctor and nurses

The role of the doctor and of the nurse is to support the operator in case of severe events, such that can lead to an immediate intervention of a doctor on the scene, e.g. major trauma. These two figures can also assist by phone the layman if special procedures are necessary to save the life of the patient, e.g. CPR (Cardio Pulmonary

Resuscitation). They can also call back the layman in order to be updated to the state of the patient and to collect other useful information about the event or just to be directly informed about an eventual worsening of the situation.

In order to work for the SOREU doctor and nurses have to satisfy some characteristics [AI]

A SOREU doctor must satisfy at least one of the following requirements:

- Doctor with a specialization as anaesthesiologist
- Doctor with experience in first aid or in emergency departments, e.g. DEA, emergency acceptance department.
- Primary assistance doctors subscribed in the regional ranking, with suitability certificate for territorial sanitary emergency activity
- Doctors with AREU’s proved formation, including medicine students and freelance professionals working with sanitary companies associated with AREU for what concerns extra hospital activities.

For what concerns nurses, they should come from emergency department, belonging to hospital or extra hospital activities.

2.1.3 ALS management

SOP1 has to define whether is necessary the intervention of an ALS or ILS on the scene of the event.

ALS and ILS are two particular kinds of available vehicle on the Lombardy territory used for the intervention in case of sanitary emergency.

The available vehicles are [I]:

- BLS, i.e. Basic Life Support (MSB, i.e. Mezzo di Soccorso di Base in Italian): this kind of vehicle is used for every kind of intervention. The personnel on board is composed by volunteers. Each volunteer has to be an adult, with a good knowledge of Italian and has to attend a course in order to be certificate as a regional emergency medical technician. The course consists in theoretical lessons, 50 hours, and practical sessions, 70 hours, with a final examination as provided by regional law [DGR 7474/2008]. On a single BLS there are 3 or 4 volunteers: a driver, one person responsible for the defibrillator, a vehicle head and eventually an assistant. The driver as to have all the necessary requirements needed in order to be allowed to drive an emergency vehicle, as provided by law [D.Lgs. 285/1992]. Volunteers aren't allowed to administer medicines, but they are able to administer first aid, e.g. cardio pulmonary resuscitation using a defibrillator. A low level of preparation is enough for facing green or white codes, but it's not sufficient in more serious situation, e.g. red or yellow codes. In these cases the BLS is sent on the scene together with a medical support, i.e. ALS or ILS, because is the only vehicle able to transport a patient.

- ALS. I.e. Advanced Life Support (MSA, i.e. Mezzo di Soccorso Avanzato in Italian): it is a medical car, on which is possible to find a doctor, a nurse, a driver and sometimes a volunteer. The presence of a doctor on the scene allows collecting detailed information about the state of the patient. The doctor can also administer medicines and stabilize the wounded due to his medical capabilities. The doctor and nurse's selection criteria are the same previously introduced for SOP1's doctors. Given that this vehicle is a car, it's not possible to carry the patient to a hospital, so it is always required a BLS together with an ALS.
- ILS, i.e. Intermediate Life Support (MSI, i.e. Mezzo di Soccorso Intermedio in Italian): sometimes for yellow codes is possible to send a vehicle with two or three volunteers and a nurse, selected with the already shown criteria. A nurse has better medical competences than a volunteer, so it could be useful for fairly critical cases. As for the ALS, the ILS should always be associated with a BLS, in order to enable the transport of the patient.
- Helicopter: it's the most expensive vehicle available, but it's also the fastest. On board is possible to find a doctor, a nurse, a pilot, an aeronautic technician and a specialist in helicopter rescue. This solution is used in severe trauma that happened in difficult areas, i.e. when ground vehicle cannot guarantee the arrival to the hospital within the golden hour. The

golden hour is the limit time of hospitalization for major traumas: by respecting this restriction the survival probabilities of the patient increases. However another important factor should be considered: the helicopter needs a wide space for landing and this condition is rare in an urban area.

Immediate Intervention of ALS,ILS or helicopter	
Medical event	Traumatic event
Patient not conscious, that cannot breathe or with compromised breath (gasping)	Amputation or sub-amputation of limbs (not fingers or toes)
Patient not conscious with difficulty breathing	Submersion
Patient with altered conscious and difficulty breathing	Fall from more than two meters high
Chest pains with associated difficulty breathing	Explosion or collapse of a structure
Difficulty breathing associated to other severe side effects, e.g. cyanosis	Person crushed or over-ran
Patient with known allergy that present the symptoms of an allergic reaction, e.g. rash or edema	Wounds due to a gun or hand weapon and penetrating wounds
Pregnancy, from sixth month, with imminent childbirth or aggravations.	All unconscious patients
	Hanging
	Car accident with ejection of patient from the vehicle
	Car accident with patient caught inside the vehicle
	High speed car accident with impact against obstacles or other vehicle
	Road accident (pedestrian, cyclist, motorcyclist) thrown apart by the impact
	Presence of dead person inside of the same vehicle
	Face, neck and chest burnt
	Electrocution with altered vital sign

Table 10: criteria for immediate intervention of advanced vehicles, divided in criteria concerning medical event or traumatic event [IV].

In SOP1 there's an operator specifically appointed for the management of ALS, ILS and helicopter. He has to choose which vehicle sends on the scene of each event associated with a severe case. The selection of events for which is necessary to send and advanced vehicles is made by the call centre's operators, together with doctor and nurses. AREU has defined a list of criteria for the sending of ALS, ILS and helicopter.

Sometimes [**Errore. L'origine riferimento non è stata trovata.**] the operator can directly send the advanced vehicle on the scene, by selecting the command on his desktop, although he has to consult the doctor or one of the available nurses in order to revaluate the case [

]. The doctor, or the nurse, can call back the scene to collect other important information in order to be able to decide whether the ALS is necessary or not.

Once the intervention of the advanced vehicle has been selected, the operator has to choose the better vehicle to send on the scene. Eleven ALS, seven ILS and a helicopter, only during the daily hours, are available in the metropolitan area of Milan and Monza.

Several factors are involved in the decision making process: the operator has to take into account the distance of the vehicles from the scene and the severity of the patient. For fairly severe event he sends an ILS, on suggestion of the doctor, and usually he chooses the nearest available car.

If the case is more severe he has to choose whether to send an ALS or the helicopter. First of all, the choice depends on the available space: if there isn't enough space for the helicopter landing, this resource is immediately rejected. Secondary the operator has to consider the hypothetical travel time to the hospital: the helicopter could also be slower than the ALS, so it's better to choose a car in order to respect the golden hour. The selected ALS should be the nearest available car to the scene of the event.

The management of the advanced vehicles is located in SOP1 in order to allow a better and faster communication between the call centre operators, the doctor and the nurses and the ALS operator during the decisional process of advanced intervention.

Sometimes, for example, the operator or the doctor can directly communicate to the ALS operator to intervene on a selected severe event before the completion of the information collection. This procedure allows guaranteeing a fast intervention of a doctor on the scene.

Request of consul before sending of ALS, ILS or helicopter	
Medical event	Traumatic event
Not conscious patient with effective breath or without information about breath	Minor trauma that involves a child, i.e. age between zero and twelve years old, or a pregnant woman.
Suspect of intoxication	Electrocution
Signs of a hypoglycaemic crisis	Road accident with more than five persons involved, without the criteria of a major trauma
Signs of a hypertensive crisis	Overturned vehicle
Pregnancy with haematic loss or a pathologic pregnancy	Amputation or sub-amputation of fingers or toes
Childbirth already happened	Limbs trauma with pain therapy needed
Neurological deficit	Burns with face, neck and chest not involved
Patients that need a special assistance, e.g. amyotrophic lateral sclerosis	
Altered cardiac frequency	
Altered pressure values	
Breathing difficulties without the presence of cyanosis	
Signs of an allergic reaction	
Chest pain in the front part of the body (area between mandible and navel)	
Convulsions or presumed post critical phase	

Table 11: criteria useful for the revaluation of the event by a doctor or a nurse before sending of advanced vehicles, divided in criteria concerning medical event or traumatic event [IV].

2.1.4 Shift supervisor

The shift supervisor is an experienced operator which performs the technical command and control part. He has access to all operators' activity and he has to manage every technical problem in the SOP1.

In case of necessity he can respond to the incoming call and fulfil the role of simple operator.

2.1.5 Command, control and communication charts

In order to better understand the interaction and the role of the different personalities working in the SOP1, the representation of a command, a control and a communication chart can be really useful.

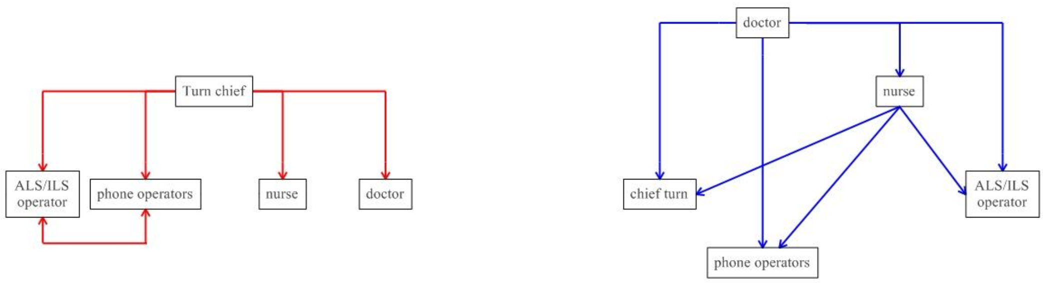


Figure 7: command chart, SOP1

These kinds of charts help the analyst during a functional analysis. A functional analysis is the process that allows understanding every part of a system, starting from the logical sequence of activities that constitute the analysed process, and including the role of all very personality and their interactions.

In this particular case, the command, control and communication charts are useful to describe the relations between the SOP1's personnel and also to define the hierarchical structure of this area. This passage is fundamental for the completion of the functional analysis of the SOREU in the following chapter.

The command chart is a graphical representation of the command hierarchy of the SOP1. One rule must be respected: each person can be command by only one personality. This means that only one chief can be found in a working area, in order to maintain the authority within the group and to reduce the possibilities of misunderstanding, coming from the presence of too many orders.

However the SOP1 has two chief, but how is it possible? Inside SOP1 there are two different kinds of competences [Figure 7]: the first one concern the technological devices present in their working space, whether the second one involves medical aspects. The turn chief has a command role every time there's a technical or organizational problem to solve. When the chief is not available is role is taken by the ALS operator, whose working space is located next to the chief's one.

For what concerns medical aspects, i.e. every decision needed for the care of the patient, from the filling of the filter, to the revaluation of his condition for the sending of an ALS, the chief is SOP1's doctor, blue scheme in Figure 7. If the doctor is temporary absent, his role is covered by a nurse, whose medical knowledges are better than the ones of the rest of the personnel.

All the other members of the team haven't got any command role, in order to preserve the authority of the technical and medical leader, respectively the turn chief and the doctor.

Figure 8: control chart, SOP1

The control chart [Figure 8] explains how the different personalities working in a system check each other work. In this case, in SOP1, the control chart is still divided in two parts, on the basis of two typology of roles covered by the personnel: the scheme related to the technological aspect is the red one, whether the blue one represents the control of the medical part of the process.

The turn chief controls all the other members of the SOP1 trough the software which collects all available information on the desktop of his computer. Also the operators and the ALS operator can check each other work thanks to the software: e.g. a phone operator can control if his colleague, responsible for the ALS, has effectively sent a vehicle on the scene of the selected events.

On the other side, all the medical aspects are controlled by the doctor: he controls all the other personalities of the SOP1, he is the reference for every medical problem together with the nurse. The last chart [Figure 9] represents the communication channels between the team. All the members of the team can directly communicate with the other ones, because the working space is quite small and all the emplacements are located in the same room. This kind of space organization helps the work of all the employees, because is fundamental to allow the personnel to share information, ideas and opinion about each event as fast as possible. That is the reason why the ALS operator works together with the SOP1 and not with the other vehicle operators in SOP2: the ALS operator can be immediately alert when the presence of an advanced vehicle on the scene is request, sometimes also before the complete generation of a triage code. The team can also communicate with the software: the software is the easier way to spread all the collected information in a logical and organized way: it helps the phone operator to control that each call has been received and that each event is associated with the triage code.

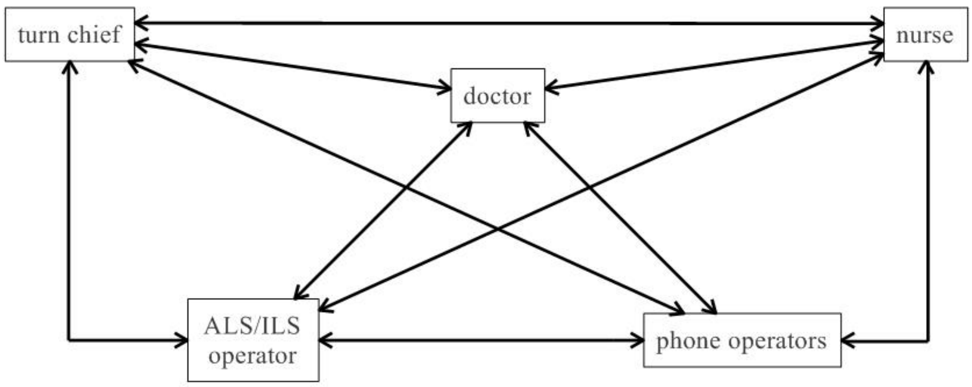


Figure 9: communication chart, SOP1

Thanks to the computer is also easier to avoid misunderstanding when someone refers to a patient, because each case is associated to the noun of the patient, but also to the location of the event.

2.2 SOP2: management of the fleet

There are six people, during the day, working in SOP2. They are all operators employed in the management of the fleet, i.e. BLSs. Three operators manage the urban area, while the other three are associated to Monza and Brianza.

They are connected to the software, so they can see the list of the active calls: they can select the calls for which the filter has generated a triage code. If there is more than one call associated to the filter, priority is given to the most severe case. For example a red code needs to respect the golden hour, so it's fundamental that the SOREU sends immediately a vehicle on the scene.

SOP2 has to assign a specific ambulance to each case: they need to know the exact position of all the available devices on the territory. Every vehicle can be located through a GPS, so the operator is able to localize them on a map on their desktop.

The localization is important because allows the operator to evaluate the distances between the event and the ambulances. Once the operator has select a case on the list, he can see on the map the position of the event and of the nearest available vehicle.

The nearer the vehicle is to the event, the faster is its arrival on the scene. This variable is fundamental for severe accident, associated to a yellow or to a red code, while in case of green or white code is secondary.

A green or a white code can be reached in a longer time, because there's no imminent risk for the patient's life. Sometimes, for these codes, the operator considers also the numbers of ambulance available in a zone and not only their distance to the scene. By doing so all the territory maintains a sanitary cover in case of severe accident, i.e. each zone can always be reached in an acceptable time by a BLS.

Another important task of the SOP2 is to constantly update the list of the ambulances and cars in service on the territory: all the vehicles take working turns of twenty-four or less hours. This list is managed by a software called GECO.

Once the operator has selected the vehicle, he radios the coordinates, so that the intervention can start.

The software records automatically the time of departure of the ambulance from its park, i.e. the place where the available vehicles wait for a new intervention to start. Up to now the ambulance keeps in contact with the SOP2 via radio: times of arrival and departure from the scene should be registered with a tablet connected to the software, as well as the times of arrival and departures from the assigned hospital.

SOP2 can control the timeline of each event on the software, as well as the hospital assigned, in order to be able to reallocate each vehicle to a park or to another active event at the end of the intervention.

The work of SOP2 ends whit the performed reallocation, after the vehicle has left the hospital, once the patient is accepted from the medical staff.

However, sometimes a patient refuses to go in hospital or the ambulance cannot find the patient on the scene. The volunteers should report that the ambulance is empty and consequently SOP2 closes the associated case in the software and reallocates the vehicle.

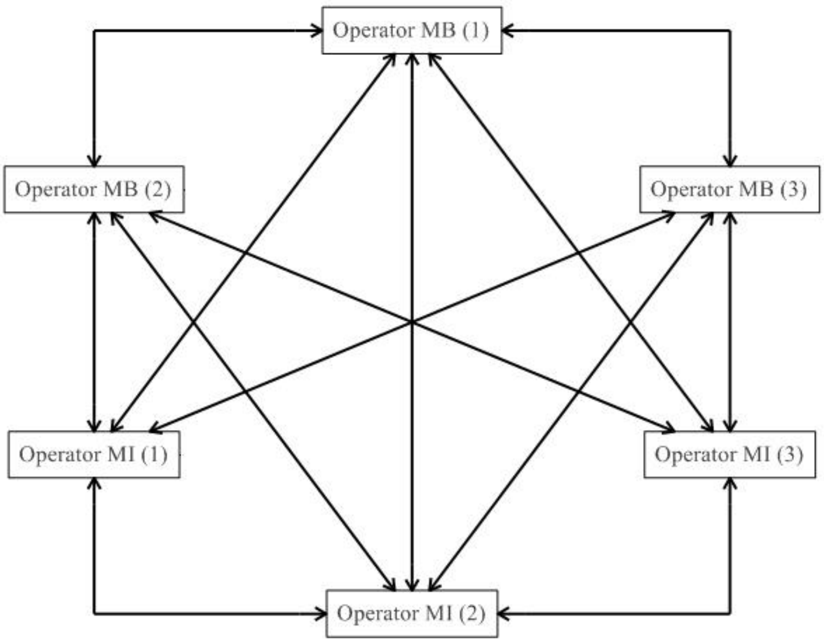


Figure 10: communication chart, SOP2

2.2.1 Command, control and communication charts

In this SOP2 is not possible to build a command or a control chart: each operator works individually on the available cases on the desktop. The only possible distinction can be made between operators working on Milan's urban area and on Monza Brianza's area.

Each operator can communicate [Figure 10] with the other ones, in order to make it possible to manage every doubt and to allow the collaboration when necessary.

2.3 SOP3: management of the patient

In this last SOP the personnel is composed by a doctors, four nurses and an operator. Their main role is to assign to each patient a destination hospital.

Also this department is connected to the main software, so the operators have access to the list of active cases. They receive calls from then scenes, but they don't speak with the laymen, but directly with the volunteers or with the doctors. This communication has a higher level of specification than the one between the operators and the laymen, because leads on technical medical aspects.

When SOP3 has selected an incoming call, the software shows some medical parameters registered on the scene by the members of the emergency vehicles. The SOREU's personnel can ask some more information about the condition of the patient, before he decides the destination hospital.

The choice of the hospital is an important and tricky step: the operator has a list of the available hospital on the territory, together with a schematic representation of the number of patients already present in each PS. The system is also capable to show the number of patient per triage code.

As for the selection of the vehicle, the choice of the hospital depends on several variables.

For what concerns green and white triage codes the choice depends on the typology of the wounds, i.e. some hospital are specialized in some disciplines more than others: for example an orthopaedic centre could be the right choice for a femoral fracture. At the same time, is important not to overload a single hospital with green or white codes: sometimes is better to select a hospital in function of the number of free beds available.

However, if the event is classified as red or yellow code, the hospital should be chosen also considering its level. As already said in the previous chapters, hospital can be classified as CTS, CTZ or PST.

For what concerns traumatic event, in case of a red code, and for the most severe yellow codes, SOP3 addresses those patients to the Trauma Centre.

Sometimes, if the conditions of the patient are too severe, he can be brought to Niguarda after a stabilization in another hospital, which can be a either a CTZ or PST.

In order to be sure that the trauma team is available to treat the patient, the SOP3's doctor calls the coordinator.

The role of coordinator is played by a member of trauma team, usually a nurse that coordinates the PS, as explained in the first chapter.

2.3.1 Importance of a medical trained personnel

In this area the personnel is mainly composed by doctor and nurses, which have been selected following the criteria introduced in SOP1's paragraph.

This choice was necessary in order to guarantee a quick and understandable communication between SOREU and the personnel on the scene. In case of severe accident, is fundamental that the two parts communicates without misunderstanding.

The SOP3 personnel must be able to understand the severity of a case without being able to see the patient: they should interpret the situation trough the collected data.

Once they have framed the situation, the personal should also associate each patient to a hospital. This passage is linked to the previous one, e.g. if the nurse misunderstand the condition of the patient, he can't be able to choose the best destination hospital, not only considering its capability to treat the patient, but also for what concerns the equilibrium of the entire health system and the correct use of its resources.

Unfortunately there isn't any written rule for the analysis of the condition of the patient and the selection of the best hospital, so the personnel perform a subjective choice. Obviously, the more a nurse, or a doctor, has worked in the SOP3, the more his experience has grown up, so it could be easier to perform a diagnosis.

2.3.2 Command, control and communication charts

The command and control charts are divided in two different typology, as for the SOP1: the red ones describe the relations with respect to technological aspects, whether the blue ones regard the medical relationships between the personnel.

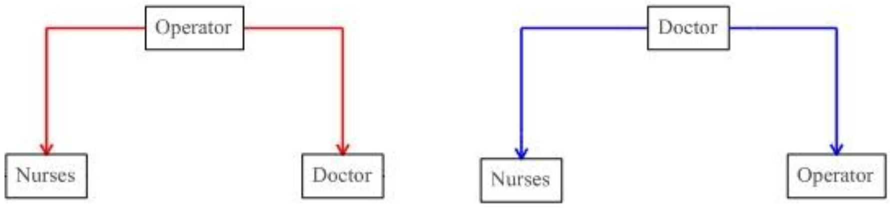


Figure 11: command chart, SOP3

Every nurse has the same role within the command and control chart, so they are represent together in a unique box.

The technical command role [Figure 11] is covered by the operator: he has the capability to face every problem liked to the technical part. He also controls all the technical part, has explained in Figure 12.

As for the SOP1 the medical chief is the doctor [Figure 11]. He also controls nurses and operator's work [Figure 12].

Figure 12: control chart, SOP3

Communication [Figure 13] within the personnel is fundamental in SOP3: as seen in the other SOPs, every member of the team can talk with the other ones, in order to reinforce cooperation and to solve all possible doubt. In particular the personalities with higher experience can be able to help their colleague in tricky situations.

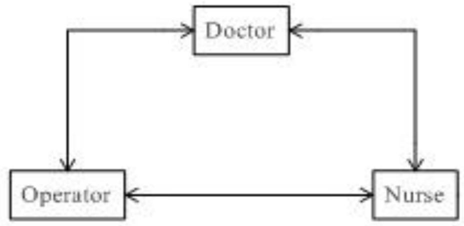


Figure 13: communication chart, SOP3

2.4 SOREU command, control and communication charts

After the description of the different SOPs, it's possible to analyse the overall structure of the SOREU.

Each SOP has its own hierarchy between its components, but is also possible to define a command, control and communication chart related to the entire SOREU.

The SOP, as already explained, interact with each other using the AREU software. The software is necessary to register all the collect information, but also because the SOPs are located in three different rooms: SOP1 and SOP3 work in two connected room, while SOP2 works in a separated area.

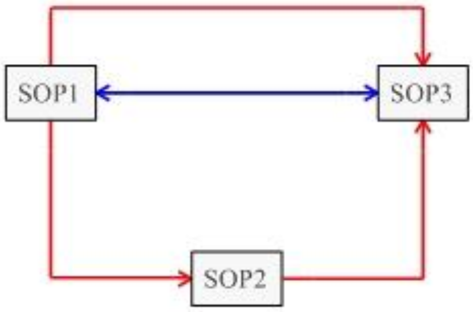


Figure 14: communication chart, SOREU

As explained in Figure 14, there are two different channels of communication: the red arrows represent the information's transfer between the SOPs using the software, while the blue arrow stands for a verbal communication. Only members of SOP1 and SOP3 can speak to each other, because they work in connected area. This choice derives from the necessity to share medical information about a patient, but sometimes is also useful in order to be able to face great emergency, when the two SOPs work together. On the contrary, SOP2 is able to work also independently, because it is not involved in any medical decision: they only have to manage the BLS fleet.

The chief of the entire SOREU is the doctor working in SOP1 [Figure 15]. However his role is not fundamental, because the SOPs generally work with different tasks, so they are able to manage themselves. In case of emergency or when the incoming event is particularly complex, he has the power to decide and to command the entire SOREU.

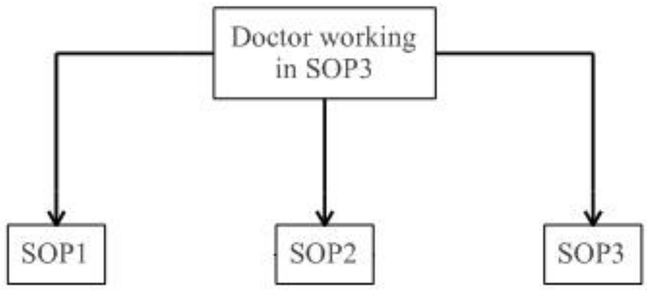


Figure 15: command chart, SOREU

The command role of the SOP1's doctor, in case of emergency, will not be deepened in this work, because we are not interested in the analysis of emergency situation, but only on the functioning of the systems in normal conditions.

The control chart [Figure 16] derives from the chronological intervention older of the different SOPs on each event.

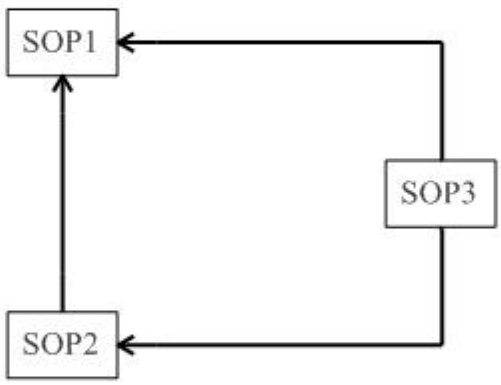


Figure 16: control chart, SOREU

The first information added in the software are collected by SOP1, so the following SOPs are able to perform a control function by opening an active event on their desktops. SOP3 has the main control function, because they intervene at the end of the chain, e.g. they can control the medical data assigned to a case, they can change a triage code and decide to send another vehicle on the scene.

The control function is not useful only for detect possible errors, but also to update and APPROFONDIRE the knowledge about each patient, because his conditions can change after the emergency call.

2.5 SOREU's GANTT chart

The following step is to understand the temporal sequence of activity performed in the SOREU. A useful instrument could be the GANTT Chart.

The GANTT chart is a graphical representation of all the actions involved in a process: trough this diagram is also possible to split up each passage of a process into its elementary components, always maintaining a logical and temporal sequences between them.

Another interesting capability of this instrument is to create logical linking between the single actions: sometimes on activity can start only if the previous one is finished, or two activities must be starting together in order to reach their objective into the process.

In this case, the GANTT Chart can easily represent how SOREU works, showing the sequence of activity performed by each SOP. The diagram can show also how the SOREU interacts with the vehicle on the territory and with Niguarda Trauma Centre.

2.6 Criticalities of the process

The analysis of the process allows the analyst to deeply understand its structure and the logical and stochastic linking involved.

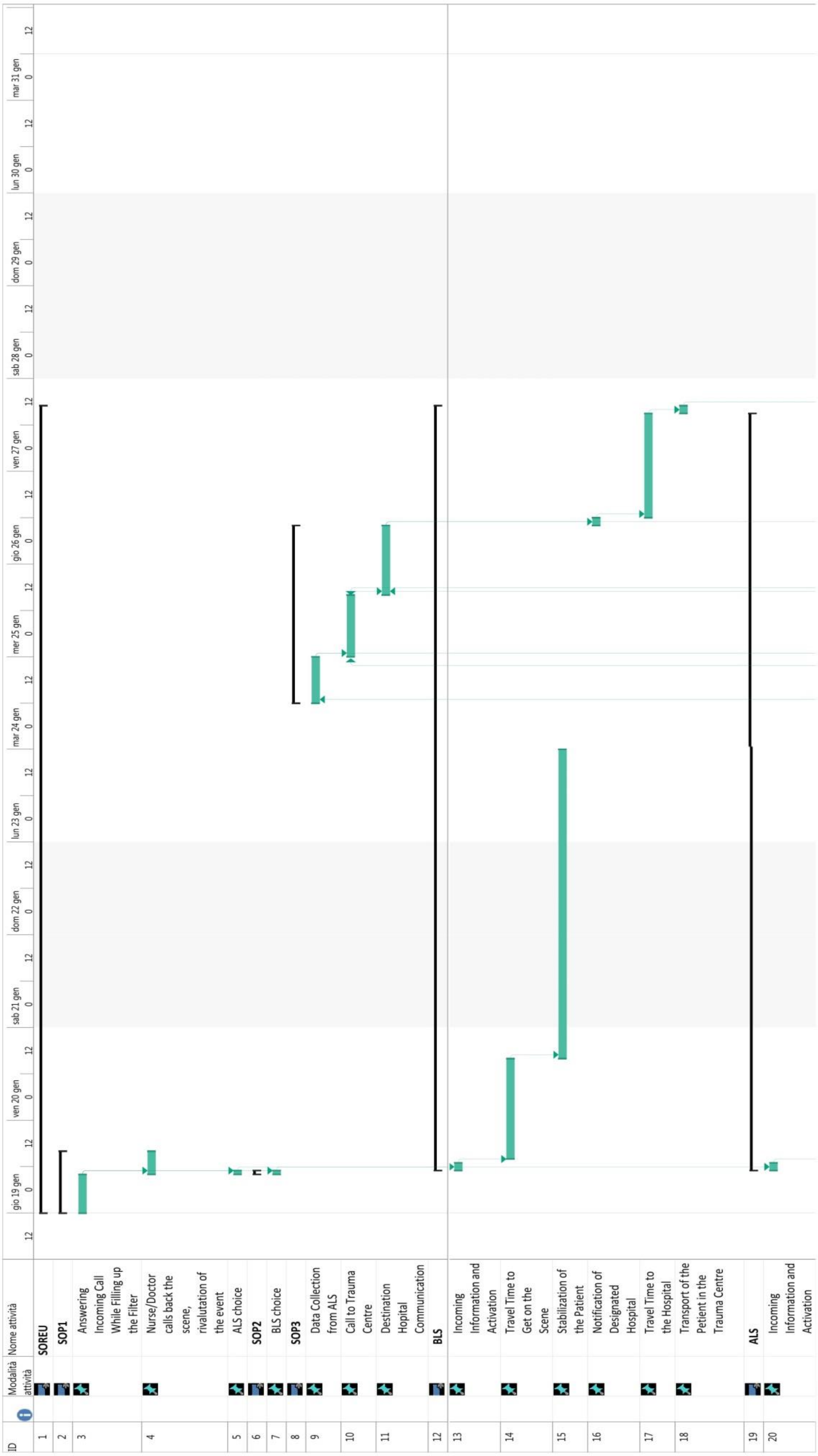
The following step is the identification of the criticalities of the process: the objective of this work is to reduce the percentage of over-triage registered at Trauma Centre.

In the previous chapter, the analysis of the data has underlined that the emergency territorial system has a key role in the generation of this problem, but how is it possible to understand which steps of this complex process major influenced the over-triage percentage?

In the following chapter some useful instruments that the analyst could use in order to identify the criticalities of a process, independently from the complexity of the analysed system, will be presented.

However is important to considering that the analysis of the criticalities is possible only if the analyst has a complete and profound knowledge of the process, otherwise he wouldn’t be able to read and understand the obtain results.

Figure 17: the following figure show the obtained GANTT chart, showing the logical sequence of operation, from the incoming call, received by SOP1, to the arrival and effective reception into the trauma centre. The last block diagram represent the GANTT sequence divided into five areas: yellow is linked to SOP1, red to SOP2, and orange to SOP3. Green represents all the activity performed on the scene, whether the blue boxes report the trauma centre coordination and activation.


ID
Modalità attività
Nome attività
gio 19 gen
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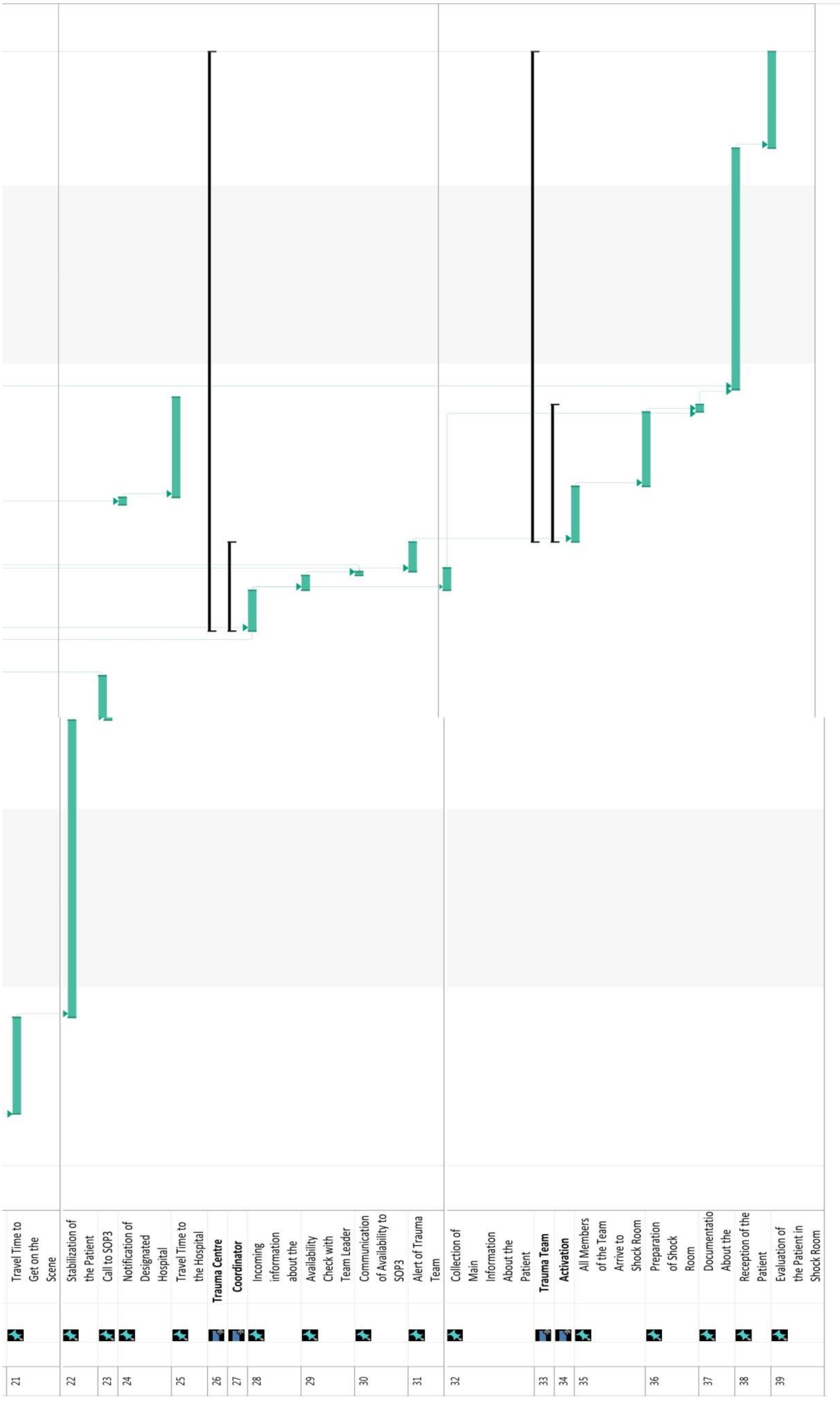
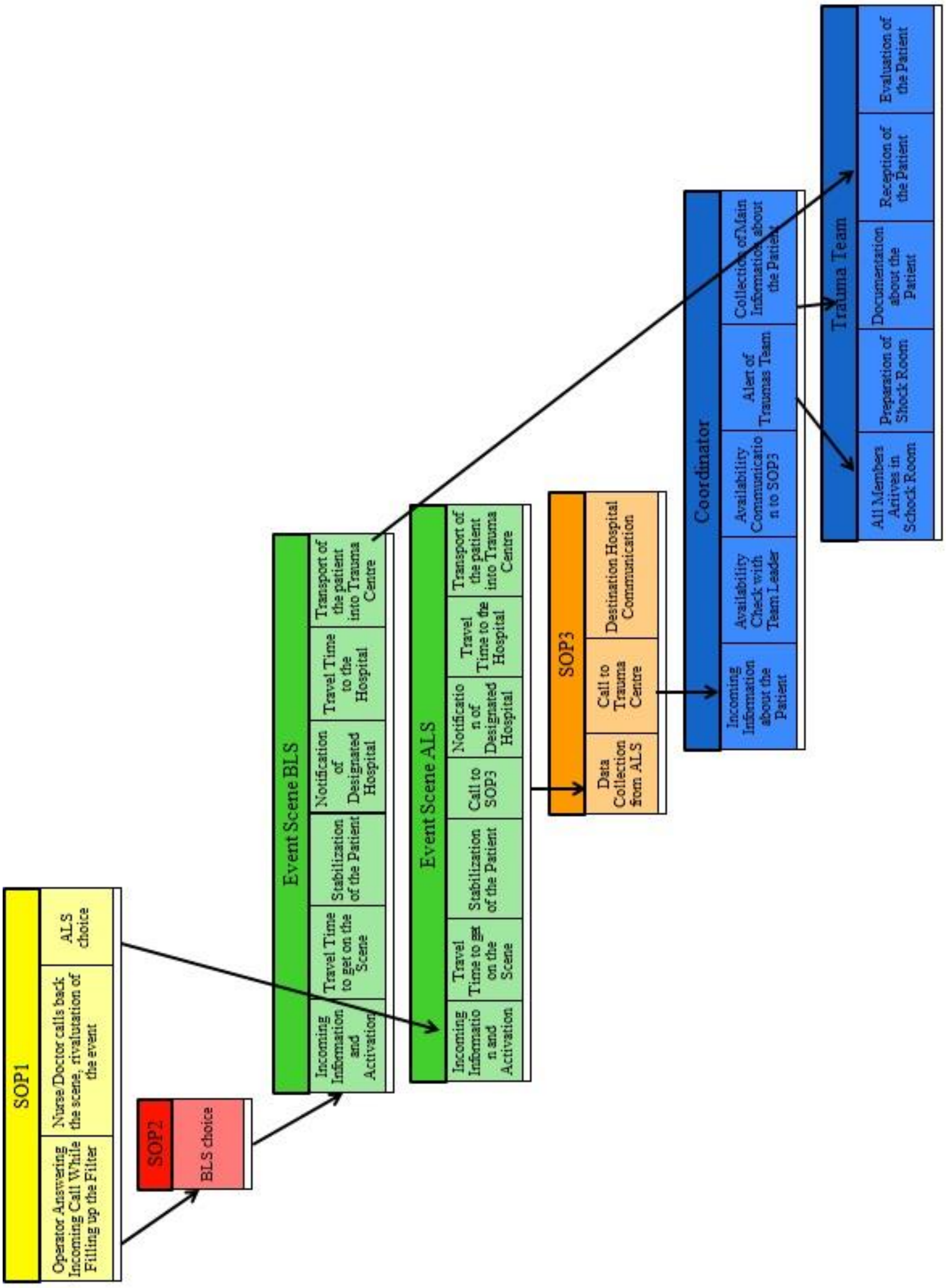
sab 21 gen
dom 22 gen
lun 23 gen
mar 24 gen
mer 25 gen
gio 26 gen
ven 27 gen
sab 28 gen
dom 29 gen
lun 30 gen
mar 31 gen
1 SOREU
2 SOP1
3 Answering Incoming Call While Filling up the Filter
4 Nurse/Doctor calls back the scene, rivalutation of the event
5 ALS choice
6 SOP2
7 BLS choice
8 SOP3
9 Data Collection from ALS
10 Call to Trauma Centre
11 Destination Hopital Communication
12 BLS
13 Incoming Information and Activation
14 Travel Time to Get on the Scene
15 Stabilization of the Patient
16 Notification of Designated Hospital
17 Travel Time to the Hospital
18 Transport of the Petient in the Trauma Centre
19 ALS
20 Incoming Information and Activation


21 Travel Time to Get on the Scene
22 Stabilization of the Patient
23 Call to SOP3
24 Notification of Designated Hospital
25 Travel Time to the Hospital
26 Trauma Centre
27 Coordinator
28 Incoming information about the
29 Availability Check with Team Leader
30 Communication of Availability to SOP3
31 Alert of Trauma Team
32 Collection of Main Information About the Patient
33 Trauma Team
34 Activation
35 All Members of the Team Arrive to Shock Room
36 Preparation of Shock Room
37 Documentatio About the
38 Reception of the Patient
39 Evaluation of the Patient in Shock Room


SOP1
Operator Answering Incoming Call While Filling up the Filter
Nurse/Doctor calls back the scene, rivalutation of the event
ALS choice
SOP2
BLS choice
Event Scene BLS
Incoming Information and Activation
Travel Time to get on the Scene
Stabilization of the Patient
Notification of Designated Hospital
Travel Time to the Hospital
Transport of the patient into Trauma Centre
Event Scene ALS
Incoming Informatio n and Activation
Travel Time to get on the Scene
Stabilization of the Patient
Call to SOP3
Notificatio n of Designated Hospital
Travel Time to the Hospital
Transport of the patient into Trauma Centre
SOP3
Data Collection from ALS
Call to Trauma Centre
Destination Hospital Communication
Coordinator
Incoming Information about the Patient
Availability Check with Team Leader
Availability Communicatio n to SOP3
Alert of Traumas Team
Collection of Main Information about the Patient
Trauma Team
All Members Arrives in Schock Room
Preparation of Shock Room
Documentation about the Patient
Reception of the Patient
Evaluation of the Patient

Chapter 3.
ALBA TECHNOLOGY: ANALYSIS OF A SYSTEM AND OF ITS CRITICALITIES

ALBA is a software developed by Remo Galvagni that can be used by risk analysts to study any kind of system, on the basis of few rules which allow being complete, consistent and realist while describing the system in order to enable decision-making under uncertainty. Its name stands for Artificial Logic Bayesian Algorithm, which means that, while analysing the system, we are dealing with an artificial algorithm, based on the logic rules inherent in the system's functioning, that can be updated continuously in time, as knowledge is acquired. The last aspect outlined is the Bayesian rule, which explains how the knowledge on the success of an event modifies the probabilities of the universe of possibilities. This is possible because the system is developed on the basis of inductive logic, which permits the analyst to use the experience and the imagination of single events to arrive to many different general conclusions, the main difference from the classical deductive analysis.

As a result, this way of thinking increases the knowledge of the system by recognizing the possible alternatives and defining their probability and, when new information is known, the system can be revised in order to obtain the same conclusions, but with new degrees of belief.

ALBA contains a tool to keep under control the state of knowledge of our system, the entropy. This variable measures the quantity of information needed in order to arrive to the true alternative. So, when new knowledge is acquired, entropy decreases because we add a piece of information that makes us closer to the certainty state, the truth. The state of certainty is what can be reached through logic conclusions and constraints emerged in the system analysis, fundamental for the analyst, since it permits simplification and a deeper knowledge of the system.

3.1 The input file

The input file of the software must be based on the logical processes, which connect the many different functions operating in the system. The used code must be univocal, clear and complete, in order to maintain a synthetic view of the system, that allows the analyst to maintain a vision of the process.

The input file consists of a series of yes/no questions, derived from the inductive thinking of the analyst, on the behaviour of the aleatory variables chosen because characteristic ad characterizing of the system.

Each question corresponds to a level, characterized by a sequence of five integers and real numbers and three alphanumeric mnemonic, in order to maintain a synthetic and easy syntax. Here there is an example of a level:

:Is the state of consciousness known?
236 0.25 0. 238 245 3 'consciousness' 'known' 'not known'

- The sentence introduced with a colon is the real question chosen by the analyst: the program is not able to see this part, it identifies a level only through the second line.

- The first integer identifies the level and it goes from 1 to 999. The level corresponds also to an event, recognized by the program by the use of the first integer.
- The first real number assigns a probability value to the failure of the event, by using a number between 0. and 1. This part is important in order to regulate the probability of each constituent. Each possible story, i.e. outcome, of the process is called a constituent. The sum of all the constituents represents the universe of possible alternatives contained in the analysed system. Each constituent is linked to a probability value calculated by ALBA starting from the failure probability of each event. The assignment of a probability value to each event influenced also the entropy value: a probability equal to 0.5 means that the analyst hasn't any knowledge about that particular event, so the entropy valued connected to that event is maximum. The probability assignment must be univocal and coherent among all the script, so set within certain rules that have been adopted in the software, the three coherence principles:
    - Convexity:

$$0 \leq p \leq 1$$

    - Simple additivity:

$$p_{set} = \sum_i p_i$$

$$\sum_i p_i = 1$$

    - Product rule:

$$p(AB) = p(A|B) * p(B) = p(B|A) * p(A)$$

  The sum of the probabilities of the constituents must sum up to 1 and the probability of each constituent is computed summing up the probability of each mutually exclusive event, or, as written before, yes/no event.
- The second real number is the CoV, i.e. Coefficient of Variation, useful for the description of the distribution together with the mean value.

- The following two integers identify respectively the subsequent level in case of success and in case of failure of the analysed event. This two numbers are useful to build the logical lattice of the input file. Sometimes these two integers assume the same value, so it means that the level has the same exit both in case of failure or success. If they assume a value equal to zero, the level becomes an exit level, in other words a conclusion of the event chain.
- The last number is simply a printing instruction for the program. This integer can assume four different values:
    - 0: the event must not be printed
    - 1: the event must be printed only in case of success
    - 2: the vent must be printed only in case of failure
    - 3: the event must always be printed

    If the analyst decides to print an event it means that it would be visible in sequence of event charactering the resulting constituents.
- The three mnemonic represents respectively the function, success and failure description. Their length is limited to twenty-one characters, in order to respect the typical synthetic view of ALBA.

The construction of an input file is an iterative process, the correct questions order comes out after several trials and corrections. The process of understanding of the system helps the analyst to build up the correct sequence of event in function of the needed results.

3.2 Logical constrains

The written input file is composed by a sequence of event, but is important to limit the system, in order to avoid a binary explosion of constituent and to reflect the correct behaviour of the system.

In order to make it possible the analyst can use the logical constrains: this expedient allows inserting in the input file all the logical linking necessary to represent the structure and the behaviour of the systems, that the analyst has studied during the functional analysis of the system.

There are two different typology of logical constrain, both of them can be related to a specific event: the first type lead to an addresses' change of subsequent selected levels, whether the second typology allows a state determination of a selected following question in function of the current event.

Every constrained has to be written under the level's description line, independently of its typology.

3.2.1 First type of logical constrains

The first typology allows the analyst to change the success and failure address of one or more selected levels depending on the success or failure of the conditioning event.

This constrain is composed by five integers, as represent in the following example:

2 65 80 55 56

- The first integer stands for the state of the conditioning random event and it can assume three different values:
  - 1: the logical constrain is relevant only if the conditioning event is in a success state
  - 2: the logical constrain is relevant only if the conditioning event is in a failure state
  - 3: the logical constrain is always applicable
- The second and the third integers stand respectively for the new success or failure address level of the conditioned event.
- The last two integers indicate the conditioned level: the conditioned level must be consecutive, because the address's change is applied to all the events included between the two selected integers. If the constrains

conditions only one vent, the two integers assume the same value, equal to the conditioned event.

3.2.2 Second type of logical constrains

The second typology of logical constrains allows the analyst to force on success or failure a conditioned event given that the conditioning one is in its success or failure state.

This logical constrain is composed by a sequence of two integers and two real numbers:

16 42 0 0

- The first integer represents the relation between the two selected events and its strength. In order to understand its meaning it could be useful two split the integers in two parts and considering separately the two numbers. The first number can assume only two values:
  - 1: the constrain is relevant only if the conditioning event is in its success state.
  - 2: the constrain is relevant only if the conditioning event is in its failure state.

  The second number represents both the state of the conditioned event and the relation's strength:
  - An odd number indicates that the conditioned level is in a success state. The number can be equal to 1, 3 or 5: the higher is the number's value, the stronger is the relationship between the levels.
  - An even number indicates that the conditioned level is in a failure state. The number can be equal to 2, 4 or 6 and represents the strength of the relationship, following the same rule explained for odd numbers.
- The second integer corresponds to the conditioned level

- The last two numbers are always equal to zero. They are meaningless and have to be added just for syntax homogeneity.

If a level is conditioned by two or more different second typology constrains, its state will be determined by the strongest one.

3.3 Stochastic constrains

The stochastic constrains allows the analyst to change the probability of an event in particular conditions, depending on the state of a conditioning event.

The probability evaluation is a key point in the STESURA of an ALBA's input file, because allows the user to add YULTERIORMENTE its acquired knowledge about the system. As will be explained further on, each probability assignation determines the grade of truth of the results obtained with ALBA: being able to define a probability different from 0.5 means that the user has at least a minimum knowledge of the event in object.

In the input file preparation the user DISPONE of two different kind of stochastic constrains. The first type regards the conditioning of probability of an event depending on a former one, whether the second typology allows to manage variations of waiting times in which probabilities has to be taken into account.

3.3.1 First type of stochastic constrain

The first typology allows the analyst to change the probability of a conditioned event giving that the conditioning event is in its success or failure state.

Its syntax is composed by two integers and two real numbers.

20 45 2e-3 0.

- The first integer represents the state of the conditioning event.it can assume two different values:
    - 10: the stochastic constrain is relevant in case of success of the conditioning event.

  - 20: the stochastic constrain is relevant in case of failure of the conditioning event.
- The second integer indicates the conditioned event.
- The first real numbers stands for the new probability value that as to be assigned to the conditioned event.
- The last real number indicates the coefficient of variation associated to the new conditioned probability distribution.

3.3.2 Second type of stochastic constrain

The second typology of stochastic constrains can be useful in the evaluation of processes in which the analyst deals with reparability and availability of single components, associated to restoration times.

In this work this kind of constrains won't be used.

3.4 ALBA results

Combining all the possible alternatives, ALBA gives, as a result, a family of constituents, i.e. all the possibilities the analyst imagined of how the system acts. ALBA is a reliable tool in risk analysis because, being its calculating power finite, it eliminates from the analysis only the constituents that have a probability below 10^{-12}, value that can be changed by the analyst, which stands for a nearly impossible event. The analyst can select the desired probability cut in ALBA's main interface [Figure 18], by changing the value of the lowest probability, located on the bottom right of the screen.

Obviously it is reliable only if the probability assignment is univocal and coherent among all the script. The sum of the probabilities of the constituents must sum up to 1 and the probability of each constituent is computed summing up the probability of each mutually exclusive event, or, as written before, yes/no event.

However the analyst is interested in the risk values related to the various constituents. In order to obtain the risk values this part must be coupled with the phenomenology modelling system, in which values of the magnitude are assigned to measure the consequences of the interested events. By combining the probabilities and the magnitudes, the result is a range of instruments that the decision-maker can use in the risk evaluation. The risk is obtained simply by multiplying risk and magnitude, without the utility factor, the subjective element that the decision maker has to add to the analysis, thanks to a systemic and systematic approach in order to permit a realistic and coherent model of the system.

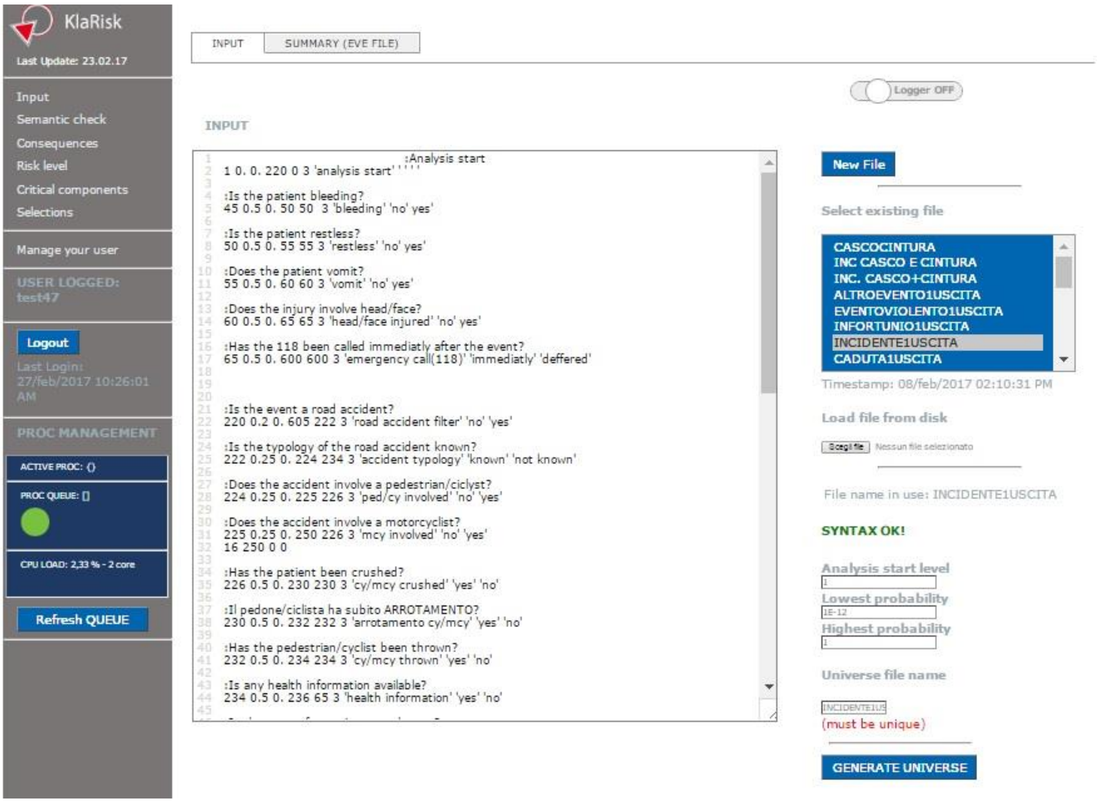


Figure 18: ALBA main interface. The input is located in the middle part of the screen. Each input can be saved in the cloud and, if necessary, recalled through the blue box on the right.

3.4.1 Consequences

The magnitude assignment is a fundamental part of ALBA's risk analysis. The analyst can associate each event, in case of success or failure to a magnitude value, in function of the consequences weight.

The magnitude file is added to the program through the consequences page, [Figure 19].

Once the consequences have been inserted in the main space in the centre of the page, the analyst should choose the related input and universe file name. Each input file can be associated to more than one universe: each time the analyst modifies the input and chooses to compute he generates a new universe. Also the application of a minimal change, e.g. a probability value, the generated universe is a new one. That's the reason why is important to select the correct universe name for the computation of the consequences.

The consequences file comprehends all the magnitude written by the analyst: not every event must be associated to a magnitude, whether some events can be associated to more than a magnitude value.

The basic syntax is:

IF (K1.EQ.570.AND.K2.EQ.1)   XDT = XDT+XC(10)

- The first number, introduced by K1, identifies the level that must be associated to the magnitude value.
- The second number, introduced by K2, identifies the state of the selected even. The magnitude is relevant only if the level is in its:
    - Success state, i.e. 1
    - Failure state, i.e. 2
- The last part of the phrase is the assignation of the magnitude. XC(I) is the consequences associated to the event. The XDT is the consequences value associated to the entire constituent: its value is cumulative, so it is made by the sum of the magnitude of the verified event composing the constituent. The basic XDT value can be either equal to zero or equal to any other number.

The initial XDT is defined in the consequences file's introduction, together with the magnitude lower and upper limits, i.e. the I acceptable range.

The consequences can also comprehend also a K3 condition. The addition of K3 is aleatory and it's useful when the magnitude value assigned to a level is not always true.

IF (K1.EQ.570.AND.K2.EQ.1.AND.K3.EQ.0)   XDT = XDT+XC(10)

In fact the K3 can assume three different values:

- K3.EQ.0: it indicates that the consequence value is relevant only when the related level is not constrained by any logical constrain.
- K3.EQ.1: it indicates that the consequence value is relevant only when the related level is constrained on its success state.
- K3.EQ.2 : it indicates that the consequence values is relevant only when the related level is constrained on its failure state

When the analyst decides not to use the K3 syntax, it means that the consequence value is always relevant, whether the vent is constrained or not.

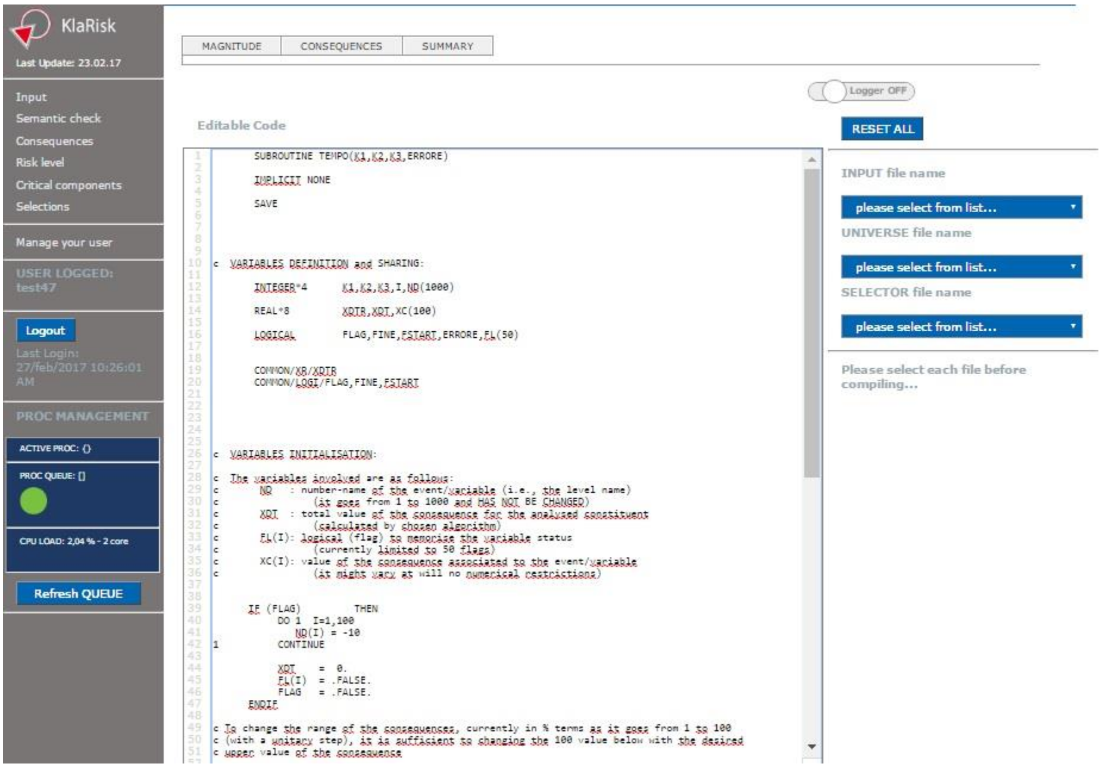


Figure 19: ALBA's consequences screen.

The FLAGS are another useful tool for the definition of the consequences. FLAGS allows the user to create relations between events, that combined can lead to a different consequence that the ones that they generate alone. This mean that, for each level is possible to create a cycle:

IF (K1.EQ.65.AND.K2.EQ.2) FL(1)=.TRUE.

IF (K1.EQ.222.AND.K2.EQ.2) THEN
XDT = XDT+XC(300)
ELSE IF (K1.EQ.222.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(200)
ENDIF

The first line defines the FLAG: each FLAG corresponds to a level considering its success or failure state. When the analyst decides to recall this successful or failure condition, inserts the FL(*N*) into the level cycle.
The cycle explains the consequence values that the described level assumes when it is on its failure or success state, but also the values that it assumes when the FLAG's condition is verified.
This tool allows the user to build up more complex consequence's files, that can be useful for the description of complex systems.

3.4.2 RDF, CCDF: risk evaluation

Once the analyst has compiled the consequences file associated to the desired input file, he can generate some useful graphs for the evaluation of risks.

These graphs are the RDF, i.e. Risk Distribution Function, and the CCDF, i.e. Complementary Cumulative Distribution Function.

3.4.2.1 Risk Distribution Function

The risk distribution function is the histogram describing how the constituent are distributed to contribute to both the relative and absolute risks and to the probability.

The constituents are distributed within one-hundred beans composing the magnitude values' spectrum.

The main characteristic of a histogram is that it can also represent the frequency values of a set of continues data, divided into class, i.e. the beans.

The frequency of occurrence of each class is equal to the area of the bean. However in ALBA the thickness is constant within the bins and it is obtained by dividing the useful spectrum by one-hundred [Equation 1], i.e. the number of desired classes, so the frequency can also be characterized by the height of each single bar.

$$Beans\ thickness = \frac{C_{max} - C_{min}}{100}$$

Equation 1: Bins thickness equation.

The example [Figure 20] shows that on the abscissa are reported the consequences values. The limit values are selected between the consequences values associated to the constituent: the program automatically chooses the lower and the higher ones.

On the ordinate is possible to read the frequency of each bean: the frequency corresponds to the contribution of each bar to the risk or to the probability, as explained by in the legend below the graph.

However it's important to understand that each bean is composed by all the constituents whose consequence value is included within the bar limits: the higher is the number of constituents falling into a gap, the higher is the bean frequency.

ALBA also allows the analyst to identify the constituents composing each bar using the beans details. This application also helps the user in the evaluation of the limit of each bar and of its frequency, both in terms of risk and probability.

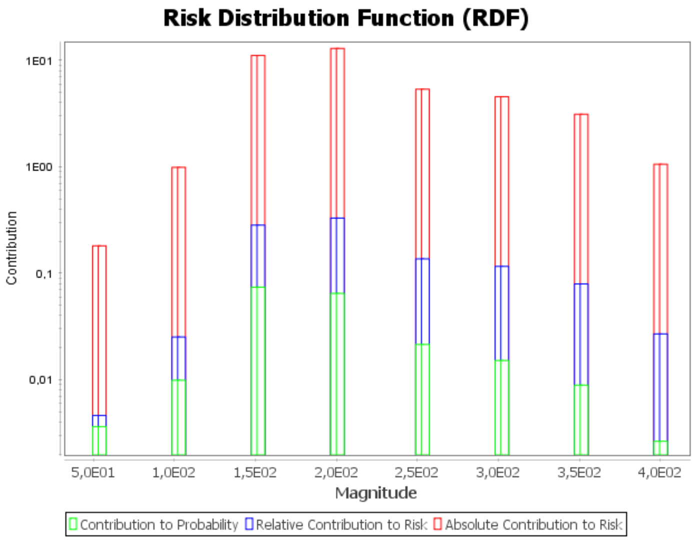


Figure 20: RDF's graph example

This tool helps the analyst and the decision maker to have a complete view of the system's risks that can be useful to choose where to invest money in order to have an improvement of the process. More than one improvement strategy is available for each process; it's a decision maker's task to choose the one that he considers the best for the process.

3.4.2.2 Complementary Cumulative Distribution Function

The CCDF curve represents the probability that the random variable X, with a given distribution function, assumes a value higher than *x*.

The CCDF function can be described by two different equations: Equation 2 can be used for discrete variables, whether Equation 3 is useful for continuous ones.

$$\overline{F_X}(x) = P(X > x) = 1 - F_X(x)$$

Equation 2: CCDF function, discrete random variables

$$\overline{F_X}(x) = \int_x^{+\infty} f_X(t)dt$$

Equation 3: CCDF function, continuous random variables

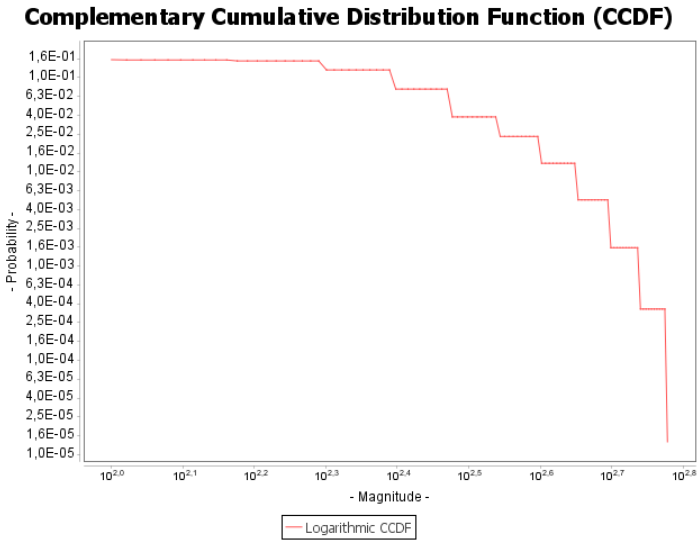


Figure 21: CCDF's graph example

The graph's slope depends on the analysed system: the higher the slope, the lower is the risk associated to the process. However, in order to be able to evaluate the risk, it is important to know what are the variables reported on the graphs axes [Figure 21].

The abscissa represents the magnitude values: as for the RDF the lower and upper limits depends on the analysed process and are chosen on the basis of the magnitude values of the different constituents.

The ordinate gives the probability, e.g. P(X>x): the ordinate's upper limit is always equal to one, in order to respect the convexity principle, whether the lower limit depends on the system results.

This graph is useful in order to understand the probability to have an accident with a consequence's value higher than a selected one, identified as the acceptable limit. This limit is set by the decision maker, considering the desired process characteristics.

3.4.3 Critical Function List

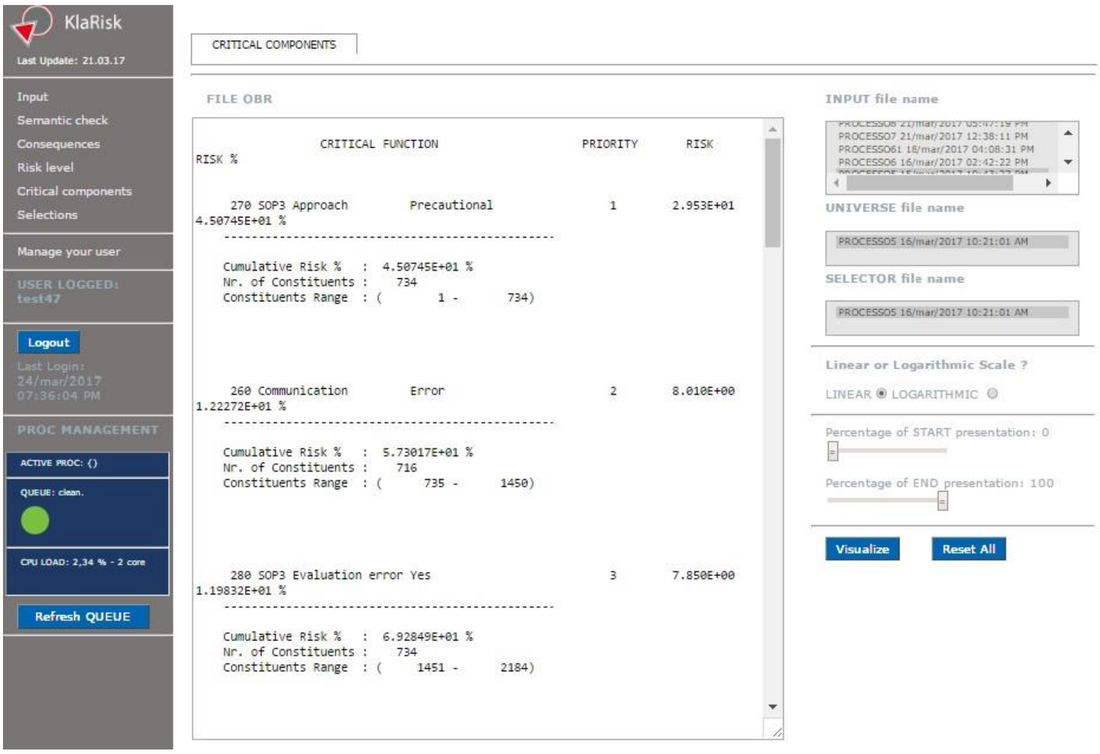


Figure 22: ALBA's partial critical function list

The critical function list [Figure 22], i.e. CFL, is another important tool for the evaluation of risk. It gives a list of the main function contributing to the overall risk, starting from the more important one. The program also gives the cumulative risk value and the number of constituents involving the selected event.

The risk value associated to this event helps the decision maker to choose precisely where to invest its money in order to improve the process.

3.4.4 Entropy

Once ALBA has generated the process' results, it is possible to evaluate another variable, the entropy.

Entropy is a measure of the amount of information needed to identify the true alternative within a universe of possible alternatives.

Entropy is a different concept from probability: the probability represents the weight p, assigned to each constituent, in term of degree of belief. On the other hand, entropy is the weight m, assigned to each constituent, in terms of rational quantity of information needed to recognize it as true.

These two weights are linked together by the following relation:

$$m = log_2 \frac{1}{p}$$

As a result, ALBA proposes the partition entropy, so the amount of information needed to identify the true constituents between the one composing the obtained partition, i.e. the generated universe. In other words this amount of information is identifiable with the number of necessary queries.

It is always possible to calculate the partition entropy, knowing the number of used queries, M, composing the partition S, and the number of obtained constituents, $N=2^M$.

When the analyst works with equiprobable event, the probability of each one is equal to:

$$p = \frac{1}{N}$$

and the partition entropy can be defined as:

$$S = \sum_{i=1}^{N} M_i = \sum_{i=1}^{N} p_i \, log_2 \frac{1}{p_i} = N \, p \, log_2 \frac{1}{p} = log_2 \frac{1}{p}$$

In case of non-equiprobable constituents, the partition entropy can be calculated as:

$$S = \sum_{i=1}^{N} M_i = \sum_{i=1}^{N} p_i \, log_2 \frac{1}{p_i}$$

This two expression depends on the probability values assigned to all the M levels, as a confirm of the dependence of the entropy by the probability assignment.

In particular, for a single aleatory event, the entropy trend is represented by Figure 23. The maximum entropy is obtained with a fifty percent probability of success of the aleatory event: this means that the analyst doesn't know anything about the considered event and the required bit of information has reached its maximum value.

A bit of information is the amount of information needed to reach the true alternative in a single aleatory event.

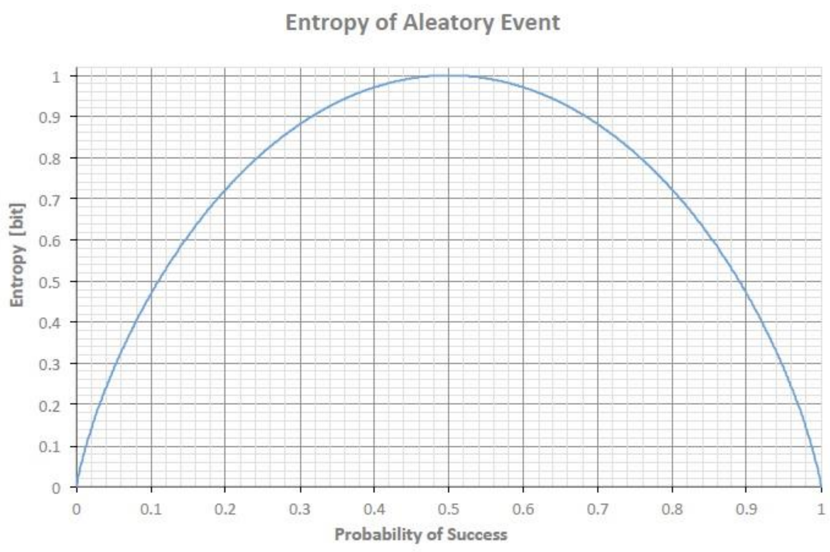


Figure 23: entropy-probability relation for an aleatory single event.

When a new piece of information is available, the uncertainty linked to an event will diminish. In this way the figurative distance from the truth is less than a bit of information. This principle explains why it's important to transfer in the input file all the acquired knowledge about the system.

The entropy values depends on the associated universe, so it is a variable function and it's coherence should be evaluated each time, considering the related partition.

This is the reason why is not possible to compare entropy's values coming from different universe, unless the two partitions are composed by the same number of constituent, i.e. have the same amount of possible alternatives.

Chapter 4.
PROCESS RISK ANALYSIS

The first step of the analysis is an attempt made to represent the entire process, in order to evaluate which steps are the most critical ones in the generation of the over-triage, that is the variable that we are trying to reduce. This kind of analysis can be defined as a risk analysis.

The over-triage is the inspected variable, i.e. the main risk that we wanted to reduce, so it must appear in the input file and all the question has the objective to define the relation and the role that each activity has in its generation.

For this reason, the first attempt is focused on the file structure's building process: the input file is really synthetic, in order to be easily evaluated. Once the results are acceptable and coherent, the input file will be extended in order to be more precise and representative of the real process.

4.1 First resolution approach

The first input file was realized in order to transfer the structure of the system in a usable ALBA's file.

First of all we decided to follow the real time sequence of the activity, in order to respect the fact that each different station or activity can correct and reduce the over-triage generated by the previous decision processes.

Therefor the first part of the file should represent the SOP1: there are two important main passages, the filter completion and the decision of necessary emergency vehicles. The filter itself can fail because of a human or an intrinsic error: the file should split up these aspects, in order to analyse them separately.

The vehicle decision process regards the ALS cars: the SOP1 personnel should decide if each case needs the intervention of a doctor on the scene, by using the activation and revaluation criteria. This means that the filter should also evaluate this important factor, in fact the presence of a doctor on the scene reduces the percentage of wrong data collection on the scene during the analysis of the patient's conditions.

Subsequently, the input file should regard the behaviour of the emergency personnel sent on the scene: they role is to collect and report data to the SOP3. An error made in this phase can affect the decision making process of the SOP3's doctor, so it could be a source of over-triage.

The final part should concern the SOP3, in particular the communication between them and the scene, but also their approach to the evaluation of the patient's conditions.

The SOP2 can be excluded in the analysis of the over-triage: the task of this function is to manage the fleet, but they are not directly involved in the decisional process. The operators should only follow the software indication, based on the SOP1's work.

If the SOP2 commits an error, the consequent is not an over-triage generation, but the delay or, in the worst case, the failure of the emergency intervention. We are not interested in the analysis of this kind of errors, because the over-triage happens only when the intervention is complete.

For what concerns the possible delay, we ignored them, assuming that the analysis regards only the interventions correctly carried out. This choice is based on the fact that an analyst should detect all the possible system's state before the analysis. In this case the system can assume three different states:

- Standard conditions: all the subsequent function correctly works in order to manage the emergency, from the layman call to the patient's hospitalization.
- Delay conditions: the system is completed in all its phases, i.e. it's in a success state, but somewhere a function has caused a delay. The delay is measured starting from the golden hour assumption useful for the red codes. The time limit to respect decreases together with the severity of the patient's condition.
- Failure of the system: the system fails before the hospitalization process, so it isn't completely able to face the emergency situation.

Each one of this states can be affected by an over-triage, but we are interested in the comprehension of this phenomenon, so is fundamental to understand its evolution through the standard sequence of activity, knowing that they have been performed within acceptable time limit and till the end.

4.1.1 Input file

The input file is reported below with relative comments about its structure.

```
:Analysis start
1 0. 0. 10 0 3 "analysis start" " " " "

:Does the operator fill up correctly the filter?
10 0.05 0. 15 12 3 "filter compiled" "correctly" "incorrectly"

:What is the typology of error?
12 0.3 0. 14 14 3 "op error" "psychomotor" "cognitive"

:Does the error make the situation worse?
```

14 0.5 0. 15 15 3 "overestimation error" "yes" "no"
1 620 0 90 90

:Does the filter correctly calculate the triage code?
15 0.0001 0. 20 16 3 "filter triage code" "correct " "incorrect "

:Is the error an overestimation?
16 0.5 0. 20 20 3 "filter triage error" "overestimation" "underestimation"
1 620 0 90 90

:Does the operator request a medical revaluation?
20 0.8 0. 25 22 3 "medical revaluation" "requested" "not requested"

:Does the operator consult the DOC104 before choosing to not ask for a revaluation?
22 0.7 0. 30 30 3 'DOC104' 'consulted' 'not consulted'

:Does the doctor misunderstands and overestimate the situation?
25 0.6 0. 30 30 3 "doctor overestimates" "yes" "no"
1 620 0 90 90

:Is an ALS needed?
30 0.2 0. 45 35 3 "ALS needed" "yes" "no"
20 45 0.05 0.

:Is the ALS sent on the scene, also if not needed?
35 0.1 0. 45 45 3 "ALS not needed" "not sent" "sent"
10 45 0.05 0.

:Does the doctor/volunteer collect all the necessary data about the patient?
45 0.1 0. 55 50 3 "patient's condition" "correctly collected" "incorrectly collected"

:Do the data look worse than in reality?
50 0.5 0.5 55 55 3 "data collected" "worse than reality" "better than reality"
1 620 0 90 90

:Does the SOP3's doctor correctly understand the data?
55 0.05 0. 60 60 3 "SOP3 understands data" "incorrectly " "correctly   "

```
:Does the SOP3 doctor overestimate the situation of the patient?
60 0.1 0. 90 90 3 "patient's conditioned" "not overestimated" "overestimated"
1 620 0 90 90

:Does the SOP3 select the trauma centre?
90 0.5 0. 610 600 3 "destination hospital" "trauma centre" "other hospital"

:Destination selected: other hospital
600 0. 0. 0 0 3 "destination  " "other hospital" " "

:Destination: trauma centre
610 0. 0. 0 0 3 "destination" "trauma centre" " "

:Destination: trauma centre with over-triage
620 0. 0. 0 0 3 "destination" "trauma centre-OT" " "
```

The input file is synthetic and direct. There are three exits levels: they mainly distinguish the destination hospital between other level structure and Trauma Centre. Moreover, this category is divided into legitimate and not, i.e. subjected to over-triage arrivals.

Each activity is represented in the file with more than one level, in order to evaluate its contribution to the over-triage. The over-triage happens when the function falls into an error: clearly a casual error can be an overestimation or an underestimation error. The underestimation in this analysis will be considered as part of a normal path, conducing to no over-triage Trauma Centre choice as destination hospital. Obviously the under-triage is not an acceptable outcome of the system, but it results not to be relevant for this analysis, so it has been summed up to the correct evaluation paths.

The over-triage appears also in all the levels regarding a decision process. Also in this case the evaluation can lead to a pessimistic or realistic representation of the situation. A pessimistic approach can degenerate into an over-triage, whether the optimistic one into an under-triage.

Talking about the file's structure, this is really simple with only one logical constrain, used several time along the file, and two stochastic constrains.

The logical constrain

1 620 0 90 90

changes the stories' exit level from "Trauma Centre" to "trauma Centre-OT" each time an activity ends up with an overestimation error or pessimistic decision. This expedient allows splitting up the SOP3's decision making outcomes following only two possibilities: trauma centre or other hospital.

The stochastic constrains are used in order to change the probability of the correct data collection on the event scene: the probability changes if an ALS is present, because of the higher competence of a doctor in respect to the knowledge of a volunteer. In particular if there isn't any doctor on the scene, the probability of a wrong data collection increases from 0.1 to 0.05.

The probability have been selected on the basis of my experience in the SOREU: no statistical data were available for a probability study, so the only possibility was to observe and to interview the personnel about their work.

Another important observation is that the probability can be verified a posteriori: the over-triage percentage should be equal to a percentage value comprehended between 60 and 70 percent, calculated on the basis of the Niguarda Trauma Centre's database. This percentage can help the auto-correction of the global input file, especially for what concerns the probability assignation.

4.1.2 Consequences file

The consequences file is composed by only five conditions, each one associated to overestimation definition levels.

The worst risk is related to the overestimation of patient's condition committed by the SOP3's doctor. In fact if this phase is subject to an error, there is no possibility to remedy because the SOP3 is the last step of the emergency evaluation.

Fort this reason this level is associated to a consequences value equal to 100: this numerical value would be a landmark during the analysis of the results, in order to quantify the magnitude of the obtained stories with a known concrete reference.

The complete consequences input file is reported below:

```
IF (K1.EQ.14.AND.K2.EQ.1)    XDT = XDT+XC(10)
IF (K1.EQ.16.AND.K2.EQ.1)    XDT = XDT+XC(30)
IF (K1.EQ.25.AND.K2.EQ.1)    XDT = XDT+XC(30)
IF (K1.EQ.50.AND.K2.EQ.1)    XDT = XDT+XC(80)
IF (K1.EQ.60.AND.K2.EQ.2)    XDT = XDT+XC(100)
```

The lower consequences are related to overestimation errors performed in the early phases of the process, that the value increases along the different phases.

4.1.3 Results

RISULTATI IN TERMINI DI P RESIDUA, ENTROIA, COSTITUENTI, COMONENTI CRITICI, ECC.

4.2 Second resolution approach

The results obtained with the first approach shows that the used strategy for the representation of the process is basically correct. However some little changes are necessary in order to focus the analysis on the detection of the critical components related to the generation of the over-triage.

Moreover an expansion of the input file can allow to a deepest analysis of the problem, so it will be performed and explained in the following input file.

4.2.1 The input file

The new input file presents a substantial change for what concerns the process exits: knowing that we are interested only in the over-triage, the only necessary output condition is the existence, or not, of this important variable.

Each story ends with a statement whose failure address identify the presence of over-triage at the end of the evaluation process, whether the success address describes all the correct evaluation cases and the under-triaged patients.

This kind of approach reduces the stories' complexity and helps the analysis of the results, especially for what concerns the evaluation of the global over-triage probability, that should be compared to database's value.

The following input file is also longer than the previous one: each error is deeply classified, in order to better define the characteristics of over-triage. All the overestimation levels are replaced by section that breaks up the committed error in different common typology, e.g. cognitive or psychomotor errors.

Another important different is that the ALS activation criteria are decomposed into direct activation criteria and revaluation cases, i.e. border cases that should be revaluate by the SOP1's doctor [IV]. The unjustified absence of this phase is analysed as for the other kinds of error, in order to understand its origin.

Moreover, the part describing data collection performed by the BLS or ALS personnel is more specific and considers all the technical and medical activity that doctors and volunteers perform on the scene, e.g. the ECG exam or simply the an oximetry control. Obviously this file considers all the basic and routine activity but not the lifesaving procedures as the CPR.

```
:Analysis Start
5 0. 0. 10 10 3 "Analysis" "Start" "--"

:Is the filter correctly compiled?
10 0.2 0. 48 15 3 "filter compilation " "correct" "incorrect"

:What kind of error does the operator?
15 0.3 0. 20 35 3 "error type" "psychomotor" "cognitive"

:Is the error caused by an external Distraction?
20 0.33 0. 25 48 3 "Distraction " "no" "yes"

:Is the error caused by tiredness?
25 0.33 0. 30 48 3 "tiredness" "no " "yes"
16 30 0. 0.

:Is the error caused by posture?
30 0.33 0. 48 48 3 "posture" "no" "yes"

:Is the error caused by a lapse?
```

35 0.33 0. 40 48 3 "lapse" "no" "yes"

:Is the error caused by lack of knowledge?
40 0.33 0. 45 48 3 "lack of knowledge" "no" "yes"
16 45 0. 0.

:Is the error caused by a misinterpretation?
45 0.33 0. 48 48 3 "Misinterpretation" "No" "Yes"

:Does the filter correctly calculate the triage code?
48 0.1 0. 50 49 3 "filter triage code" "correct " "incorrect"

:Is the error caused by the filter's structure (weight and question's chain)?
49 0.0001 0. 50 50 3 "filter error" "structure" "calculation"

:Does the operators consider instantaneous activation criteria?
50 0.80 0. 110 55 3 "activation criteria" "detected" "undetected"
15 110 0. 0.

:Are the criteria really present?
55 0.2 0. 75 60 3 "criteria" "not present" "present"

:Is the error caused by a lack of knowledge?
60 0.33 0. 65 75 3 "lack of knowledge" "no" "yes"

:Is the error caused by a memory fail?
65 0.33 0. 70 75 3 "memory fail" "no" "yes"
16 70 0. 0.

:Is the error caused by distraction?
70 0.33 0. 75 75 3 "distraction " "no" "yes"

:Does the operators consider the revaluation criteria?
75 0.7 0. 110 80 3 "revaluation criteria" "detected" "undetected"
10 110 0.80 0.

:Are the revaluation criteria really present?

80 0.2 0. 100 85 3 "criteria" "not present" "present"

:Is the error caused by a lack of knowledge?
85 0.33 0. 90 100 3 "lack of knowledge" "no" "yes"

:Is the error caused by memory fail?
90 0.33 0. 95 100 3 "memory fail" "no" "yes"
16 95 0. 0.

:Is the error caused by distraction?
95 0.33 0. 100 100 3 "distraction " "no" "yes"

:Is the revaluation forced by doctor?
100 0.95 0. 110 105 3 "forced by doctor" "yes" "no"
10 110 0.80 0.

:Is the revaluation forced by operator?
105 0.9 0. 110 110 3 "forced by operator" "yes" "no"
10 110 0.80 0.

:Is the ALS sent on the scene?
110 0.95 0. 120 120 3 "ALS" "sent" "not sent"
15 185 0. 0.
2 255 255 225 225
10 125 0.025 0.
10 145 0.025 0.
10 165 0.025 0.
10 190 0.05 0.
10 205 0.025 0.
10 260 0.01 0.
20 270 0.4 0.
20 305 0.4 0.

:SERVICE LEVEL
120 0. 0. 125 125 3 "evaluation start" "personnel on scene" "---"

:Is the temperature correctly detect?

125 0.05 0. 145 130 3 "temperature" "correct" "incorrect"
20 225 0.2 0.

:Is the error caused by a reading error?
130 0.80 0. 135 145 3 "reading error" "no" "yes"

:Is the error caused by a wrong instruments usage?
135 0.15 0. 140 145 3 "instruments usage" "correct" "incorrect"
16 140 0. 0.

:Is the error caused by the instrument itself?
140 0.05 0. 145 145 3 "instrument" "work" "fault"

:Is the blood pressure correctly detect?
145 0.05 0. 165 150 3 "blood pressure" "correct" "incorrect"
20 225 0.4 0.

:Is the error caused by a reading error?
150 0.80 0. 155 165 3 "reading error" "no" "yes"

:Is the error caused by a wrong instruments usage?
155 0.15 0. 160 165 3 "instruments usage" "correct" "incorrect"
16 160 0. 0.

:Is the error caused by the instrument itself?
160 0.05 0. 165 165 3 "instrument" "work" "fault"

:Is the oximetry correctly detect?
165 0.05 0. 185 170 3 "oximetry" "correct" "incorrect"
20 225 0.4 0.

:Is the error caused by a reading error?
170 0.80 0. 175 185 3 "reading error" "no" "yes"

:Is the error caused by a wrong instruments usage?
175 0.15 0. 180 185 3 "instruments usage" "correct" "incorrect"
16 180 0. 0.

:Is the error caused by the instrument itself?
180 0.05 0. 185 185 3 "instrument" "work" "fault"

:Is the ultrasound present on the available vehicle?
185 0.75 0. 190 205 3 "ultrasound" "present" "missing"

:Is the ultrasound analysis correctly performed?
190 0.1 0. 205 195 3 "ultrasound" "correct" "incorrect"
20 225 0.5 0.

:Is the error caused by a reading error?
195 0.70 0. 200 205 3 "reading error" "no" "yes"

:Is the error caused by a wrong instrument usage?
200 0.25 0. 204 205 3 "instrument usage" "correct" "incorrect"
16 204 0. 0.

:Is the error caused by the instrument itself?
204 0.05 0. 205 205 3 "instrument" "work" "fault"

:Is the ECG exam correctly performed?
205 0.05 0. 225 210 3 "ECG" "correct" "incorrect"
20 225 0.6 0.

:Is the error caused by a reading error?
210 0.05 0. 215 225 3 "reading error" "no" "yes"

:Is the error caused by a wrong instruments usage?
215 0.90 0. 220 225 3 "instruments usage" "correct" "incorrect"
16 220 0. 0.

:Is the error caused by the instrument itself?
220 0.05 0. 225 225 3 "instrument" "work" "fault"

:What is the global information quality?
225 0.02 0. 230 230 3 "information quality" "good" "low"

20 245 0.4 0.
20 280 0.4 0.

:What is the doctor approach on patient's evaluation?
230 0.2 0. 240 235 3 "DOC Approach" "objective" "precautionary"
24 245 0. 0.

:Why is the DOC's approach precautionary?
235 0.5 0. 245 245 3 "DOC why precautionary?" "legitimate worry" "legal protection "

:Does the DOC commit a cognitive error?
240 0.01 0. 245 245 3 "doc cognitive error" "no" "yes"
24 245 0. 0.

:Is the DOC's global evaluation correct?
245 0. 0. 255 255 3 "DOC evaluation" "correct" "wrong"
20 280 0.70 0.

:SERVICE LEVEL
255 0. 0. 260 260 3 "SOP 3 start" "data collection" "---"

:Is the communication with the scene possible?
260 0.05 0. 270 265 3 "communication" "ok" "error"
24 290 0. 0.

:What is the typology of performed error?
265 0.95 0. 290 290 3 "SOP3 error type" "fault" "comprehension"

:What is the SOP3's approach on patient's evaluation?
270 0.2 0. 280 275 3 "SOP3 approach" "objective" "precautionary"
24 290 0. 0.

:Why is the SOP3's approach precautionary?
275 0.5 0. 290 290 3 "SOP3 why precautionary?" "legitimate worry" "legal protection "

:Is there an evaluation error?
280 0.1 0. 290 285 3 "SOP3 evaluation error" "no" "yes"

24 290 0. 0.

:Where does the error come from?
285 0.9 0. 290 290 3 "SOP3 source of error" "information" "wrong diagnosis"

:What is the global level of the SOP3's evaluation?
290 0 0. 295 295 3 "SOP3 evaluation" "correct" "not correct"
15 300 0. 0.
26 300 0. 0.

:SERVICE LEVEL
295 0 0. 300 300 3 "hospital choice" "-------" "---"

:Is the patient's condition correctly estimate?
300 0.1 0. 305 999 3 "patient" "correctly estimated" "overestimated"
26 999 0. 0.

:What is the SOP3 approach in the final patient's condition estimation?
305 0.2 0. 315 310 3 "approach" "objective" "precautionary"

:Why does the SOP3 overestimate patient's conditions?
310 0.5 0. 999 999 3 "why precautionary?" "legitimate worry" "legal protection"
26 999 0. 0.
16 999 0. 0.

:Does the SOP3 identify other structures for the patient's treatment?
315 0.05 0. 320 999 3 "other structures" "unidentified" "identified"
26 999 0. 0.

:Why does the SOP3 use a precautionary approach?
320 0.05 0. 999 999 3 "alternatives" "unavailable" "available"
15 999 0. 0.
26 999 0. 0.

:Over-triage
999 0. 0. 0 0 3 "over-triage" "no" "yes"

An increase in the file's complexity produces the necessity of a higher number of stochastic and logic constrains.

The first important logical constrain regards the exit level:

nn 999 0. 0.

The questions linked to the 999^{th} level, both in condition of success or failure state, are completed by a second typology logical constrain that enables to define the presence or the absence of over-triage.

However, this constrain is not sufficient to describe the over-triage: only the error levels regarding the SOP3 activities are linked to the final statement. This means that, without the insertion of other constrain the input file would not consider the SOP1, ALS and BLS's personnel overestimation errors.

Along the input file is possible to find some conclusive levels: these questions define the global accuracy of the activities performed in the previously described area, e.g. the data collection on the scene described by level 225. These levels allow influencing the outcome of the ensuing decision: this link recreates the influence that each activity, or macro-activity, has on the successive process' phases.

The section's global evaluation levels are influenced by the result of the meso-activities contained in that part of the process. The meso-activities can be associated to stochastic constrains, that change the probability of having a high section accuracy.

The ALS' presence level has a high importance in the input file: it is linked to several constrains in order to underline its influence on the patient evaluation performed on the scene. In fact, if there is a doctor on the scene, the probability of overestimation of the event is lower, due to his medical knowledge. The different capability of a doctor instead of a volunteer are reported in the input file with the use of stochastic constrains, that cause a decrease in the error probability during the data collection.

4.2.2 Consequences file

The consequences file follows the same principles explained for the first tentative:

The reference value is 100, associated to an error during the SOP3's evaluation of the patient.

```
IF (K1.EQ.49.AND.K2.EQ.1)     XDT = XDT+XC(60)
IF (K1.EQ.49.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.15.AND.K2.EQ.2)     XDT = XDT+XC(10)
IF (k1.EQ.20.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.25.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.30.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.35.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.40.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.45.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.60.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.65.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.70.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.85.AND.K2.EQ.2)     XDT = XDT+XC(40)
IF (k1.EQ.90.AND.K2.EQ.2)     XDT = XDT+XC(40)
IF (k1.EQ.95.AND.K2.EQ.2)     XDT = XDT+XC(40)
IF (k1.EQ.110.AND.K2.EQ.2)    FL(1)= .TRUE.

IF (k1.EQ.130.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(7)
ELSE IF (k1.EQ.130.AND.K2.EQ.2)     THEN
XDT = XDT+XC(10)
ENDIF

IF (k1.EQ.135.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(7)
ELSE IF (k1.EQ.135.AND.K2.EQ.2)     THEN
XDT = XDT+XC(10)
ENDIF

IF (k1.EQ.140.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(7)
ELSE IF (k1.EQ.140.AND.K2.EQ.2)     THEN
XDT = XDT+XC(10)
ENDIF

IF (k1.EQ.150.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(10)
ELSE IF (k1.EQ.150.AND.K2.EQ.2)     THEN
XDT = XDT+XC(15)
ENDIF

IF (k1.EQ.155.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(10)
ELSE IF (k1.EQ.155.AND.K2.EQ.2)     THEN
```

```
XDT = XDT+XC(15)
ENDIF

IF (k1.EQ.160.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(10)
ELSE IF (k1.EQ.160.AND.K2.EQ.2)     THEN
XDT = XDT+XC(15)
ENDIF

IF (k1.EQ.170.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.170.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.175.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.175.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.180.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.180.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.195.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.195.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.200.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.200.AND.K2.EQ.2) THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.204.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.204.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.210.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(34)
ELSE IF (k1.EQ.210.AND.K2.EQ.2)     THEN
```

```
XDT = XDT+XC(50)
ENDIF

IF (k1.EQ.215.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(34)
ELSE IF (k1.EQ.215.AND.K2.EQ.2)     THEN
XDT = XDT+XC(50)
ENDIF

IF (k1.EQ.220.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(34)
ELSE IF (k1.EQ.220.AND.K2.EQ.2)     THEN
XDT = XDT+XC(50)
ENDIF

IF (k1.EQ.230.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.235.AND.K2.EQ.2)     XDT = XDT+XC(60)
IF (k1.EQ.240.AND.K2.EQ.2)     XDT = XDT+XC(80)
IF (k1.EQ.260.AND.K2.EQ.2)     XDT = XDT+XC(50)

IF (k1.EQ.265.AND.K2.EQ.1)     THEN
XDT = XDT+XC(50)
ELSE IF (k1.EQ.265.AND.K2.EQ.2) THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.270.AND.K2.EQ.2)     XDT = XDT+XC(30)
IF (k1.EQ.275.AND.K2.EQ.2)     XDT = XDT+XC(70)

IF (k1.EQ.285.AND.K2.EQ.1)     THEN
XDT = XDT+XC(100)
ELSE IF (k1.EQ.285.AND.K2.EQ.2) THEN
XDT = XDT+XC(100)
ENDIF

IF (k1.EQ.290.AND.K2.EQ.2.AND.FL(1)) THEN
XDT=XDT+XC(80)
ELSE IF (k1.EQ.290.AND.K2.EQ.2)     THEN
XDT = XDT+XC(0)
ENDIF

IF (k1.EQ.300.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.310.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.315.AND.K2.EQ.2)     XDT = XDT+XC(60)
IF (k1.EQ.320.AND.K2.EQ.2)     XDT = XDT+XC(70)
```

Obviously the file has a higher complexity than the one presented before, because of the detailed description of the evaluation errors. The used strategy considers each error as a potential contribution to risk, i.e. the final over-triage, so each level is related to a consequence value.

The presence of the flag allows obtaining a shorter and more compact file, which is also easier to understand. The flag is related to the present of the ALS on the scene: if the doctor is available for the patient evaluation, the consequence of an eventual error is different than in case of a volunteer's evaluation, as happens for the probability values.

4.2.3 Results

The same input file was used with different probability cuts. With the selection of a probability cut is possible to reduce the number of constituents, by excluding the stories with probability lower than the chosen cut.

First of all, the input file was associated with a cut of 10^{-12}: this value allows considering all the generated universe, because a probability lower than this value corresponds to nearly impossible events. In fact, the residual probability, i.e. the sum of all the excluded stories is nearly zero [Table 12].

The problem using this kind of probability cut is the elevated number of generated constituents. A large number of constituents increase the difficulty of analysis performed by ALBA. This is the reason why Table 12 reports also the results obtained by using a lower probability cut.

Process' name	Probability cut	Constituent's number	Entropy	Residual probability	Cumulated probability
Process 9	10^-12	7971719	10.46	2.45*10^-9	9.999*10^-1
Process 93	10^-9	86391	10.45	4.93*10^-4	9.995*10^-1

Table 12: results obtained as outcome of complete process input file, by using different probability cuts.

By observing the results comparison is clear that the major difference is in the constituents' number. The reduction of this value can lead the analyst to choose the correspondent probability cut for the analysis of the consequences and of the critical components: this choice is acceptable only if the residual probability doesn't exclude a big universe's part. The residual probability is higher than the values associated to process nine's simulation, but the cumulated probability of both the processes covers the 99.99 percent of the global probability, equal to a hundred percent. Moreover the entropy values are nearly identical, because the number of information insert in the two input file are the same.

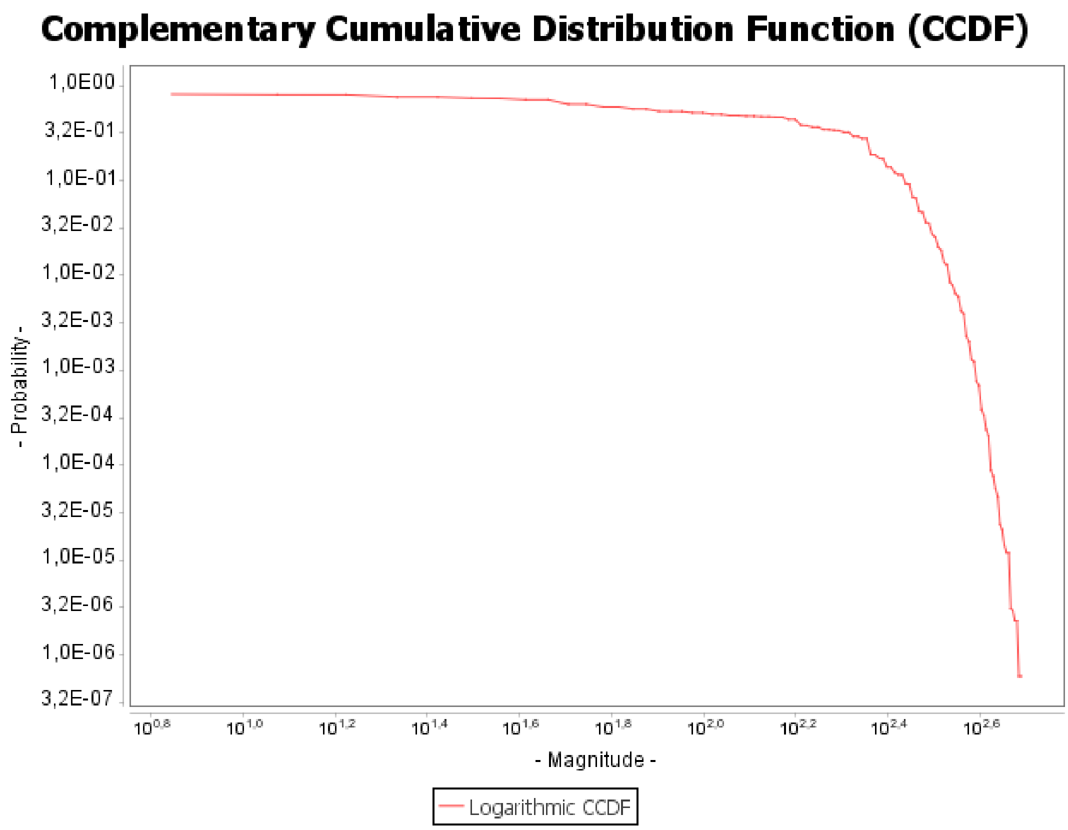


Figure 24: complete process' CCDF, obtained with a probability cut equal to 10^{-9}

The following results are related to the analysis conduct with the lower probability cut, in order to reduce ALBA's calculation times.

The consequences simulation performed with the probability cut 10^{-9}, generates the following CCDF and RDF.

The CCDF [Figure 24] underlines that the probability to have a magnitude higher than the reference point, chosen of the consequence's values assignation, is equal to circa forty percent. This means that these stories generates a risk associated to a magnitude worse than the evaluation error performed by the SOP3 doctor, i.e. the magnitude is bigger than 100. This key point can be useful for the decision maker, in order to understand the meaning of the graph thanks to this direct reference to reality.

The RDF [Figure 25] shows that the contribution to the risk decreases the for higher magnitude values: the stories connected to more severe consequences are less probable and have a littler contribution to the risk than the constituents associated to lower magnitude. This trend is useful for the decision maker, that has to decide if is better to invest on high probability or high magnitude values.

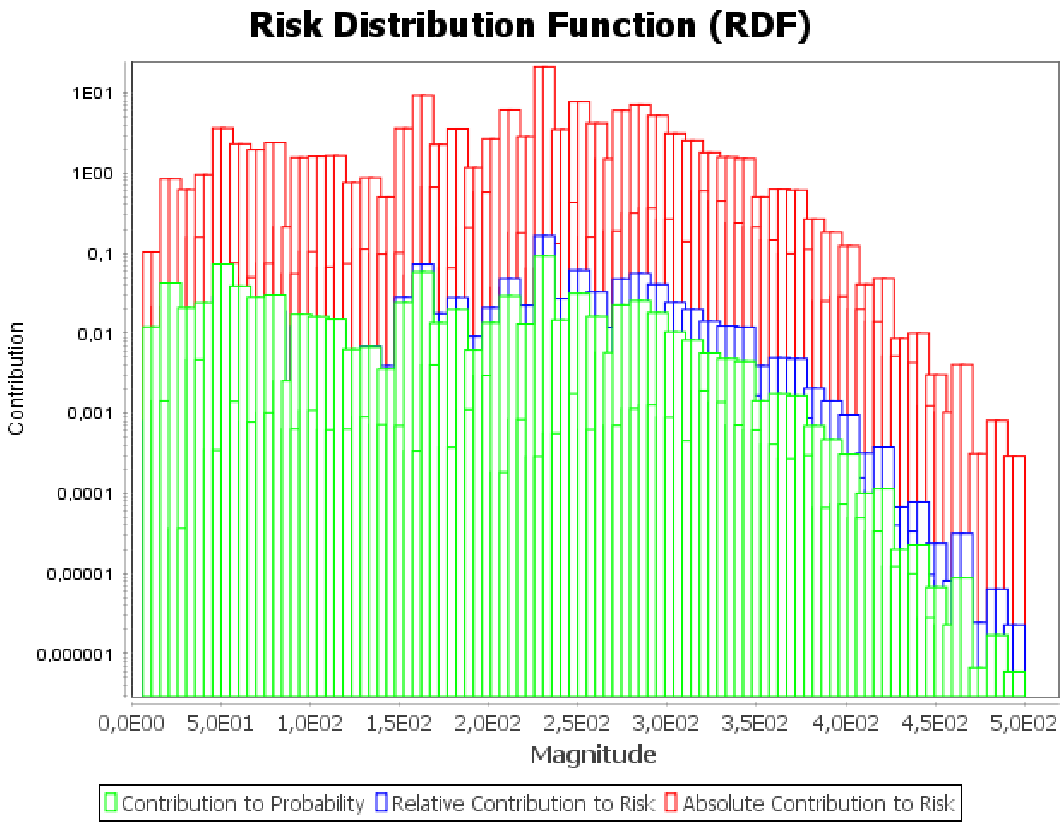


Figure 25: complete process' RDF, obtained with a probability cut equal to 10-9

Another important tool for the decision maker is the CFL [**Errore. L'origine riferimento non è stata trovata.**]. This list gives the decision maker a clear view of the critical points of the process, together with their percentage contribution to risk. In this case, the most critical steps are reported in the table below.

The SOP3 approach is the most critical part of the process: this point covers nearly one third of the global risk. The precautionary approach used by the SOP3 depends on the subjectivity of each person, so this value could change in function of the considered doctor. The same reasoning can be used in the evaluation of the second critical point: each operator can incorrectly compile the filter, but the probability to commit a mistake depends on the operator itself. For these two categories the available solutions proposed in the following paragraph will consider the subjective components. This subjective component makes it difficult to find out an efficient solution, that can lead to a real and concrete reduction of the over-triage.

CFL		Risk Percentage
1	SOP3 approach: precautionary	28.31 %
2	Filter compilation: incorrect	23.65 %
3	Filter triage code: incorrect	11.41 %
4	SOP3: evaluation error	6.30 %
5	DOC approach: precautionary	4.84 %
6	Communication DOC-SOP3: error	3.76 %
7	ECG: incorrect	3.48 %
8	Oximetry: incorrect	3.33 %
9	Blood pressure: incorrect	3.26 %
10	Temperature: incorrect	3.20 %
11	Ultrasound: incorrect	2.33 %
12	Activation criteria: undetected	2.28 %

Table 13: entire process analysis' CFL

The third critical component, the incorrect filter’s triage code, depends on the algorithm itself, i.e. there is only an objective component, which is the structure and the functioning of the machine, without considering the quality of the insert information. Also this step will be analyzed within the resolution approach.

All these results are acceptable because the described input file generates an over-triage probability equal to sixty-one percent. This value has been calculated using the selection ALBA’s function.

This function allows the user to count and select all the stories with some defined characteristics. In this case, the selection regards all the events containing the over-triage level, i.e. number 999, in its failure state, i.e. positive generation of over-triage.

However, this function gives a numerical value of involved constituents, but it's not able to calculate the sum of their probability, which is the searched value.

In order to obtain this probability value, the solution is to reduce the number of involved constituents, in order to manually sum up their probability values.

The only available solution is to reduce the probability cut, in order to consider only the most important generated stories: Table 14 shows the selected probability cuts and the ones involved in the generation of the over-triage.

Process' Name	Probability Cut	Number of Constituents	Number of Constituents positive to Over-triage Selection
Process 93	10^{-9}	863971	726322
Process 91	10^{-3}	131	90
Process 92	10^{-2}	10	6

Table 14: global number of constituents and number of the ones involved in the generation of over-triage generated by using three different probabilities cut (10^{-9}, 10^{-3}, 10^{-2})

The use of a cut equal to 10-2 eliminates all the stories with a probability lower than one percent. In order to obtain a more complete result, the best choice is to use a 10-3 cut, excluding all the stories with a probability lower than 0.1 percent.

Both results are reported in the table below, in order to underline the importance to consider also the stories with a probability included between 1 and 0.1 percent.

Process' name and probability cut	Probability of Over-triage
Process 91 [cut 10^{-3}]	60.7 %
Process 92 [cut 10^{-2}]	46.5 %

Table 15: over-triage percentage associated to complete process' simulation obtained by using a probability cut of 10^{-3} and 10^{-2}

The obtained result is lower than the desired 66%, but is acceptable considering that the obtained value derives by the sum of only a part of the generated stories. Moreover the objective is to detect the critical components of the process, so we are not interested in a perfect representation of the real process, but in an acceptable reproduction of reality, obtained using some approximations. These approximations allow declaring that the CFL obtained is reliable and representative of reality.

4.3 Risk analysis results' discussion: available solution strategies

The results obtained from the analysis of the entire process, have underlined the critical points of the system in the creation of the over-triage.

The CFL is the starting point for the proposal of solution strategies, suitable for the reduction of the over-triage. Another starting point is Niguarda's database, that can give a posteriori representation of the actual system.

Combining these two tools is possible to propose some solution to the decision maker, that will choose were to invest in order to actuate a real reduction of the problem.

Starting from the first critical component, i.e. SOP3's precautionary approach, a problem is immediately evident. This system is based on subjective judgment of part of the personnel: especially in SOP3, the doctor has to perform a decision on the basis of the collected data. In this kind of processes is impossible for a person to be completely objective in the analysis of the patient. Each SOP3's worker tries to be conservative in order not to underestimate a patient.

Obviously, considering only the involved patient, an underestimation error is worse than an overestimation one, because it can lead to an incorrect hospital treatment that can cause a damage of the patient's wellness.

However is important to maintain a global view of the process, by considering not only a single patient, but the entireness of the sanitary system. In order to guarantee an adequate functioning of the complete system, it's fundamental that each patient is hospitalized in the most appropriate trauma centre level. This expedient allows using the sanitary resource in the best available way.

It's necessary to find out a solution to help the SOP3's personnel not to consider only the single patient, trying to reduce the emotionally part that influences their decision. A human can't be programmed in order to be totally objective in the evaluation of a patient, because a wrong decision can lead to the death of the patient, so it's completely understandable that the personnel tends to use a precautionary approach.

The human part involved in the process can be support by an algorithm, as already happens in SOP1. This algorithm can objectively consider the patient's condition and can propose a destination hospital, i.e. if the patient should be received in a PST, CTZ or CTS. The human part can't be delayed, so the algorithm can only suggest a destination, but the ultimate choice is made by the SOP3's personnel.

Combining the objective approach of the machine and the human's subjective approach can be the right solution that should allow reducing the over-triage, without implementing the under-triage.

The following problem concerns the choice of the parameters or data that should be include in this new kind of algorithm. The SOP3's personnel should collect and insert medical data into the algorithm: this data could be the same used at the moment, but they can be associated to a weight. The weight, as already happens in the SOP1's filter, is associated to the importance that each data has in the classification of the severity of a patient's condition. For example considering blood pressure, this data can be associated to different weights on the basis of its value. If the pressure is critical, the associate weight would be higher than in case of normal blood pressure.

This mechanism includes the necessity to evaluate the importance of each parameter in the classification of the severity of a case, but also how its value affected the patient's state. This analysis can be made by studying the Niguarda's database, but also in medical literature.

This new filter can also include some contextual parameters, especially in case of road accident. This category is the major cause of over-triage and it depends on some external parameters, inherent to the accident scene. By adding these contextual parameters, the SOP3's would evaluate some additional data. These parameters are also easy to collect on the scene, so the coefficient of error would be minimal.

The insertion of a new filter in the last phase of the process can also be useful for the reduction of second and third critical components. In fact the compilation error and the intrinsic error of the filter are related to the first part of the whole process: by adding a new filter some of the first incoming information would be registered again by the SOP3, so the over-triage generated at the start can be reduced. A generation of over-triage in SOP1 can lead to a better estimation of the patient on the scene that can be translated in a more correct final evaluation in SOP3.

Another important strategy can be the study of the SOP1 filter in order to obtain two different kinds of advantages.

First of all it will be possible to reduce the percentage of generated red codes, in particular for road accidents, starting from a database's analysis. From the database is possible to understand which parameters mostly influence the generation of over-triage. Once these parameters are detected, it could be possible to study the reaction of the filter's results to some changes in its structure.

This strategy can secondary help in the realization of the SOP3's filter, than can be built by taking inspiration by the existing filter, but also considering the sensitivity analysis performed starting from the database.

The key point of the solution strategy will be the existing filter, so in the next paragraph it will be analyzed together with the Niguarda's database.

Chapter 5.
OPERATIONAL ANALYSIS OF AREU FILTER

The previous chapter has underlined the role of the AREU filter in the proposed solution strategies.

First of all is important to present the algorithm at the basis of the filter, in order to understand how the filter works.

An ALBA's analysis of the algorithm will be performed after the overall presentation of the AREU filter, in order to evaluate and to propose some changes useful for the improvement of the system, considering also the data extract from the database

The objective is to find out which parameters mostly affect the generation of an high percentage of over-triage, both considering the data collected and analysed in chapter one and the results obtained through ALBA's filter representation.

5.1 AREU filter's presentation

During the previous description of the SOP1 [2.1] was possible to understand who uses the filter and in which contest: the SOP1's operator answer to the incoming call and perform an interview. They follow the AREU filter in order to be sure to ask the layman all the required information about the event.

First of all is fundamental to specify that the incoming events are divided into three main typology, each one associated with a different kind of filter:

- Medical filter: focused on vital signs, symptoms, known pathologies and age of the patient.
- Traumatic filter: focused on the typology of the event and on the possible aggravation due to the contest of the accident, e.g. height of the fall or car overturned. At the end also vital signs are registered. In case of more than one person involved, the operator should collect the data related to the most severe patient.
- Environmental filter: focused on the typology of the event and on the possible aggravation due to the environment interested and to the number of persons involved.

Considering that the objective of this work is the reduction of the over-triage, we will analyse only the traumatic filter. In fact the trauma centre works only on traumatic severe events, so the analysis of other kind of filter would be useless.

The interview starts with the collection of name, surname and age of the patient. Sometimes this kind of information is not available or not correct. For this reason, but also in order to evaluate the reliability of the source, a layman can be classified as:

- First person: the layman coincides with the patient.
- Second person: the layman was on the scene when the event occurred.
- Third person: the layman is not on the scene and he has received information from someone else.

Once this basic data have been noted, the operator opens the filter and selects the event typology. The traumatic filter is further divided into categories, specifying the traumatic event mechanism.

The proposed mechanisms are:

- Fall: this typology includes all kind of falling cases not consequent to a medical event. The fall can simply happen from and height comparable from the human one, e.g. from upright position, or can be a precipitation from a major height.
- Road accident: it includes all kind of vehicles that can be involved in an accident, i.e. motorcycle, cycle and car, but it also comprehends a pedestrian collision.
- Domestic, sport or work accident: it’s a broad category, comprehending all the traumatic that can happen at work or at home, but also while doing sports activity. It can include burns, amputations, crushing, wounds, but also submerging mechanism or contusion and many other mechanisms.
- Violent events: this category is composed by every kind of violent event, such as a beating, or armed aggressions. It also includes self-harm events performed with weapons.
- Other events: this filter describes wounded inflicted by animals, e.g. bites, or sings, intoxications and major events. Major events comprehend explosions and fires that can lead to a high number of wounded and deaths, so an emergency procedure is required. For this reasons they will not be deeply analysed in this work, because in this case the SOREU follows an emergency specific protocol.

After the selection of the desired filter, the operator follows a guided path while he performs the interview. The algorithm chooses automatically the questions that the operator has to fill up on the basis of the previous answer. For example if the event is a road accident, once the filter has been selected, the software asks the operator which kind of vehicle has been involved in the accident. If the chosen filter is the one inherent to a fall, the system proposes a question about the height of the fall.

Thanks to this guided chain of question the operator works in a schematic way that allows not forgetting to collect important data and to face each kind of possible incoming event.

Furthermore the filter proposes a group of answer to each question: this is necessary in order to calculate a triage code at the end of the interview. Each answer corresponds to a weight and the sum of all the registered weights gives the event's triage code. It is important to consider that sometime the layman can't be able to provide an answer to every operator's question. This happens because the layman is often overwrought by the situation that he is facing and because he hasn't got a medical preparation. The operator has the possibility to insert this not available information, by selecting the answer *not known.*

Once the operator has chosen the answer, the filter goes on proposing the following question. Obviously the operator can go back to correct, or to change the given answer, since the layman can add some useful information during the interview.

Moreover sometimes the algorithm allows the selection of more than one answer: this happens when the question concerns sides effects or the selections of the wounded districts.

However sometimes the operator can add some additional information within the notes associated to the filter: this notes don't influence the estimation of the triage code, but they can be useful for the doctor revaluation but also for the SOP3 personnel during the decision of the destination hospital.

The completion of the filter is a fundamental passage for the patient evaluation: the interview gives a first idea about the severity of the situation and determines the following steps for cure of the patient through the triage code.

At the end of interview the operator sees also the colour code, but he can see the numerical value [**Errore. L'origine riferimento non è stata trovata.**] of the triage coming from the sum of all the collected weight.

The yellow code is the larger category in terms of numerical values, but also considering the typology of cases that it can represent. This hypothesis is confirmed by the Trauma Centre's data, as explained in **Errore. L'origine riferimento non è stata trovata.**. For this reasons the majority of the over-triage cases are linked to a yellow code.

However the collected data are referred to the triage code associated to the patient during the SOP3 revaluation. In this particular phase the triage can be changed from the one calculated by the filter.

Unfortunately no data are available about the filter triage code, so the percentage of yellow codes generated in SOP1 is approximated to the number of the yellow codes entering in Niguarda's hospital.

Triage code	Numerical Obtained Value N
White	N < 49
Green	50 < N < 199
Yellow	200 < N < 399
Red	N > 400

Table 16: triage codes and their numerical related values.

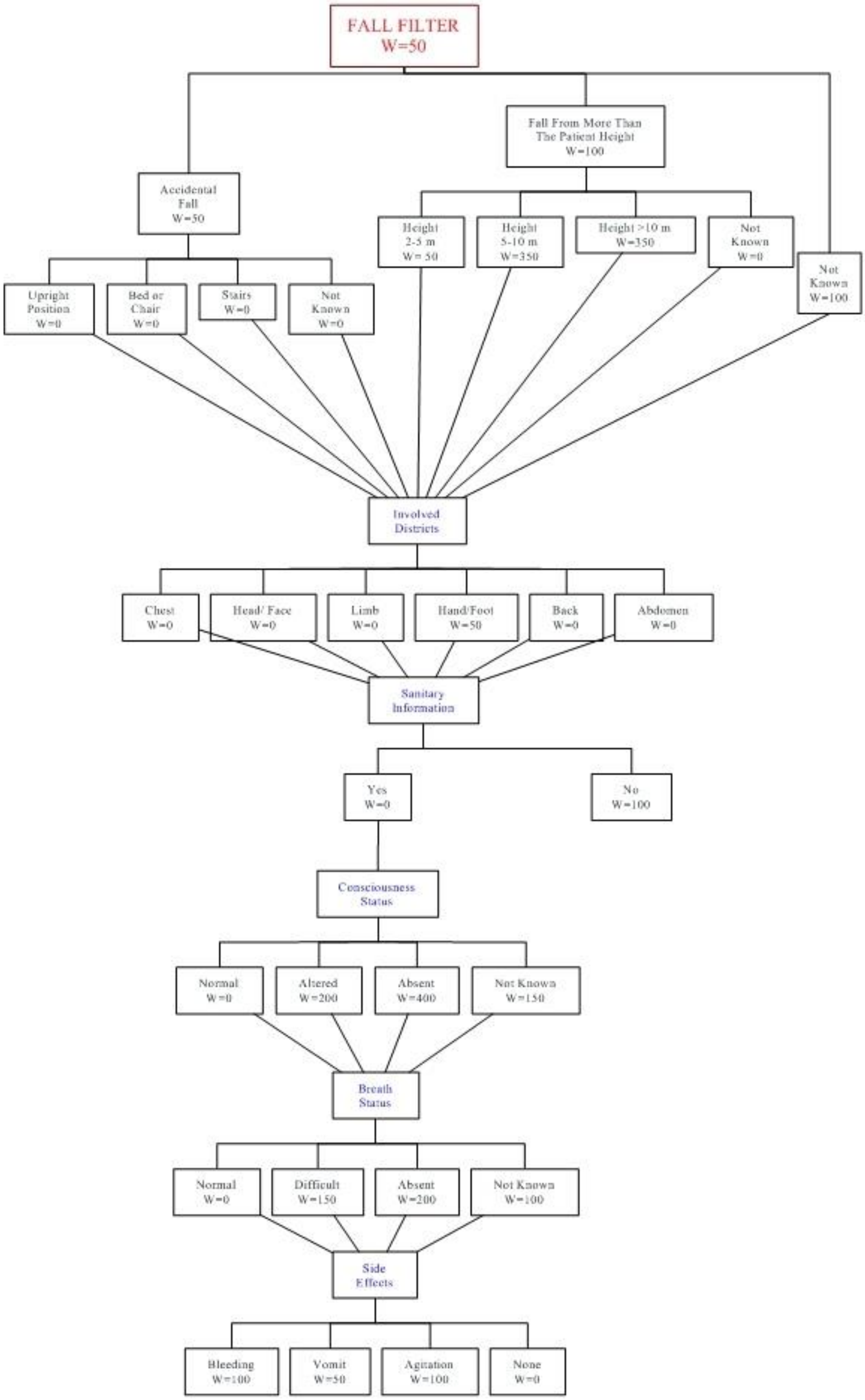
The detailed structure of the filter and the weight associated to each possible answer are explained and listed in the following tree diagrams.

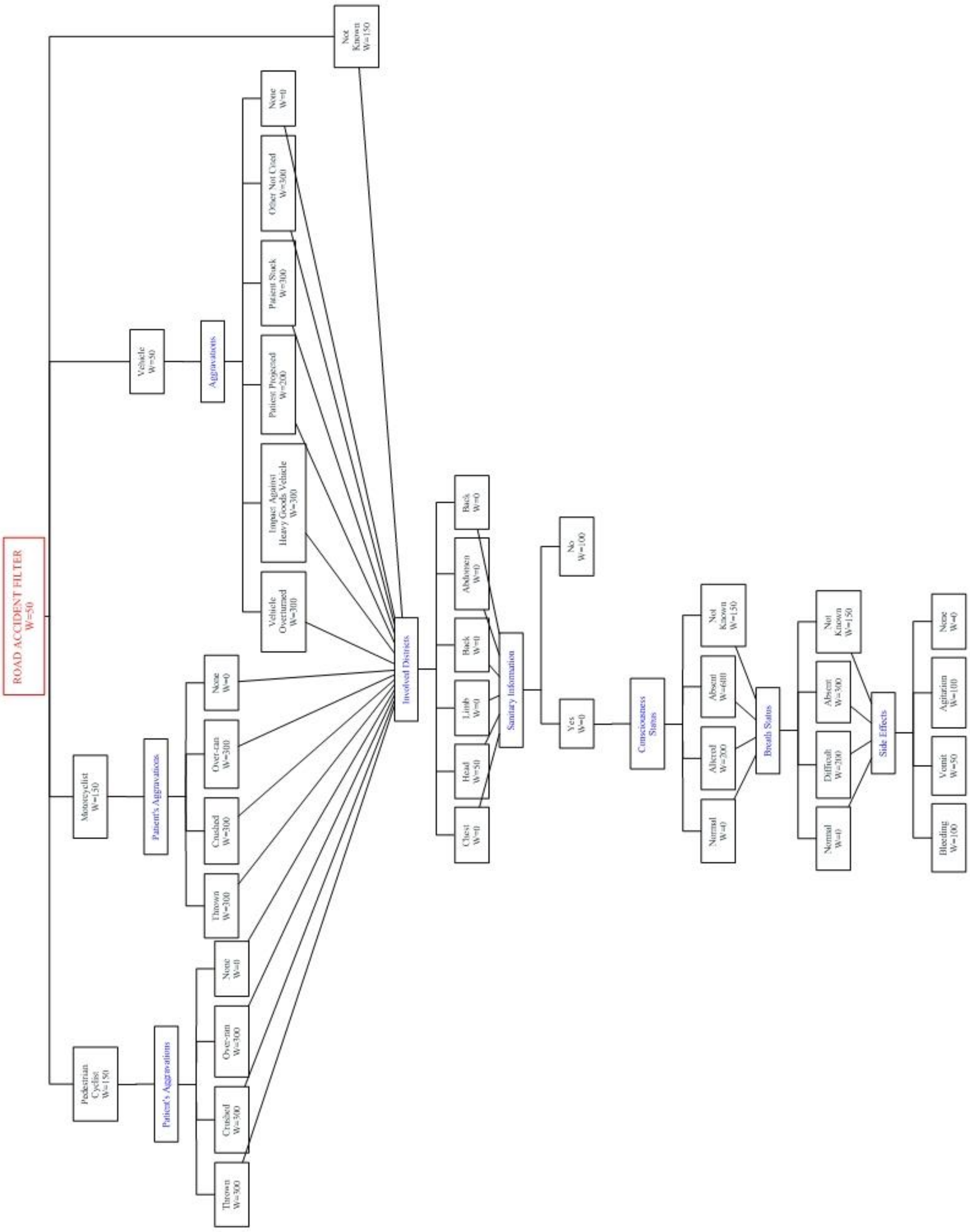
It is possible to see that the part referring to the medical parameters is easy and regards some basic aspects that everyone can comprehend and verify on the wounded. Although this information seems to be useless because of their simplicity, they can be very significant for a first anamnesis of the patient, performed during a revaluation in SOP1 or provided to BLS or ALS' personnel before the intervention.

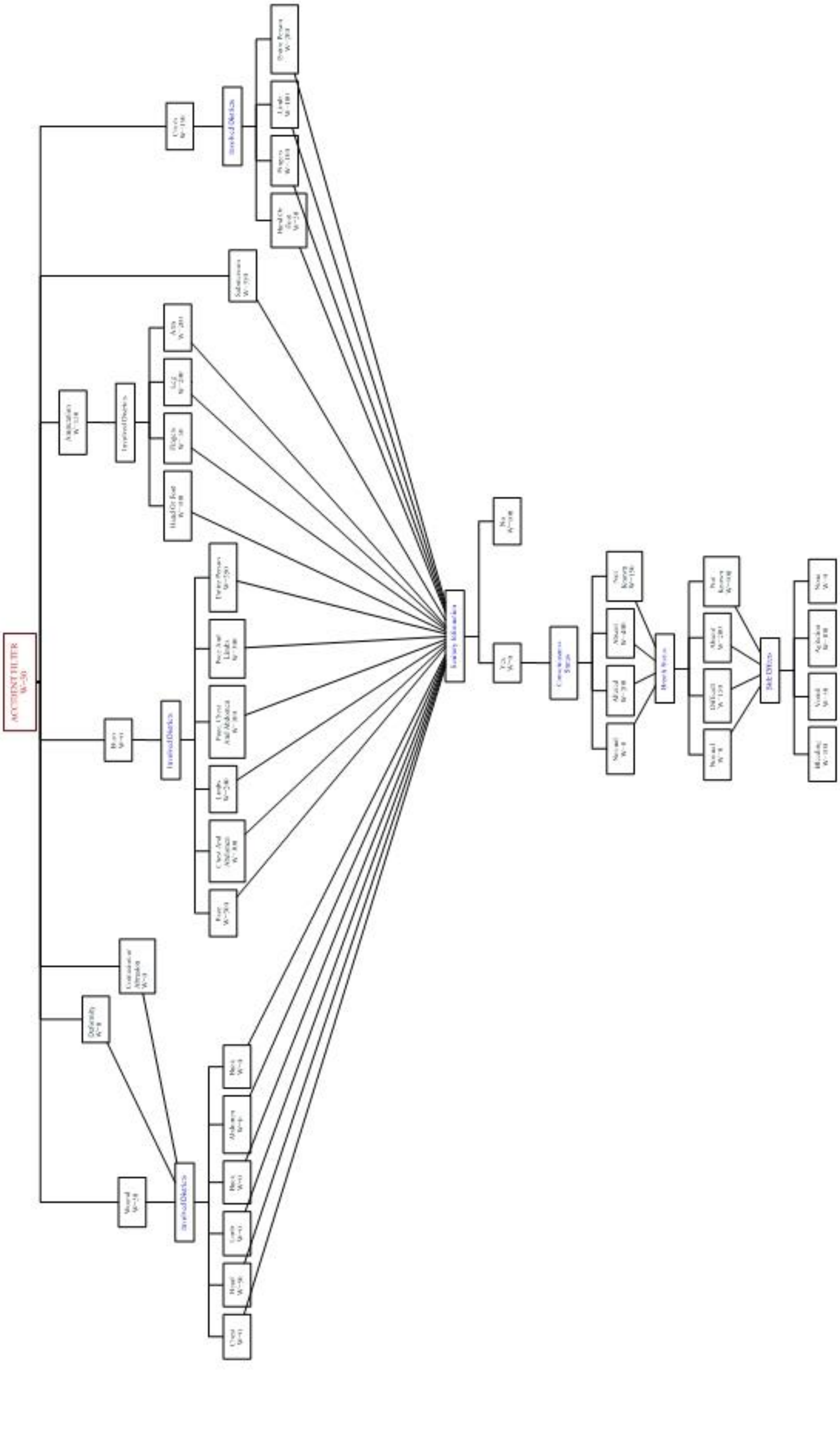
However the different filter are similar in terms of questions and associated weight: The majority of the differences are observable in the question regarding the mechanisms of the event.

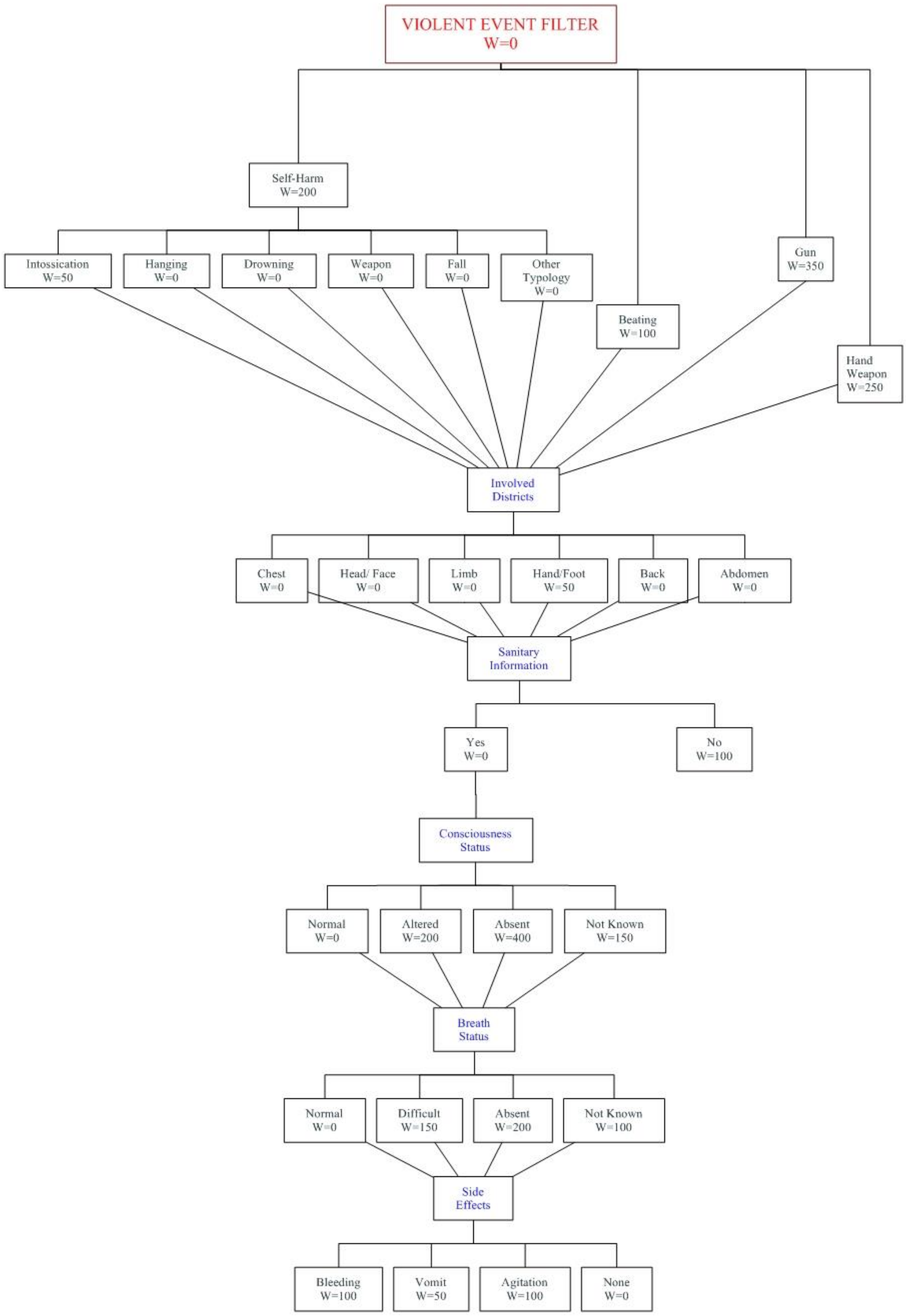
Knowing that the layman hasn't got the capability to give specific medical information, the questions are focused on the trauma's mechanism. Considering that high energy impact are often linked to severe traumas, this kind of information can be useful in the evaluation of the patient, especially because the more a mechanism is associable to a severe trauma, the higher is its weight in the filter.

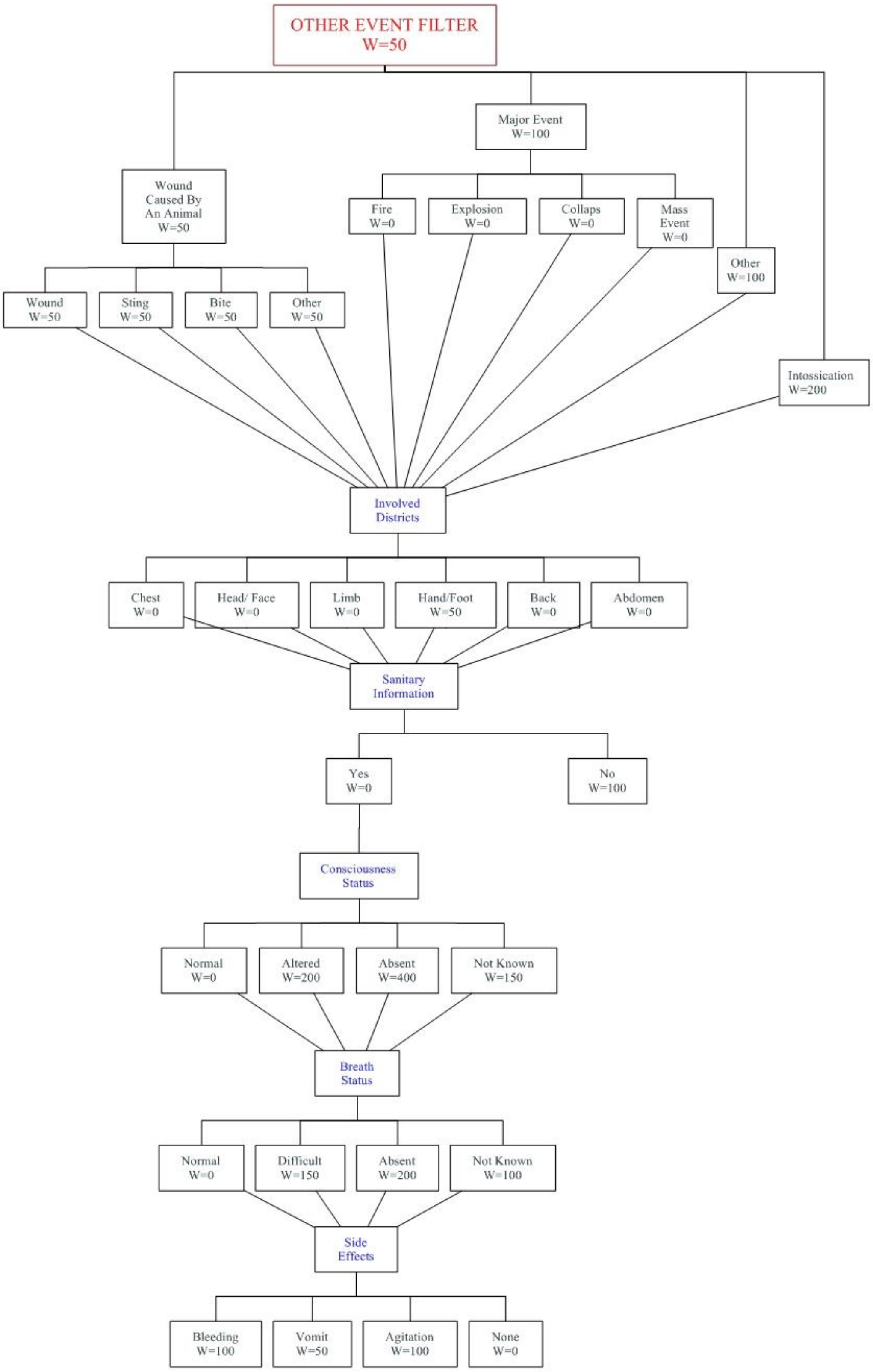
Figure 26: the following five figures represent the SREU filter structure as tree schemes. Each tree's topic is identified by the box at the top, describing the typology of the filter. The link represents the logical question's sequence and each question is associated to its possible answers, followed by their corresponding weights.


FALL FILTER
W=50
Accidental Fall W=50
Fall From More Than The Patient Height W=100
Not Known W=100
Upright Position W=0
Bed or Chair W=0
Stairs W=0
Not Known W=0
Height 2-5 m W= 50
Height 5-10 m W=350
Height >10 m W=350
Not Known W=0
Involved Districts
Chest W=0
Head/ Face W=0
Limb W=0
Hand/Foot W=50
Back W=0
Abdomen W=0
Sanitary Information
Yes W=0
No W=100
Consciousness Status
Normal W=0
Altered W=200
Absent W=400
Not Known W=150
Breath Status
Normal W=0
Difficult W=150
Absent W=200
Not Known W=100
Side Effects
Bleeding W=100
Vomit W=50
Agitation W=100
None W=0


ROAD ACCIDENT FILTER
W=50
Pedestrian Cyclist
W=150
Motorcyclist
W=150
Vehicle
W=50
Not Known
W=150
Patient's Aggravations
Thrown
W=300
Crushed
W=300
Over-run
W=300
None
W=0
Aggravations
Vehicle Overturned
W=300
Impact Against Heavy Goods Vehicle
W=300
Patient Projected
W=200
Patient Stuck
W=300
Other Not Cited
W=300
None
W=0
Involved Districts
Chest
W=0
Head
W=50
Limb
W=0
Back
W=0
Abdomen
W=0
Back
W=0
Sanitary Information
Yes
W=0
No
W=100
Consciousness Status
Normal
W=0
Altered
W=200
Absent
W=600
Not Known
W=150
Breath Status
Normal
W=0
Difficult
W=200
Absent
W=300
Not Known
W=150
Side Effects
Bleeding
W=100
Vomit
W=50
Agitation
W=100
None
W=0




VIOLENT EVENT FILTER
W=0
Self-Harm
W=200
Intossication
W=50
Hanging
W=0
Drowning
W=0
Weapon
W=0
Fall
W=0
Other
Typology
W=0
Beating
W=100
Gun
W=350
Hand
Weapon
W=250
Involved
Districts
Chest
W=0
Head/ Face
W=0
Limb
W=0
Hand/Foot
W=50
Back
W=0
Abdomen
W=0
Sanitary
Information
Yes
W=0
No
W=100
Consciousness
Status
Normal
W=0
Altered
W=200
Absent
W=400
Not Known
W=150
Breath
Status
Normal
W=0
Difficult
W=150
Absent
W=200
Not Known
W=100
Side
Effects
Bleeding
W=100
Vomit
W=50
Agitation
W=100
None
W=0


OTHER EVENT FILTER
W=50
Major Event
W=100
Wound
Caused By
An Animal
W=50
Fire
W=0
Explosion
W=0
Collaps
W=0
Mass
Event
W=0
Other
W=100
Wound
W=50
Sting
W=50
Bite
W=50
Other
W=50
Intossication
W=200
Involved
Districts
Chest
W=0
Head/ Face
W=0
Limb
W=0
Hand/Foot
W=50
Back
W=0
Abdomen
W=0
Sanitary
Information
Yes
W=0
No
W=100
Consciousness
Status
Normal
W=0
Altered
W=200
Absent
W=400
Not Known
W=150
Breath
Status
Normal
W=0
Difficult
W=150
Absent
W=200
Not Known
W=100
Side
Effects
Bleeding
W=100
Vomit
W=50
Agitation
W=100
None
W=0

5.2 ALBA's approach for the representation of the filter

The association between filter's weight and mechanism's parameter have been developed in literature starting from data collected on field. The question is: do these weights properly represent the current severity of the several involved parameters?

In order to find out an acceptable answer, we have tried to represent the AREU's filter with ALBA.

This task results is a critical passage in the research of the importance of each parameter: in fact an analyst should be able to represent a system in its actual state, before he can be able to propose and verify the effectiveness of any solution or improvement.

The difficulty lies in the fact that we want to translate the filter in ALBA as a classification algorithm, not in a list of every generable story. In this way the results will show how the stories are divided into the four available triage codes.

This structure will allow performing some sensibility analysis on the selected mechanism's parameters. The choice of the sensitive parameters will be presented together with the sensitivity analysis.

All the attempts performed for the transcription of the filter into an input file, will be presented in the following paragraphs, respecting the chronological order of creation. The cognitive process followed for the generation of each input will be presented, together with its transcription and with the obtained incorrect motivated results.

5.2.1 First resolution attempt

The firs resolution strategy works towards the representation of the filter without directly insert the weight's values of the answers. In fact the possible process outcomes, i.e. the triage code, have been used as ALBA exits, so they are represented as final levels. By doing so it was necessary to separately calculate the overall weight of the stories: for each answer we must compare the obtained weight with the different triage limits. If the weight was major than four-hundred the event goes to the red code’s exit.

Obviously all the filter answers that aren’t associated to any weight value have been neglected in the writing of the input file. This was possible because the attention is focused on the information than contributes to the determination of the triage code.

The construction of this input file has been really complicated and it takes a long time to correctly represent all the filter typology respecting the existing logical constrains. On the other hand, the probability assignation was easy: each question was associated to a probability equal to fifty percent. This choice should eliminate the frequency of different typology of events and the utility factor, i.e. all the subjective elements that can influence the decision maker, in this case the operator, while he has to compile the filter. In this phase, we want to analyse only the structure of the filter, not the influence of all the existing externals factors.

The consequences were linked only to the exits, in this way the results would have been referred to the frequency of each triage category.

The input file is shown below, together with the consequences file.

5.2.1.1 Input file

```
:Analysis start
1 0. 0. 5 0 3 'analysis start' ' ' ' '

:Is the event a fall(with no medical event)?
5 0.5 0. 7 220 3 'fall filter' 'yes' 'no'

:Is the typology/cause of the fall known?
7 0.5 0. 9 13 3 'cause of fall known' 'yes' 'no'
2 170 0 13 13

:Did the patient accidentally fall from stairs/bed/chair/upright position?
9 0.5 0. 13 11 3 'accidental fall' 'yes' 'no'

:Did the patient fall from more than 5m?
```

11 0.5 0. 600 202 3 'fall's height' 'h>5m' 'h<5m'

:Is any health information available?
13 0.5 0. 15 65 3 'health information' 'available' 'not available'

:Is the state of consciousness known?
15 0.5 0. 30 20 3 'consciousness' 'not known' 'known'
1 0 43 30 30
1 60 0 50 50

:Is the state of consciousness just altered?
20 0.5 0. 30 25 3 'altered consciousness' 'yes' 'no'
1 600 590 60 60
1 0 590 43 43

:Does the patient respond?
25 0.5 0. 70 600 3 'patient's response' 'present' 'absent'

:Is any information about the breath available?
30 0.5 0. 35 600 3 'breath status' ' known' 'not known'
2 600 590 60 60

:Does the patient breathe?
35 0.5 0. 40 600 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
40 0.5 0. 43 600 3 'breathing' 'normal' 'difficult'
1 45 0 43 43

:Does the patient present any side effect?
43 0.5 0. 600 60 3 'side effect' 'yes' 'no'
15 58 0. 0.

:Is the patient only bleeding?
45 0.5 0. 60 50 3 'bleeding' 'yes' 'no'
1 0 590 60 60

:Is the patient restless or does the patient vomit?
50 0.5 0. 600 55 3 'restless/vomits' 'yes' 'no'
1 600 590 60 60

:Does the patient present both vomit/agitation and bleeding?
55 0.5 0. 600 58 3 'vomit/agit.+bleeding' 'yes' 'no'

:Does the patient present both vomit and agitation?
58 0.5 0. 600 60 3 'vomit+agit 'yes' 'no'

:Does the injury involve head/face?
60 0.5 0. 590 65 3 'head/face injured' 'yes' 'no'

:Has the 118 been called immediately after the event?
65 0.5 0. 590 580 3 'emergency call(118)' 'immediately' 'differed'

:Is any information about the breath available?
70 0.5 0. 75 113 3 'breath status' ' known' 'not known'

:Does the patient breathe?
75 0.5 0. 80 43 3 'patient breath' 'present' 'absent'
2 45 590 43 43
2 600 590 60 60

:Does the patient breathe normally?
80 0.5 0. 140 43 3 'breathing' 'normal' 'difficult'
2 60 0 50 50
2 45 0 43 43

:Does the patient present any side effect?
113 0.5 0. 115 65 3 'side effect' 'yes' 'no'
15 128 0. 0.

:Is the patient only bleeding?
115 0.5 0. 60 120 3 'bleeding' 'yes' 'no'

:Is the patient restless or does the patient vomit?

120 0.5 0. 590 125 3 'restless/vomits' 'yes' 'no'

:Does the patient present both vomit/agitation and bleeding?
125 0.5 0. 60 128 3 'vomit/agit.+bleeding' 'yes' 'no'
1 600 590 60 60

:Does the patient present both vomit and agitation?
128 0.5 0. 600 60 3 'vomit+agit.' 'yes' 'no'

:Does the patient present any side effect?
140 0.5 0. 145 161 3 'side effect' 'yes' 'no'
15 158 0. 0.

:Is the patient only bleeding?
145 0.5 0. 160 150 3 'bleeding' 'yes' 'no'
1 0 580 160 160
:Is the patient restless or does the patient vomit?
150 0.5 0. 65 155 3 'restless/vomits' 'yes' 'no'

:Does the patient present both vomit/agitation and bleeding?
155 0.5 0. 160 158 3 'vomit/agit+bleeding' 'yes' 'no'
1 590 0 160 160

:Does the patient present both vomit and agitation?
158 0.5 0. 590 160 3 'vomit+agit.' 'yes' 'no'

:Does the injury involve head/face?
160 0.5 0. 65 65 3 'head/face injured' 'yes' 'no'

:Does the injury involve head/face? (with no side effects)
161 0.5 0. 65 65 3 'head/face injured' 'yes(no s.e.)' 'no(no s.e.)'
2 580 570 65 65
1 580 0 65 65

:Is the state of consciousness known?
170 0.5 0. 30 175 3 'consciousness' 'not known' 'known'
1 600 590 60 60

1 0 590 43 43

:Is the state of consciousness just altered?

175 0.5 0. 30 180 3 'altered consciousness' 'yes' 'no'

1 600 590 60 60

1 600 0 45 45

:Does the patient respond?

180 0.5 0. 182 600 3 'patient's response' 'present' 'absent'

:Is any information about the breath available?

182 0.5 0. 184 43 3 'breath status' ' known' 'not known'

2 45 0 43 43

2 60 0 50 50

:Does the patient breathe?

184 0.5 0. 186 43 3 'patient breath' 'present' 'absent'

2 600 590 60 60

:Does the patient breathe normally?

186 0.5 0. 190 43 3 'breathing' 'normal' 'difficult'

2 45 590 43 43

2 600 590 60 60

:Does the patient present any side effect?

190 0.5 0. 192 200 3 'side effect' 'yes' 'no'

15 58 0. 0.

:Is the patient only bleeding?

192 0.5 0. 65 194 3 'bleeding' 'yes' 'no'

:Is the patient restless or does the patient vomit?

194 0.5 0. 200 196 3 'restless/vomits' 'yes' 'no'

1 590 0 200 200

:Does the patient present both vomit/agitation and bleeding?

196 0.5 0. 590 198 3 'vomit/agit+bleeding' 'yes' 'no'

:Does the patient present both vomit and agitazion?

198 0.5 0. 200 200 3 'vomit+agit. 'yes' 'no'

1 600 0 200 200

:Does the injury involve head/face?

200 0.5 0. 580 65 3 'head/face injured' 'yes' 'no'

:Is any health information available?

202 0.5 0. 204 590 3 'health information' 'available' 'not available'

:Is the state of consciousness known?

204 0.5 0. 30 206 3 'consciousness' 'not known' 'known'

1 600 590 60 60

:Is the state of consciousness just altered?

206 0.5 0. 600 208 3 'altered consciousness' 'yes' 'no'

:Does the patient respond?

208 0.5 0. 210 600 3 'patient's response' 'present' 'absent'

:Is any information about the breath available?

210 0.5 0. 212 43 3 'breath status' ' known' 'not known'

2 600 590 60 60

2 45 590 43 43

:Does the patient breathe?

212 0.5 0. 214 600 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?

214 0.5 0. 113 43 3 'breathing' 'normal' 'difficult'

2 600 590 60 60

:Is the event a road accident?

220 0.5 0. 222 270 3 'road accident filter' 'yes' 'no'

:Is the typology of the road accident known?

222 0.5 0. 224 234 3 'accident typology' 'known' 'not known'

:Does the accident involve a pedestrian/ciclyst/motorciclyst?
224 0.5 0. 226 250 3 'ped/cy/mcy involved' 'yes' 'vehicle involved'

:Does the patient present aggravating?
226 0.5 0. 228 234 3 'aggravating' 'present' 'absent'
15 232 0. 0.

:Has the patient been crushed?
228 0.5 0. 600 230 3 'cy/mcy crushed' 'yes' 'no'

:Was the patient over-ran?
230 0.5 0. 600 232 3 'over-ran cy/mcy' 'yes' 'no'

:Has the pedestrian/cyclist been thrown?
232 0.5 0. 600 234 3 'cy/mcy thrown' 'yes' 'no'

:Is any health information available?
234 0.5 0. 236 590 3 'health information' 'yes' 'no'

:Is the state of consciousness known?
236 0.5 0. 238 30 3 'consciousness' 'known' 'not known'
2 600 0 45 45

:Is the state of consciousness altered?
238 0.5 0. 600 240 3 'altered consciousness' 'yes' 'no'

:Does the patient respond?
240 0.5 0. 242 600 3 'patient response' 'present' 'absent'

:Is any information about the breath available?
242 0.5 0. 244 43 3 'breath status' 'known' 'not known'
2 600 590 60 60

:Does the patient breathe?
244 0.5 0. 246 600 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
246 0.5 0. 113 600 3 'breathing' 'normal' 'difficult'

:Is any information about the breath available?
247 0.5 0. 248 600 3 'breath status' 'known' 'not known'

:Does the patient breathe?
248 0.5 0. 248 600 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
249 0.5 0. 43 600 3 'breathing' 'normal' 'difficult'
1 600 590 60 60
1 45 590 43 43

:Does the patient present aggravating?
250 0.5 0. 252 13 3 'aggravating' 'present' 'absent'
2 258 0 25 25
2 263 0 15 15

:Is the patient stuck in the vehicle?
252 0.5 0. 600 253 3 'patient stuck' 'yes' 'no'

:Is the impact against a heavy goods vehicle?
253 0.5 0. 600 254 3 ‘heavy goods vehicle’ 'yes' 'no'

:Does the vehicle overturn because of the accident?
254 0.5 0. 600 255 3 'vehicle overturned' ''yes' 'no'

:Is there any other impact indicator?(death person on board, vehicle deformed..)
255 0.5 0. 600 256 3 'other indicators' 'yes' 'no'
25 256 0. 0.

:Has the patient been thrown outside the vehicle?
256 0.5 0. 234 234 3 'thrown out of vehicle 'yes' 'no'
1 0 600 234 236
1 247 0 240 240

:Is any information about the breath available??
258 0.5 0. 260 43 3 'breath status' ' known' 'not known'
2 45 0 43 43
2 60 0 50 50

:Does the patient breathe?
260 0.5 0. 262 600 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
262 0.5 0. 140 43 3 'breathing' 'normal' 'difficult'
2 45 590 43 43
2 600 590 60 60

:Is any information about the breath available?
263 0.5 0. 35 600 3 'breath status' ' known' 'not known'
1 60 0 50 50

:Is the event an accident (work/sport/home...)?
270 0.5 0. 272 400 3 'accident filter' 'yes' 'no'
15 396 0. 0.

:Is the accident a wound?
272 0.5 0. 13 274 3 'wound' 'yes' 'no'

:Did the accident cause a contusion/abrasion/deformity?
274 0.5 0. 276 320 3 'cont/abr/def' 'yes' 'no'

:Is any health information available?
276 0.5 0. 278 580 3 'health information' 'available' 'not available'

:Is the state of consciousness known?
278 0.5 0. 284 280 3 'consciousness' 'not known' 'known'

:Is the state of consciousness just altered?
280 0.5 0. 30 282 3 'altered consciousness' 'yes' 'no'
1 0 43 30 30

1 60 0 50 50

:Does the patient respond?

282 0.5 0. 302 600 3 'patient's response' 'present' 'absent'

:Is any information about the breath available??

284 0.5 0. 286 43 3 'breath status' ' known' 'not known'

1 45 0 43 43

1 60 0 50 50

:Does the patient breathe?

286 0.5 0. 288 43 3 'patient breath' 'present' 'absent'

2 600 590 60 60

:Does the patient breathe normally?

288 0.5 0. 290 43 3 'breathing' 'normal' 'difficult'

2 45 590 43 43

2 600 590 60 60

:Does the patient present any side effect?

290 0.5 0. 292 60 3 'side effect' 'yes' 'no'

15 298 0. 0.

2 65 580 60 60

:Is the patient only bleeding?

292 0.5 0. 65 294 3 'bleeding' 'yes' 'no'

:Is the patient restless or does the patient vomit? (only one side effect)

294 0.5 0. 60 296 3 'restless/vomits' 'yes' 'no'

:Does the patient present both vomit/agitation and bleeding?

296 0.5 0. 590 298 3 'vomit/agit.+bleeding' 'yes' 'no'

:Does the patient present both vomit and agitation?

298 0.5 0. 60 60 3 'vomit+agit.' 'yes' 'no'

1 600 590 60 60

:Is any information about the breath available??
302 0.5 0. 304 290 3 'breath status' ' known' 'not known'

:Does the patient breathe?
304 0.5 0. 306 43 3 'patient breath' 'present' 'absent'
2 45 0 43 43
2 60 0 50 50

:Does the patient breathe normally?
306 0.5 0. 308 113 3 'breathing' 'normal' 'difficult'

:Does the patient present any side effect?
308 0.5 0. 310 65 3 'side effect' 'yes' 'no'
15 316 0. 0.
2 580 570 65 65

:Is the patient only bleeding?
310 0.5 0. 60 312 3 'bleeding' 'yes' 'no'
1 580 570 65 65
1 580 0 60 60

:Is the patient restless or does the patient vomit?
312 0.5 0. 60 314 3 'restless/vomits' 'yes' 'no'
1 65 580 60 60

:Does the patient present both vomit/unrest and bleeding?
314 0.5 0. 65 316 3 'vomit/agit.+bleeding' 'yes' 'no'

:Does the patient present both vomit and agitation?
316 0.5 0. 590 60 3 'vomit+agitation' 'yes' 'no'

:Is the accident a burn?
320 0.5 0. 322 346 3 'burn' 'yes' 'no'

:Is the extension/district of the burn known?
322 0.5 0. 324 331 3 'burnt district' 'known' 'not known'

15 328 0. 0.
1 45 65 43 43
1 590 0 45 50

:Does the burn involve face, chest and/or abdomen?
324 0.5 0. 330 326 3 'burnt face/chest/abd' 'yes' 'no'
1 0 590 43 43
1 0 600 338 338

:Does the burn involve only limbs?
326 0.5 0. 331 328 3 'burnt limbs' 'yes' 'no'
1 45 65 43 43
1 590 0 45 50

:Does the burn involve the entire person?
328 0.5 0. 600 600 3 ‘entire person burnt 'yes' 'no'

:Is any health information available?
330 0.5 0. 332 600 3 'health information' 'available' 'not available'
1 339 0 336 336

:Is any health information available?
331 0.5 0. 332 590 3 'health information' 'available' 'not available'

:Is the state of consciousness known?
332 0.5 0. 600 334 3 'consciousness' 'not known' 'known'

:Is the state of consciousness just altered?
334 0.5 0. 600 336 3 'altered consciousness' 'yes' 'no'

:Does the patient respond?
336 0.5 0. 338 600 3 'patient's response' 'present' 'absent'

:Is any information about the breath available??
338 0.5 0. 340 43 3 'breath status' ' known' 'not known'
2 0 590 43 43

:Is any information about the breath available??
339 0.5 0. 340 600 3 'breath status' ' known' 'not known'

:Does the patient breathe?
340 0.5 0. 342 600 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
342 0.5 0. 43 600 3 'breathing' 'normal' 'difficult'

:Is the accident a crush?
346 0.5 0. 348 376 3 'crush' 'yes' 'no'
15 356 0. 0.

:Does the crush involve hand/foot?
348 0.5 0. 331 350 3 'hand/foot crushed' 'yes' 'no'
1 45 65 43 43
1 590 0 45 50

:Does the crush involve fingers?
350 0.5 0. 358 354 3 'fingers crushed' 'yes' 'no'

:Does the crush involve a limb?
354 0.5 0. 330 356 3 'limb crushed' 'yes' 'no'
1 45 590 43 43
1 590 0 45 45

:Does the crush involve the entire person?
356 0.5 0. 600 600 3 'entire person crushed' 'yes' 'no'

:Is any health information available?
358 0.5 0. 359 65 3 'health information' 'available' 'not available'

:Is the state of consciousness known?
359 0.5 0. 338 360 3 'consciousness' 'not known' 'known'
1 45 65 43 43
1 590 0 45 50

:Is the state of consciousness just altered?

360 0.5 0. 339 362 3 'altered consciousness' 'yes' 'no'

1 45 590 43 43

1 590 0 45 45

:Does the patient respond?

362 0.5 0. 364 600 3 'patient's response' 'present' 'absent'

:Is any information about the breath available??

364 0.5 0. 366 113 3 'breath status' ' known' 'not known'

2 65 0 115 115

:Does the patient breathe?

366 0.5 0. 368 43 3 'patient breath' 'present' 'absent'

2 45 590 43 43

2 590 0 45 45

:Does the patient breathe normally?

368 0.5 0. 370 43 3 'breathing' 'normal' 'difficult'

2 45 65 43 43

2 590 0 45 50

:Does the patient present any side effect?

370 0.5 0. 371 65 3 'side effect' 'yes' 'no'

15 374 0. 0.

2 580 570 65 65

:Is the patient only bleeding?

371 0.5 0. 580 372 3 'bleeding' 'yes' 'no'

:Is the patient restless or does the patient vomit?

372 0.5 0. 65 373 3 'restless/vomits' 'yes' 'no'

:Does the patient present both vomit/agitation and bleeding?

373 0.5 0. 65 374 3 'vomit/agit.+bleeding' 'yes' 'no'

:Does the patient present both vomit and agitation?

374 0.5 0. 590 590 3 'vomit+agit' 'yes' 'no'

:Is the accident an amputation?

376 0.5 0. 378 396 3 'amputation' 'yes' 'no'

15 380 0. 0.

:Does the amputation involve fingers?

378 0.5 0. 358 379 3 'amputate fingers' 'yes' 'no'

1 382 0 358 358

:Does the amputation involve a hand/foot?

379 0.5 0. 330 380 3 'hand/foot amputate' 'yes' 'no'

1 0 600 338 338

1 45 590 43 43

1 590 0 45 45

:Does the amputation involve a leg or an arm?

380 0.5 0. 600 600 3 'leg/arm amputate' 'yes' 'no'

:Is the state of consciousness known?

382 0.5 0. 339 384 3 'consciousness' 'not known' 'known'

1 45 590 43 43

1 590 0 45 45

:Is the state of consciousness just altered?

384 0.5 0. 339 386 3 'altered consciousness' 'yes' 'no'

1 0 590 43 43

:Does the patient respond?

386 0.5 0. 388 600 3 'patient's response' 'present' 'absent'

:Is any information about the breath available??

388 0.5 0. 389 43 3 'breath status' ' known' 'not known'

2 45 65 43 43

2 590 0 45 50

:Does the patient breathe?

389 0.5 0. 390 43 3 'patient breath' 'present' 'absent'
2 0 590 43 43

:Does the patient breathe normally?
390 0.5 0. 391 43 3 'breathing' 'normal' 'difficult'
2 45 590 43 43
2 590 0 45 45

:Does the patient present any side effect?
391 0.5 0. 392 580 3 'side effect' 'yes' 'no'
15 395 0. 0.

:Is the patient only bleeding?
392 0.5 0. 65 393 3 'bleeding' 'yes' 'no'

:Is the patient restless or does the patient vomit?
393 0.5 0. 65 394 3 'restless/vomits' 'yes' 'no'

:Does the patient present both vomit/agitation and bleeding?
394 0.5 0. 590 395 3 'vomit/agit.+bleeding' 'yes' 'no'

:Does the patient present both vomit and unrest?
395 0.5 0. 590 590 3 'vomit+agit.' 'yes' 'no'

:Is the accident a submersion?
396 0.5 0. 600 600 3 'submersion' 'yes' 'no'

:Is the event a violent one?
400 0.5 0. 401 406 3 'violent event filter' 'yes' 'no'
15 404 0. 0.

:Is the violent event a beating?
401 0.5 0. 13 402 3 'beating' 'yes' 'no'

:Is the violent event caused by a weapon?
402 0.5 0. 403 404 3 'weapon' 'yes' 'no, self-harm'

:What kind of weapon has been used?

403 0.5 0. 331 330 3 'kind of weapon' 'hand weapon' 'gun'

2 600 590 60 60

1 405 0 340 340

:Is the type of self-harm known?

404 0.5 0. 202 202 3 'type of self-harm' 'known' 'not known'

:Does the patient breathe normally?

405 0.5 0. 43 600 3 'breathing' 'normal' 'difficult'

1 45 0 43 43

1 60 0 50 50

:Is the event an intoxication?

406 0.5 0. 202 407 3 'intoxication filter' 'yes' 'no'

:Is the event cause by an animal?

407 0.5 0. 13 408 3 'animal injury filter' 'yes' 'no'

:Is the injury different from the one cited?

408 0.5 0. 331 409 3 'other modality' 'yes' 'no'

1 45 60 43 43

1 60 0 50 50

:Is the event a major event?

409 0.5 0. 331 680 3 'major event filter' 'yes' 'no'

1 45 60 43 43

1 60 0 50 50

:Different kind of event

610 0. 0 0 0 3 'kind of event' 'not a fall' ' '

:Triage code: white

570 0. 0 0 0 3 'triage code' 'white' ' '

:Triage code: green

580 0. 0 0 0 3 'triage code' 'green' ' '

```
:Triage code: yellow
590 0. 0 0 0 3 'triage code' 'yellow' ' '

:Triage code: red
600 0. 0 0 0 3 'triage code' 'red' ' '
```

The input file is rich of logical constrains, in order to reduce the number of necessary levels. In particular these constrains allow to bring the different filter back to their common part, i.e. the one related to the collection of the sanitary information about the patient, but always maintaining a separate weight calculation. Although the file is really long and complex, the presence of the logical constrains allows obtaining only 761 constituents.

This number is quite small, but is associated to a high value of entropy, 6.5, given that the amount of information insert in the input file is really low, i.e. we have supposed to have not got any knowledge about each level.

5.2.1.2 Consequences file

```
IF (K1.EQ.570.AND.K2.EQ.1)    XDT = XDT+XC(10)
IF (K1.EQ.580.AND.K2.EQ.1)    XDT = XDT+XC(50)
IF (K1.EQ.590.AND.K2.EQ.1)    XDT = XDT+XC(80)
IF (K1.EQ.600.AND.K2.EQ.1)    XDT = XDT+XC(100)
```

The consequences file is quite easy and synthetic: each triage code’s level is linked to a magnitude value, in order to make it easy to read within the solutions the percentage allocation of the obtained stories.

The CCDF shows the probability to have a triage code higher than the one linked to the magnitude value on the abscissa.

The RDF should show the probability of each triage code within all the possible outcomes of the process.

5.2.1.3 Results and associated problems

The obtained graphs [Figure 27 and Figure 28] underlines that the yellow and red codes comprehend the majority of the constituents: this result could be acceptable, because the yellow code summarizes the larger amount of global weight, together with the red one.

The first observable problem is that this type of representation of the systems is not enough flexible to allow a sensitivity analysis: for every weight's change is necessary to recalculate the exit of each story, but also the logical constrains linked to the exit's changes.

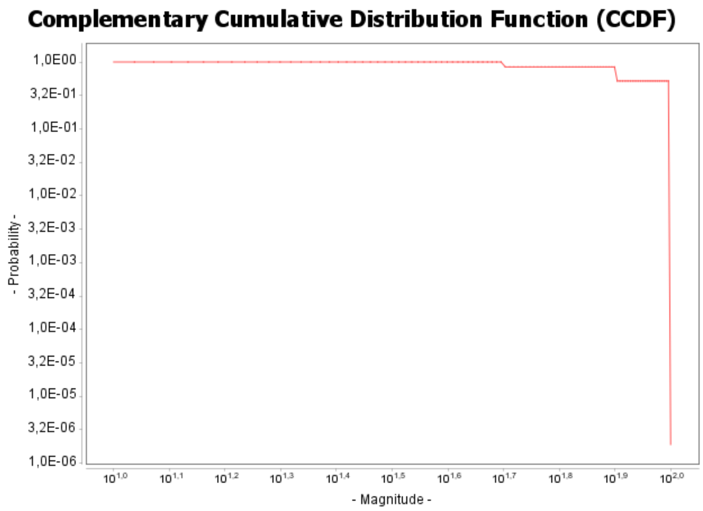


Figure 27: AREU filter's CCDF: first approach

Secondary, although the objective is a classification algorithm, the probability value should reflect the presence of multiple answers to the questions: each level should comprehend a reference to the other possible answer and can't be independent by these ones. This problem derives from the translation of an algorithm based on multiple answers to one based on binary answers: each filter's question must be represents by more than one level in order to respect ALBA's logic.

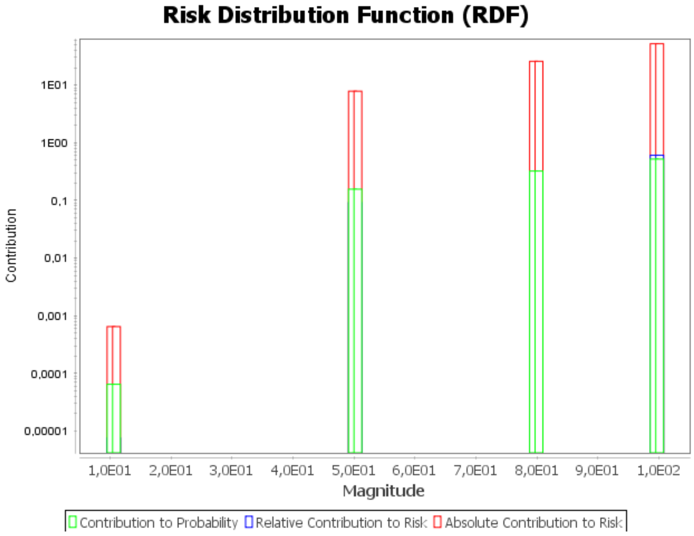


Figure 28: AREU filter's RDF: first approach

5.2.2 Second resolution approach

After the analysis of the first approach, it's clear that the new input file should be constructed using a different point of view. First of all is important to directly introduce the weight's value into the input file or into the consequences values, in order to allow a sensitivity analysis, useful for a study of the parameters responsible of the over-triage.

Since the weights couldn't be represents as the probability of failure of the events, the logical strategy was to insert them as consequences values.

Given that the weights have been introduced into the consequences file, the input file can be simplified with the reduction of the possible exits to only one outcome: the generation of the triage code, without distinguish its colour.

This simplification allows also the reduction of the logical constrains: the main function of the logical constrains introduced into the first approach was to direct the constituents to the correct exits, in function of the reached weight. Since this process is no more useful, the second generated input file has got few logical constrains.

The second problem underlined in the first resolution approach was the incorrect probability value assignation. This time the probability has been calculated on the basis of the possible selectable answers for each filter's question.

As explained at the end of the previous paragraph, the more are the answers associated to a filter's question, the more are the level to be used to translate the question into ALBA language. This means that the probability that the operator selects one of the possible choices is equal to the ratio between one and the number of available answers. For example, the consciousness state can be described by four different outcomes, each one associated to a probability of 0.25.

This reasoning is reliable for question with multiple dependent answers: the operator can choose only one option for this kind of question. Whether the question has got multiple stochastic independent answers, the operator can select more than one option: this means that the probability of selection of each answer is independent by the other one, so it's always equal to 0.5. For example, a patient can present more than one side effect, but also none of them.

5.2.2.1 Input file

In order to better organize the analysis, the input file is divided into five parts, corresponding to the five available filter's typology. Each part has got a unique identical exit and is associated to a consequences input file.

The five input files are reported below, with a title on the top, in order to distinguish their topic.

Fall Filter

```
:Analysis start
1 0. 0. 5 0 3 'analysis start' ' ' ' '

:Is the event a fall(with no medical event)?
5 0.2 0. 605 7 3 'fall filter' 'no' 'yes'

:Is the typology/cause of the fall known?
7 0.33 0. 9 13 3 'cause of fall' 'known' 'not known'

:Did the patient accidentally fall from stairs/bed/chair/upright position?
9 0.33 0. 10 13 3 'accidental fall' 'no' 'yes'
16 10 0 0
```

:Did the patient fall from more than his height?
10 0.33 0. 11 11 3 'precipitation' 'no' 'yes'

:Did the patient fall from more than 5m?
11 0.5 0. 13 13 3 'fall's height' 'h>5m' 'h<5m'

:Is any health information available?
13 0.5 0. 15 65 3 'health information' 'available' 'not available'

:Is the state of consciousness known?
15 0.25 0. 20 30 3 'consciousness' 'known' 'not known'

:Is the state of consciousness just altered?
20 0.25 0. 25 30 3 'altered consciousness' 'no' 'yes'

:Does the patient respond?
25 0.25 0. 27 30 3 'patient responds' 'no' 'yes'
16 27 0 0

:Is the patient unconscious?
27 0.25 0. 30 30 3 'patient unconscious' 'no' 'yes'

:Is any information about the breath available??
30 0.25 0. 35 45 3 'breath status' ' known' 'not known'

:Does the patient breathe?
35 0.25 0. 40 45 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
40 0.25 0. 42 45 3 'normal breath' 'no' 'yes'
16 42 0 0

:Does the patient breathe difficultly?
42 0.25 0. 45 45 3 'difficult breath' 'no' 'yes'

:Is the patient bleeding?
45 0.5 0. 50 50 3 'bleeding' 'no' yes'

:Is the patient restless?
50 0.5 0. 55 55 3 'restless' 'no' yes'

:Does the patient vomit?
55 0.5 0. 60 60 3 'vomit' 'no' yes'

:Does the injury involve head/face?
60 0.5 0. 65 65 3 'head/face injured' 'no' yes'

:Has the 118 been called immediately after the event?
65 0.5 0. 600 600 3 'emergency call(118)' 'immediately' 'differed'

:Generation of a triage code
600 0. 0 0 0 3 'triage code' 'generated' ' '

:Other event
605 0. 0 0 0 3 'other event' 'other filter' ' '

<u>Road Accident Filter</u>
:Analysis start
1 0. 0. 220 0 3 'analysis start' ' ' ' '

:Is the event a road accident?
220 0.2 0. 270 222 3 'road accident filter' 'no' 'yes'

:Is the typology of the road accident known?
222 0.25 0. 224 234 3 'accident typology' 'known' 'not known'

:Does the accident involve a pedestrian/cyclist?
224 0.25 0. 225 226 3 'ped/cy involved' 'no' 'yes'

:Does the accident involve a motorcyclist?
225 0.25 0. 250 226 3 'mcy involved' 'no' 'yes'
16 250 0 0

:Has the patient been crushed?

226 0.5 0. 230 230 3 'cy/mcy crushed' 'yes' 'no'

:Was the patient over-ran?
230 0.5 0. 232 232 3 'cy/mcy over-ran' 'yes' 'no'

:Has the pedestrian/cyclist been thrown?
232 0.5 0. 234 234 3 'cy/mcy thrown' 'yes' 'no'

:Does the accident involve a vehicle?
250 0.25 0. 252 252 3 'vehicle involved' 'no' 'yes'

:Is the patient stuck in the vehicle?
252 0.5 0. 253 253 3 'patient stuck' 'yes' 'no'
16 256 0 0

:Does the accident involve a heavy goods vehicle?
253 0.5 0. 254 254 3 ‘heavy vehicle’ 'yes' 'no'

:Does the vehicle overturn because of the accident?
254 0.5 0. 255 255 3 'vehicle overturned' ''yes' 'no'

:Is there any other impact indicator?(death person on board, vehicle deformed..)
255 0.5 0. 256 256 3 'other indicators' 'yes' 'no'

:Has the patient been thrown outside the vehicle?
256 0.5 0. 234 234 3 'thrown out of vehicle 'yes' 'no'

:Is any health information available?
234 0.5 0. 236 65 3 'health information' 'yes' 'no'

:Is the state of consciousness known?
236 0.25 0. 238 245 3 'consciousness' 'known' 'not known'

:Is the state of consciousness just altered?
238 0.25 0. 240 244 3 'altered consciousness' 'no' 'yes'

:Does the patient respond?

240 0.25 0. 242 244 3 'patient responds' 'no' 'yes'
16 242 0 0

:Is the patient unconscious?
242 0.25 0. 245 244 3 'patient unconscious' 'no' 'yes'

:Is any information about the breath available??
244 0.25 0. 245 45 3 'breath status' ' known' 'not known'

:Does the patient breathe?
245 0.25 0. 246 45 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
246 0.25 0. 247 45 3 'normal breath' 'no' 'yes'
16 42 0 0

:Does the patient breathe difficultly?
247 0.25 0. 45 45 3 'difficult breath' 'no' 'yes'

:Is the patient bleeding?
45 0.5 0. 605 50 3 'bleeding' 'no' yes'

:Is the patient restless?
50 0.5 0. 55 55 3 'restless' 'no' yes'

:Does the patient vomit?
55 0.5 0. 60 60 3 'vomit' 'no' yes'

:Does the injury involve head/face?
60 0.5 0. 65 65 3 'head/face injured' 'no' yes'

:Has the 118 been called immediately after the event?
65 0.5 0. 600 600 3 'emergency call(118)' 'immediately' 'differed'

:Generation of a triage code
600 0. 0 0 0 3 'triage code' 'generated' ' '

:Other event

605 0. 0 0 0 3 'other event' 'other filter' ' '

Accident Filter

:Analysis start

1 0. 0. 270 0 3 'analysis start' ' ' ' '

:Is the event an accident (work/sport/home...)?

270 0.2 0. 605 272 3 'accident filter' 'no' 'yes'

:Is the accident a wound?

272 0.14 0. 274 13 3 'wound' 'no' 'yes'

:Did the accident cause a contusion/abrasion?

274 0.14 0. 276 13 3 'cont/abr' 'no' 'yes'

:Did the accident cause a deformity?

276 0.14 0. 320 13 'deformity' 'no' 'yes'

:Is the accident a burn?

320 0.14 0. 346 322 3 'burn' 'no' 'yes'

2 65 65 55 55

:Is the extension/district of the burn known?

322 0.14 0. 324 13 3 'burnt district' 'known' 'not known'

:Does the burn involve the entire person?

324 0.14 0. 326 13 3 'burnt person' 'no' 'yes'

:Does the burn involve limbs?

326 0.14 0. 328 13 3 'burnt limbs' 'no' 'yes'

:Does the burn involve chest and abdomen?

328 0.14 0. 330 13 3 'chest/abdomen burnt' 'no' 'yes'

:Does the burn involve head and face?

330 0.14 0. 332 13 3 'head/face burnt' 'no' 'yes'

:Does the burn involve both face chest and abdomen?
332 0.14 0. 334 13 3 'face/chest/abd burnt' 'no' 'yes'
16 334 0 0

:Does the burn involve both face and limbs?
334 0.14 0. 13 13 3 'face/limbs bunt' 'no' 'yes'

:Is the accident a crush?
346 0.14 0. 376 347 3 'crush' 'no' 'yes'
2 65 65 55 55

:Does the crush involve the entire person?
347 0.25 0. 348 13 3 'entire person crushed' 'no' 'yes'

:Does the crush involve hand/foot?
348 0.25 0. 350 13 3 'hand/foot crushed' 'no' 'yes'

:Does the crush involve fingers?
350 0.25 0. 354 13 3 'fingers crushed' 'no' 'yes'
16 354 0 0

:Does the crush involve a limb?
354 0.25 0. 13 13 3 'limb crushed' 'no' 'yes'

:Is the accident an amputation?
376 0.14 0. 396 378 3 'amputation' 'no' 'yes'
2 65 65 55 55
16 396 0 0

:Does the amputation involve fingers?
378 0.25 0. 379 13 3 'amputate fingers' 'no' 'yes'

:Does the amputation involve a hand/foot?
379 0.25 0. 380 13 3 'hand/foot amputate' 'no' 'yes'
16 380 0 0

:Does the amputation involve a leg or an arm?

380 0.25 0. 13 13 3 'leg/arm amputate' 'no' 'yes'

:Is the accident a submersion?

396 0.14 0. 13 13 3 'submersion' 'no' 'yes'

:Is any health information available?

13 0.5 0. 15 65 3 'health information' 'available' 'not available'

:Is the state of consciousness known?

15 0.25 0. 20 30 3 'consciousness' 'known' 'not known'

:Is the state of consciousness just altered?

20 0.25 0. 25 30 3 'altered consciousness' 'no' 'yes'

:Does the patient respond?

25 0.25 0. 27 30 3 'patient responds' 'no' 'yes'

16 27 0 0

:Is the patient unconscious?

27 0.25 0. 30 30 3 'patient unconscious' 'no' 'yes'

:Is any information about the breath available??

30 0.25 0. 35 45 3 'breath status' ' known' 'not known'

:Does the patient breathe?

35 0.25 0. 40 45 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?

40 0.25 0. 42 45 3 'normal breath' 'no' 'yes'

16 42 0 0

:Does the patient breathe difficultly?

42 0.25 0. 45 45 3 'difficult breath' 'no' 'yes'

:Is the patient bleeding?

45 0.5 0. 50 50 3 'bleeding' 'no' yes'

:Is the patient restless?
50 0.5 0. 55 55 3 'restless' 'no' yes'

:Does the patient vomit?
55 0.5 0. 60 60 3 'vomit' 'no' yes'

:Does the injury involve head/face?
60 0.5 0. 65 65 3 'head/face injured' 'no' yes'

:Has the 118 been called immediately after the event?
65 0.5 0. 600 600 3 'emergency call(118)' 'immediately' 'differed'

:Generation of a triage code
600 0. 0 0 0 3 'triage code' 'generated' ' '

:Other event
605 0. 0 0 0 3 'other event' 'other filter' ' '

<u>Violent Event Filter</u>
:Analysis start
1 0. 0. 400 0 3 'analysis start' ' ' ' '

:Is the event a violent one?
400 0.2 0. 605 401 3 'violent event filter' 'no' 'yes'

:Is the violent event a beating?
401 0.25 0. 402 13 3 'beating' 'no' 'yes'

:Is the violent event caused by a hand weapon?
402 0.25 0. 403 13 3 'hand weapon' 'no' 'yes'

:Is the violent event caused by a gun?
403 0.25 0. 404 13 3 'gun' 'no' 'yes'
16 404 0 0

:Is the violent event a self-harm?
404 0.25 0. 13 13 3 'self-harm' 'no' 'yes'

:Is any health information available?
13 0.5 0. 15 65 3 'health information' 'available' 'not available'

:Is the state of consciousness known?
15 0.25 0. 20 30 3 'consciousness' 'known' 'not known'

:Is the state of consciousness just altered?
20 0.25 0. 25 30 3 'altered consciousness' 'no' 'yes'

:Does the patient respond?
25 0.25 0. 27 30 3 'patient responds' 'no' 'yes'
16 27 0 0

:Is the patient unconscious?
27 0.25 0. 30 30 3 'patient unconscious' 'no' 'yes'

:Is any information about the breath available??
30 0.25 0. 35 45 3 'breath status' ' known' 'not known'

:Does the patient breathe?
35 0.25 0. 40 45 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
40 0.25 0. 42 45 3 'normal breath' 'no' 'yes'
16 42 0 0

:Does the patient breathe difficultly?
42 0.25 0. 45 45 3 'difficult breath' 'no' 'yes'

:Is the patient bleeding?
45 0.5 0. 50 50 3 'bleeding' 'no' yes'

:Is the patient restless?
50 0.5 0. 55 55 3 'restless' 'no' yes'

:Does the patient vomit?

55 0.5 0. 60 60 3 'vomit' 'no' yes'

:Does the injury involve head/face?

60 0.5 0. 65 65 3 'head/face injured' 'no' yes'

:Has the 118 been called immediately after the event?

65 0.5 0. 600 600 3 'emergency call(118)' 'immediately' 'differed'

:Generation of a triage code

600 0. 0 0 0 3 'triage code' 'generated' ' '

:Other event

605 0. 0 0 0 3 'other event' 'other filter' ' '

Other Event Filter

:Analysis start

1 0. 0. 405 0 3 'analysis start' ' ' ' '

:Is the event part of the 'other event' filter?

405 0.2 0. 605 406 3 'other event filter' 'no' 'yes'

:Is the event an intoxication?

406 0.25 0. 407 13 3 'intoxication filter' 'no' 'yes'

:Is the event cause by an animal?

407 0.25 0. 408 13 3 'animal injury filter' 'no' 'yes'

:Is the injury different from the one cited?

408 0.25 0. 409 13 3 'other modality' 'no' 'yes'

16 409 0 0

:Is the event a major event?

409 0.5 0. 13 13 3 'major event filter' 'no' 'yes'

:Is any health information available?

13 0.5 0. 15 65 3 'health information' 'available' 'not available'

:Is the state of consciousness known?
15 0.25 0. 20 30 3 'consciousness' 'known' 'not known'

:Is the state of consciousness just altered?
20 0.25 0. 25 30 3 'altered consciousness' 'no' 'yes'

:Does the patient respond?
25 0.25 0. 27 30 3 'patient responds' 'no' 'yes'
16 27 0 0

:Is the patient unconscious?
27 0.25 0. 30 30 3 'patient unconscious' 'no' 'yes'

:Is any information about the breath available??
30 0.25 0. 35 45 3 'breath status' ' known' 'not known'

:Does the patient breathe?
35 0.25 0. 40 45 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
40 0.25 0. 42 45 3 'normal breath' 'no' 'yes'
16 42 0 0

:Does the patient breathe difficultly?
42 0.25 0. 45 45 3 'difficult breath' 'no' 'yes'

:Is the patient bleeding?
45 0.5 0. 50 50 3 'bleeding' 'no' yes'

:Is the patient restless?
50 0.5 0. 55 55 3 'restless' 'no' yes'

:Does the patient vomit?
55 0.5 0. 60 60 3 'vomit' 'no' yes'

:Does the injury involve head/face?
60 0.5 0. 65 65 3 'head/face injured' 'no' yes'

```
:Has the 118 been called immediately after the event?
65 0.5 0. 600 600 3 'emergency call(118)' 'immediately' 'differed'

:Generation of a triage code
600 0. 0 0 0 3 'triage code' 'generated' ' '

:Other event
605 0. 0 0 0 3 'other event' 'other filter' ' '
```

The represented file allows an operative analysis of the filter, but must be associated to a consequences file, in order to complete the analysis with the question weights.

5.2.2.2 Consequences file

The consequences file represents the answers’ weights and, as the input file, is divided into five parts, in order to represent separately the five different filters.

Each weight reported in the algorithm has been directly inserted into ALBA code.

The weights are included between zero and six-hundreds.

Another important problem were the negative weights linked to some answers: the FLAGS allows to delate this kind of problem , allow using only positive values

Each different consequences file is characterized by the presence of FLAG 1: this FLAG represents a differed incoming emergency call. This condition is associated to a negative weight and is present in every filter’s typology.

The consequences file is available below, divided as the input file:

<u>Fall filter</u>

```
IF (K1.EQ.13.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.15.AND.K2.EQ.2)    XDT = XDT+XC(150)
IF (K1.EQ.20.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.27.AND.K2.EQ.2)    XDT = XDT+XC(400)
IF (K1.EQ.30.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.35.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.42.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.45.AND.K2.EQ.2)    XDT = XDT+XC(100)
```

```
IF (K1.EQ.50.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.55.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.60.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.65.AND.K2.EQ.2) FL(1)=.TRUE.

IF (K1.EQ.7.AND.K2.EQ.2) THEN
XDT = XDT+XC(150)
ELSE IF (K1.EQ.7.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(50)
ENDIF

IF (K1.EQ.9.AND.K2.EQ.2) THEN
XDT = XDT+XC(100)
ELSE IF (K1.EQ.9.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(0)
ENDIF

IF (K1.EQ.10.AND.K2.EQ.2) THEN
XDT = XDT+XC(150)
ELSE IF (K1.EQ.10.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(50)
ENDIF

IF (K1.EQ.11.AND.K2.EQ.1)    XDT = XDT+XC(350)
IF (K1.EQ.11.AND.K2.EQ.2)    XDT = XDT+XC(50)
```

<u>Road accident filter</u>

```
IF (K1.EQ.45.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.50.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.55.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.60.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.65.AND.K2.EQ.2) FL(1)=.TRUE.



IF (K1.EQ.234.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.236.AND.K2.EQ.2)    XDT = XDT+XC(150)
```

```
IF (K1.EQ.238.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.242.AND.K2.EQ.2)    XDT = XDT+XC(600)
IF (K1.EQ.244.AND.K2.EQ.2)    XDT = XDT+XC(150)
IF (K1.EQ.245.AND.K2.EQ.2)    XDT = XDT+XC(300)
IF (K1.EQ.247.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.226.AND.K2.EQ.1)    XDT = XDT+XC(300)
IF (K1.EQ.230.AND.K2.EQ.1)    XDT = XDT+XC(300)
IF (K1.EQ.232.AND.K2.EQ.1)    XDT = XDT+XC(300)
IF (K1.EQ.252.AND.K2.EQ.1)    XDT = XDT+XC(300)
IF (K1.EQ.253.AND.K2.EQ.1)    XDT = XDT+XC(300)
IF (K1.EQ.254.AND.K2.EQ.1)    XDT = XDT+XC(300)
IF (K1.EQ.255.AND.K2.EQ.1)    XDT = XDT+XC(300)
IF (K1.EQ.256.AND.K2.EQ.1)    XDT = XDT+XC(200)

IF (K1.EQ.222.AND.K2.EQ.2) THEN
XDT = XDT+XC(200)
ELSE IF (K1.EQ.222.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(100)
ENDIF

IF (K1.EQ.224.AND.K2.EQ.2) THEN
XDT = XDT+XC(200)
ELSE IF (K1.EQ.224.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(100)
ENDIF

IF (K1.EQ.225.AND.K2.EQ.2) THEN
XDT = XDT+XC(200)
ELSE IF (K1.EQ.225.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(100)
ENDIF

IF (K1.EQ.250.AND.K2.EQ.2) THEN
XDT = XDT+XC(100)
ELSE IF (K1.EQ.250.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(0)
ENDIF
```

<u>Accident Filter</u>

```
 IF (K1.EQ.13.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.15.AND.K2.EQ.2)    XDT = XDT+XC(150)
IF (K1.EQ.20.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.27.AND.K2.EQ.2)    XDT = XDT+XC(400)
IF (K1.EQ.30.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.35.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.42.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.45.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.50.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.55.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.60.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.65.AND.K2.EQ.2) FL(1)=.TRUE.

IF (K1.EQ.272.AND.K2.EQ.2.) THEN
XDT = XDT+XC(100)
ELSE IF (K1.EQ.272.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(0)
ENDIF

IF (K1.EQ.274.AND.K2.EQ.2.) THEN
XDT = XDT+XC(50)
ELSE IF (K1.EQ.274.AND.K2.EQ.2.AND.FL(1)) THEN
XDT=XDT+XC(-50)
ENDIF

IF (K1.EQ.276.AND.K2.EQ.2.) THEN
XDT = XDT+XC(50)
ELSE IF (K1.EQ.276.AND.K2.EQ.2.AND.FL(1)) THEN
XDT=XDT+XC(-50)
ENDIF



IF (K1.EQ.320.AND.K2.EQ.2.) THEN
XDT = XDT+XC(50)
```

```
ELSE IF (K1.EQ.320.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(-50)
ENDIF

IF (K1.EQ.322.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.324.AND.K2.EQ.2)    XDT = XDT+XC(350)
IF (K1.EQ.326.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.328.AND.K2.EQ.2)    XDT = XDT+XC(300)
IF (K1.EQ.330.AND.K2.EQ.2)    XDT = XDT+XC(300)
IF (K1.EQ.332.AND.K2.EQ.2)    XDT = XDT+XC(300)
IF (K1.EQ.334.AND.K2.EQ.2)    XDT = XDT+XC(300)

IF (K1.EQ.350.AND.K2.EQ.2)    FL(2)=.TRUE.

IF (K1.EQ.346.AND.K2.EQ.2.) THEN
XDT= XDT+XC(200)
ELSE IF (K1.EQ.346.AND.K2.EQ.2.AND.FL(1)) THEN
XDT= XDT+XC(100)
ENDIF

IF (K1.EQ.347.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.348.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.350.AND.K2.EQ.2)    XDT = XDT+XC(-100)
IF (K1.EQ.354.AND.K2.EQ.2)    XDT = XDT+XC(100)

IF (K1.EQ.376.AND.K2.EQ.2.) THEN
XDT=XDT+XC(200)
ELSE IF (K1.EQ.376.AND.K2.EQ.2.AND.FL(1)) THEN
XDT=XDT+XC(100)
ENDIF

IF (K1.EQ.379.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.380.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.378.AND.K2.EQ.2.)   XDT=  XDT+XC(-50)


IF (K1.EQ.396.AND.K2.EQ.2.) THEN
```

```
XDT = XDT+XC(400)
ELSE IF (K1.EQ.396.AND.K2.EQ.2.AND.FL(1)) THEN
XDT=XDT+XC(300)
ENDIF
```

<u>Violent event filter</u>

```
IF (K1.EQ.13.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.15.AND.K2.EQ.2)    XDT = XDT+XC(150)
IF (K1.EQ.20.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.27.AND.K2.EQ.2)    XDT = XDT+XC(400)
IF (K1.EQ.30.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.35.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.42.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.45.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.50.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.55.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.60.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.65.AND.K2.EQ.2) FL(1)=.TRUE.

IF (K1.EQ.401.AND.K2.EQ.2) THEN
XDT = XDT+XC(100)
ELSE IF (K1.EQ.401.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(0)
ENDIF

IF (K1.EQ.402.AND.K2.EQ.2) THEN
XDT = XDT+XC(250)
ELSE IF (K1.EQ.402.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(150)
ENDIF

IF (K1.EQ.403.AND.K2.EQ.2) THEN
XDT = XDT+XC(350)
ELSE IF (K1.EQ.403.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(250)
ENDIF
```

```
IF (K1.EQ.404.AND.K2.EQ.2) THEN
XDT = XDT+XC(200)
ELSE IF (K1.EQ.404.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(100)
ENDIF
```

Other event filter

```
IF (K1.EQ.13.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.15.AND.K2.EQ.2)    XDT = XDT+XC(150)
IF (K1.EQ.20.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.27.AND.K2.EQ.2)    XDT = XDT+XC(400)
IF (K1.EQ.30.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.35.AND.K2.EQ.2)    XDT = XDT+XC(200)
IF (K1.EQ.42.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.45.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.50.AND.K2.EQ.2)    XDT = XDT+XC(100)
IF (K1.EQ.55.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.60.AND.K2.EQ.2)    XDT = XDT+XC(50)
IF (K1.EQ.65.AND.K2.EQ.2) FL(1)=.TRUE.

IF (K1.EQ.406.AND.K2.EQ.2) THEN
XDT = XDT+XC(200)
ELSE IF (K1.EQ.406.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(100)
ENDIF

IF (K1.EQ.407.AND.K2.EQ.2) THEN
XDT = XDT+XC(50)
ELSE IF (K1.EQ.407.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(-50)
ENDIF

IF (K1.EQ.408.AND.K2.EQ.2) THEN
XDT = XDT+XC(250)
ELSE IF (K1.EQ.408.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(150)
ENDIF
```

```
IF (K1.EQ.409.AND.K2.EQ.2) THEN
XDT = XDT+XC(250)
ELSE IF (K1.EQ.409.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(150)
ENDIF
```

5.2.2.3 Results

This part will present the results obtained for the five distinct input file. First of all some basic data are reported in Table 17 .

Filter's typology	Constituents' number	Entropy	Residual probability
Fall filter	2057	2.29	/
Road accident filter	25011	2.87	$1.35 * 10^{-14}$
Accident filter	5669	2.46	/
Violent event filter	2057	2.27	$5.53 * 10^{-15}$
Other event filter	2057	2.22	/

Table 17: results of the filter's second resolution approach: number of constituents, entropy and residual probability values divided per filter's typology.

This data have been obtained using a cut of 10^{-12} , in fact the residual probability is low or equal to zero for each file.

The entropy values are not really useful, because we are not working on a risk analysis, but the objective is a filter's output classification.

In order to calculate the percentage value related to each triage colour, the CCDF, RDF and beans are fundamental. [Figure 31, Figure 30, Figure 29, Figure 32 and Figure 33]

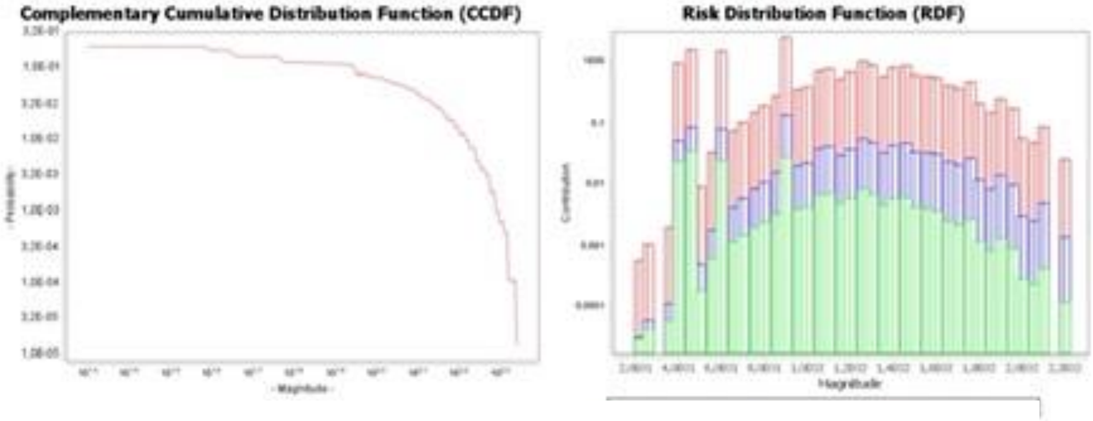


Figure 31: AREU filter’s second resolution approach: fall filter’s CCDF and RDF

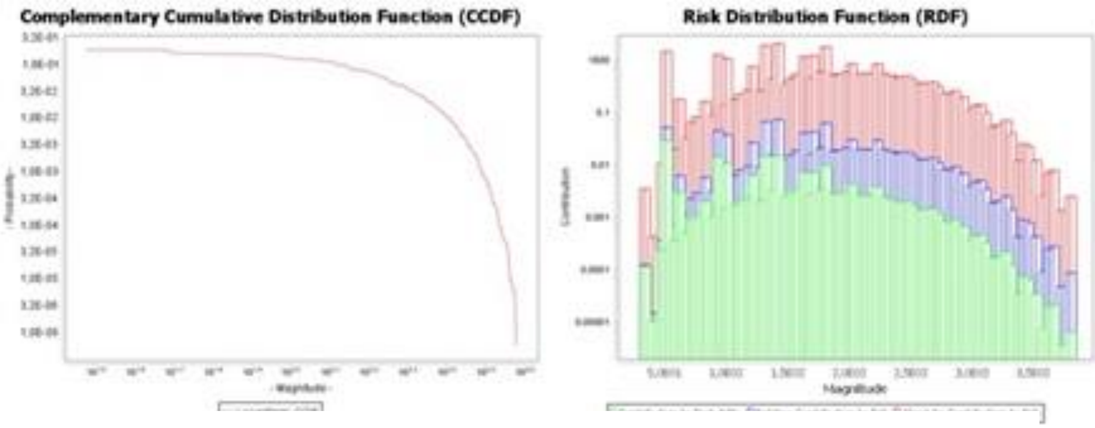


Figure 30: AREU filter’s second resolution approach: road accident filter’s CCDF and RDF

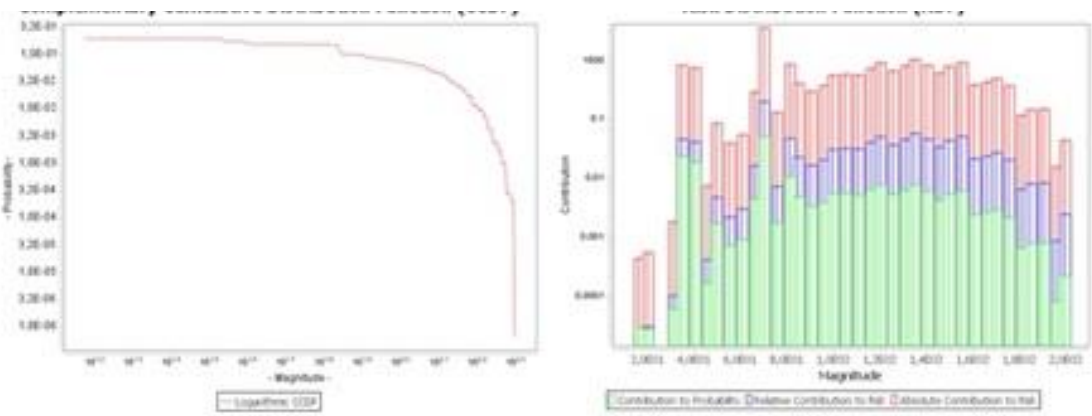


Figure 29: AREU filter’s second resolution approach: accident filter’s CCDF and RDF

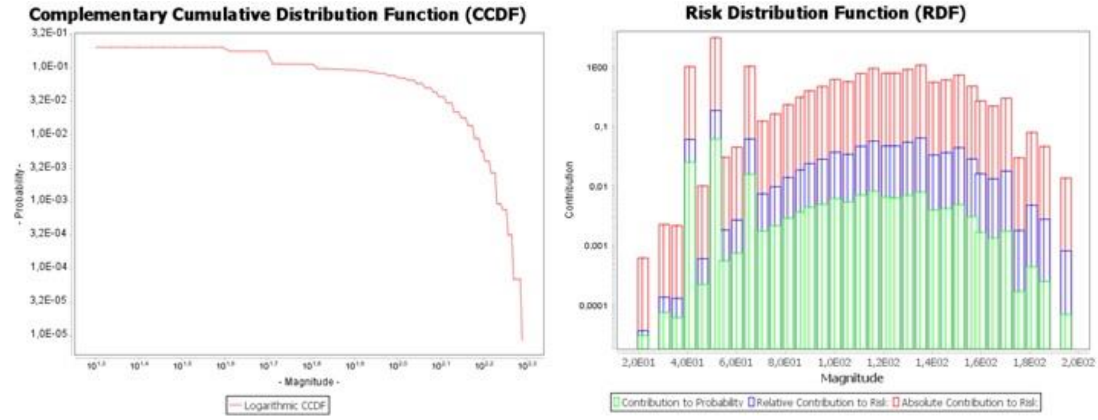


Figure 32: AREU filter's second resolution approach: violent event filter's CCDF and RDF

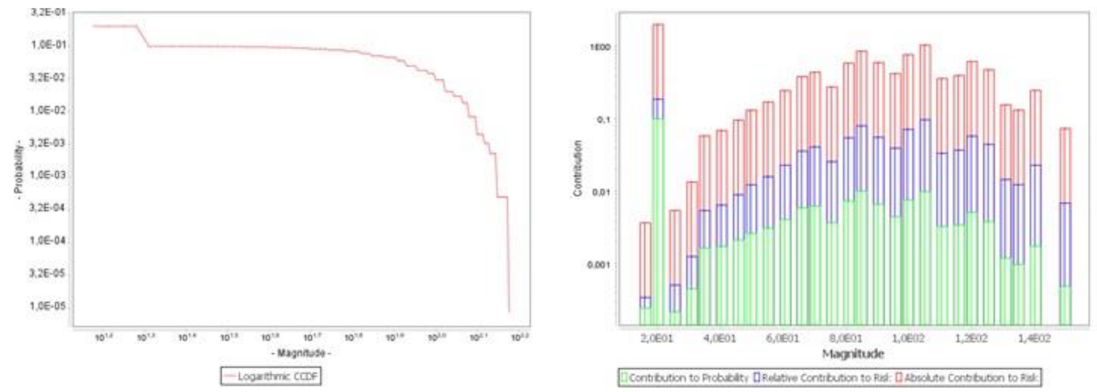


Figure 33: AREU filter's second resolution approach: other event filter's CCDF and RDF

In fact each triage code can be associated to a numerical gap [5.1-**Errore. L'origine riferimento non è stata trovata.**]: these numerical limits can be transformed using the formula presented for the weights calculation. By doing so, it is possible to associate each code to a specific area on the CCDF and RDF graphs.

In order to calculate the colour triage percentage the beans allow being more precise, giving the complexity of the RDF and CCFD graphs.

The obtained results are reported in Table 18

Triage colour	Fall filter	Road accident filter	Accident filter	Violent event filter	Other event filter
White [%]	0	0	11	0	0.10
Green [%]	11.25	0	14.50	12.50	9.50
Yellow [%]	8.10	1	37.50	46.50	44.50
Red [%]	80.65	99	37.00	41.00	45.90

Table 18: triage colour's percentage obtained with the second resolution approach for each filter's typology

This table is a picture of the actual possible outcome of the analysed filter: the red and yellow codes cover the majority of cases. This result was quite expected, given that we are working with traumatic events.

However this result is useless if not combined with a study of the more influent parameter in the generation of the over-triage.

As explained at the end of chapter one, this operational analysis should be useful for detect which impact parameters can be insert in a hypothetical new filter, or checklist, in the SOP3 evaluation path. In the next paragraphs, the actual data will be compared to the outcome of some sensibility analysis.

5.3 Parameters choice, starting from Niguarda's database

The Niguarda database comprehends 2843 cases, collected in six years work. In the first chapter [**Errore. L'origine riferimento non è stata trovata.**] are reported the over-triage percentage.

In this paragraph the objective is to analyse this percentage of cases, in order to identify which parameters are more common in the over-triaged patients.

This analysis will be performed especially on road accident cases: in fact, this is the only category associated to a large number of contextual not medical parameters.

Moreover the large majority of cases, precisely the 67.53% [Table 8], derived by a road accident and the over-triage connected to this typology of event is 31%, i.e. considering the number of patient dismissed before a real hospitalization [1.3-Table 9].

The parameters scheduled into the database are divided considering of the vehicle involved, so there are four different parameters category. Some of these parameters are aggravating, whether other one concern life saver expedients. In Table 19 is possible to comprehend the role of each accident typology in the generation of the over-triage. In order to quantify its value, only yellow and red codes, associated to an ISS<15, have been considered.

Road Accident Typology	Number of cases	Yellow Codes		Yellow codes with ISS< 15	
Pedestrian	453	353	77.92%	245	54.08%
Cyclist	186	143	76.88%	104	55.91%
Motorcyclist	762	587	77.03%	429	56.30%
Vehicle	514	143	80.35%	352	68.48%

Table 19: Over-triage's percentage obtained by the database analysis, considering the ISS values. The analysis is referred to the different road accident’s scheduled typologies.

The importance’s classification of each parameter has been performed following the same modality presented for the accident typology. The results are reported in the following .

Twelve of these parameters, more than a half, are referred to over-triage case. This means that these parameters should be studied, in particular it’s important to understand how they affect the outcomes of the AREU filter.

However, not all this parameters are considered in the filter, some of them are considered only in a posteriori analysis. This sensitivity analysis will also regard the addition of some question, concerning these parameters, in the AREU filter.

This process will underline the importance of some parameters already present in the filter, but also the importance of those that are not considered.

Pedestrian	Number of cases	Red and yellow codes with ISS<15	
Thrown	267	140	52.43%
Over-ran	79	32	40.51%
Charged on vehicle	103	49	47.57%

Cyclist	Number of cases	Red and yellow codes with ISS<15	
With helmet	8	5	62.5%
Helmet lost in the impact	1	1	100%
Over-ran	4	0	0%
Thrown	55	36	65.45%
No accident	42	29	69.05%

Motorcycle	Number of case	Red and yellow codes with ISS<15	
With helmet	764	425	56.97%
Helmet lost in the impact	74	32	43.24%
No accident	31	25	80.64%
Over-ran	16	8	50%
High velocity	390	180	46.15%
Thrown	567	309	54.50%

Vehicle	Number of cases	Red and yellow codes with ISS<15	
With safety belt	317	237	74.76%
Ejection	41	18	43.90%
Extrication> 20 min	125	61	48.8%
Dead person on board	19	7	36.84%
Cabin deformed	210	121	57.61%
High velocity	301	191	63.45%
Overturning	104	79	75.96%

Table 20: over-triage's percentage calculated for each aggravating or life-saver parameters present in the Niguarda's database. The values major than 70% are coloured in red, whether the green ones represent the percentage >50%.

5.4 Sensitivity analysis

The sensitivity analysis is performed by changing the consequences file associated to the road accident input.

The first attempt are conducted without changing the consequences file structure, but only reducing the weight associated to some parameters. The parameters already present in the filter but also significant for the over-triage generation are: vehicle overturning and patient thrown due to the impact, both for cyclist, motorcyclist and pedestrian.

In order to see the impact of these parameters in the triage colours percentages, their value has been reduced following two steps. The results are reported in the Table 21.

Attempt's name	Red codes	Yellow codes	Green codes
Basic input	99%	1%	0.0%
Weights' change 1	81.50%	17.50%	1%
Weights' change 2	79.50%	19.50%	1%
Parameters addition	80.96%	19%	0.04%
Parameters addition + weights' change 2	79.50%	18.63%	1.83%

Table 21: triage codes percentage. In the first row are reposted the real actual values, whether the second and third line regard the reduction of some parameters already present in the filter. In line four are presented the results coming by adding some new levels, containing some new parameters. The last row reports a combination of reduction of present parameters and the addiction of some new ones.

The weights reduction is proportional to the over-triage percentage linked to each parameter. In particular, the projection has been associated to a reduction of 30% in first change approach and of 50% in the second consequences file. The car over-turning has been firstly reduced of the 40%, whether in the second consequences file its reduction was of the 70%. The choice of this reduction percentage is aleatory: it is useful only to demonstrate that a change in the weights can lead to a reduction of the red codes percentage.

Another strategy was to insert some other parameters that can be easily evaluated by a layman on the scene, than could decrease the global weight of some stories. In this case, the parameters are related to safety device, as safety belt or helmet: in the parameters analysis the presence of this safety device is related to a high percentage of over-triage. This information means that they are really effective in preventing the user from severe traumas. For this reason they should be considered in a preliminary evaluation of the patient, but they can also be recalled in the hypothetical SOP3 filter. The presence of a safety helmet reduces the patient weights of 80 point, whether the safety belt lead to a reduction of 100 points.

Another addiction to the input file is inherent to the vehicle deformation caused by the impact. This parameter is not considered in the SOP1 filter, but can be useful information once the patient arrives at the hospital.

This parameter can't be associated to a negative weight, but an evaluation of the deformation of the vehicle can be useful, especially in SOP3 evaluation, where the extrication time should also be considered, so it is associated to a little weight, i.e. 50.

The new input file is reported below:

```
 :Analysis start
1 0. 0. 220 0 3 'analysis start' ' ' ' '

:Is the event a road accident?
220 0.2 0. 605 222 3 'road accident filter' 'no' 'yes'

:Is the typology of the road accident known?
222 0.25 0. 224 234 3 'accident typology' 'known' 'not known'

:Does the accident involve a pedestrian?
224 0.25 0. 225 226 3 'pedestrian involved' 'no' 'yes'
2 234 234 232 232

:Does the accident involve a motorcyclist/cyclist?
225 0.25 0. 250 226 3 'mcy/cy involved' 'no' 'yes'
16 250 0 0

:Has the patient been crushed?
226 0.5 0. 230 230 3 'cy/mcy/ped crushed' 'yes' 'no'

:Has the patient been rolled over?
230 0.5 0. 232 232 3 'pat. overolled' 'yes' 'no'

:Has the pedestrian/cyclist been thrown?
232 0.5 0. 233 233 3 'cy/mcy/ped thrown' 'yes' 'no'

:Did the cyclyst/motorcyclist wear an helmet?
233 0.5 0. 235 235 3 'helmet on' 'yes' 'no'

:Did the cyclist/motorcyclist fall without be involved in an accident?
235 0.5 0. 234 234 3 'cy/mcy accident' 'yes' 'no'
```

:Does the accident involve a vehicle?
250 0.25 0. 251 251 3 'vehicle involved' 'no' 'yes'

:Did the patient wear the a safety belt?
251 0.5 0. 252 252 3 'safety belt' 'yes' 'no'

:Is the patient stuck in the vehicle?
252 0.5 0. 253 253 3 'patient stuck' 'yes' 'no'

:Does the accident involve a heavy goods vehicle?
253 0.5 0. 254 254 3 'hv involved' 'yes' 'no'

:Does the vehicle overturn because of the accident?
254 0.5 0. 255 255 3 'vehicle overturned' ''yes' 'no'

:Is the vehicle's cabin deformed due to the impact?
255 0.5 0. 256 256 3 'cabin deformed' 'yes' 'no'

:Is there any other impact indicator?(ex. death person on board)
258 0.5 0. 259 259 3 'other indicators' 'yes' 'no'

:Has the patient been thrown outside the vehicle?
259 0.5 0. 234 234 3 'thrown out of vehicle 'yes' 'no'

:Is any health information available?
234 0.5 0. 236 65 3 'health information' 'yes' 'no'

:Is the state of consciousness known?
236 0.25 0. 238 244 3 'consciousness' 'known' 'not known'

:Is the state of consciousness just altered?
238 0.25 0. 240 244 3 'altered consciousness' 'no' 'yes'

:Does the patient respond?
240 0.25 0. 242 244 3 'patient responds' 'no' 'yes'
16 242 0 0

:Is the patient unconscious?
242 0.25 0. 244 244 3 'patient unconscious ' 'no' 'yes'

:Is any information about the breath available??
244 0.25 0. 245 45 3 'breath status' ' known' 'not known'

:Does the patient breathe?
245 0.25 0. 246 45 3 'patient breath' 'present' 'absent'

:Does the patient breathe normally?
246 0.25 0. 247 45 3 'normal breath' 'no' 'yes'
16 42 0 0

:Does the patient breathe difficultly?
247 0.25 0. 45 45 3 'difficult breath' 'no' 'yes'

:Is the patient bleeding?
45 0.5 0. 50 50 3 'bleeding' 'no' yes'

```
:Is the patient restless?
50 0.5 0. 55 55 3 'restless' 'no' yes'

:Does the patient vomit?
55 0.5 0. 60 60 3 'vomit' 'no' yes'

:Does the injury involve head/face?
60 0.5 0. 65 65 3 'head/face injured' 'no' yes'

:Has the 118 been called immediately after the event?
65 0.5 0. 600 600 3 'emergency call(118)' 'immediately' 'differed'

:Generation of a triage code
600 0. 0 0 0 3 'triage code' 'generated' ' '

:Other event
605 0. 0 0 0 3 'other event' 'other filter' ' '
```

	Number of Constituents	Entropy	Residual probability
Parameters Addition	54926	2.94	0

Table 22: number of constituents, entropy and residual probability obtained after a simulation with parameters addition

This input file is used for the evaluation of the variation of outcomes percentages obtained only with the addition of new levels, but also combining the second weights change and the addition effects.

The results obtained from this two analysis are reported in Table 22.

These strategies allow reducing the red codes percentage of the 20 %. A more effective reduction is not possible, because of the presence of the medical interview: in fact, in case of road accident, the weights associate to all the medical data are higher than in other cases. This filter structure allows being conservative in the filter patients’ evaluation, even if the contextual parameters are not available or if they have been strongly reduced.

By combining the two proposed approaches, i.e. the parameters change and the addition of safety instruments, the reduction of potential over-triage doesn’t change with respect to the single approaches results. This behavior depends again on the medical part of the filter.

In conclusion it is important to consider than this reduction concerns only the road accident filter. However it could be useful considering the starting percentage values associated of this typology of event, i.e. 99% of red codes, is a really conservative assumption, hypothesis confirmed by the database data. By improving this part of the filter is possible to obtain a good reduction of the overall process over-triage.

Another important conclusion is that this parameters and operational analysis could be useful in the creation of an additional SOP3 filter: the analysis of the database helps in the selection of the most important parameters in the generation of the over-triage that should be reconsidered by SOP3, whether the operational analysis could be useful in the new algorithm building process.

Chapter 6.
CONCLUSIONS: SOLUTIONS EVALUATION AND FUTURE POSSIBLE DEVELOPMENT

The analysis conduct on the whole process and on SOP1 filter have underlined that it is possible to reduce the over-triage percentage.

The first available strategy could be the insertion of a SOP3 filter or checklist in order to reduce the subjective approach, typical of a human being.

The SOP3 filter, or checklist, should be based on some medical parameters that can be evaluated on the event scene. These medical parameters are already collect by the doctors or by the volunteers. In order to be sure that all the parameters are correctly evaluated, they should be register into the filter, so that a machine can calculate the status of the patient and help the doctor to decide the best destination hospital.

Another possibility is to select the necessary medical parameters and their associate importance starting from the RTS, i.e. Revised Trauma Score [III].

The RTS is a physiological score that can be helpful in the evaluation of major traumas. This scoring method considers respiratory rate, systolic blood pressure and GCS. Each evaluated category is associated to a score included between zero and four [Table 23]. The sum of the three values indicates the severity of the patient: the lower the value, the more severe ore the patient’s condition.

An RTS major than eleven can be considered as a major trauma. This evaluating methodology doesn’t request a deep medical analysis, it is based only on simple parameters that can be collected also is the ALS is not present on the scene.

GCS		SBP		RR	
Calculated values	RTS value	Calculated values	RTS value	Calculated values	RTS value
13-15	4	>89	4	>29	4
9-12	3	76-89	3	10-29	3
6-8	2	50-75	2	6-9	2
4-5	1	1-49	1	1-5	1
3	0	0	0	0	0

Table 23: description of scores associated to GCS, SBP, and RR for the evaluation of RTS

The difference between a hypothetical filter and a hypothetical checklist is that the filter can also consider the parameters values, giving a more precise idea of the gravity of the patient. The checklist can only evaluate the presence and the absence of the various values.

If the decision maker would decide to invest on the construction of a SOP3 filter, it would be necessary to conduct a study in order to associate to each parameter a weight, or to conduct an evaluation based on the RTS. Each medical data would be associate to different weights, in function its value: the more the parameters indicates a severe state of the patient, the higher the associated weight.

This expedient would allow constructing an algorithm similar to one already present in SOP1, capable to produce a triage code for each patient. The outcome could be associated to a colour code, but also to the trauma centre level suitable for the patient’s treatment. In this case it would necessary to decide how to distribute the various weights values within PSTs, CTZs and CTSs.

The PST can approximately be associate to the green codes, whether the CTZ to the yellow one and the CTS to the red one. Sometimes, as said in chapter one, the yellow code can be treated in a CTS, so the filter can also evaluate the presence of the condition already listed [Table 3] that allows the transport of a yellow code patient to a CTS.

This solution would help the SOP3 in the individuation of the correct hospital destination. Obviously, the SOP3 personnel would maintain the ultima decision about each patient; the filter mechanism would only suggest the best hospital typology.

This choice is based on the fact that the filter should be synthetic and easy to complete, based only on main medical data and on some contextual parameters: the filter would not be able to evaluate other additional information that can be collect on the scene.

On the contrary, the personnel, starting from the filter outcome, can modify the hospital level evaluating the additional incoming information.

In conclusion, the SOP3 should be improved by adding a filter, based on the algorithm already existent for the SOP1, able to evaluate some basic medical and contextual data, in order to propose the most suitable hospital level. The filter would only assist the personnel in its choice, in order to reduce the precautionary human factor in the evaluation of a patient's condition severity.

This solution would reduce the percentage of first and third critical components, both regarding the SOP3 [**Errore. L'origine riferimento non è stata trovata.**]. The second point is: which contextual parameters should be inserted in SOP3 filter?

The database reports a large list of contextual parameters. Some of them are already considerate in the SOP1 filter, but other ones can't be evaluated by a layman.

The educated personnel on the scene should evaluate these parameters [Table 24], in order to give the SOP3 this important information. The weights associated to these parameters should be calculated considering also their relationship with the over-triage generation.

A layman during an emergency call cannot be able to evaluate these parameters, especially the extrication time, which assumes the present of firemen on the scene.

The ALS or BLS personnel have competences and time to collect this information on the scene, so they can be referred to SOP3.

Cyclist/Motorcyclist	Vehicle
Fall without previous impact	Extrication time > 20 min
Helmet lost in the impact	Dead person in same vehicle
	Cabin deformed
	High velocity

Table 24: contextual parameters not considered in SOP1 filter

The new filter could also involve some parameters already insert in SOP1 algorithm. This modify would be useful to improve the SOP3 evaluation, but would also help to reduce the error caused by the filter itself and by its incorrect filling, i.e. the second highlight critical component.

In fact the only way to reduce this risk is to work on the filter structure or on the following passages. The SOP1 is the first step of the emergency evaluation: this could be an advantage for the process improvement. In an event chain each passage can correct the error made by the previous one: for this reason SOP3 modifications are enough to reduce also the SOP1 contribution to the overall over-triage. Moreover the generation of an over-triage in SOP1 increases the number of ALS send on the scene: obviously, the presence of a doctor in the emergency phases reduces the probability to have an incorrect patient's condition evaluation. In other word, the SOP1 over-triage can lead to a more objective and complete analysis of the event: this means that the SOP3 can take a decision based on more confident data.

In order to improve this reduction effect, the new filter can contain also the more influence parameters. The sensitivity analysis has underline which contextual information is more involved in the over-triage creation: this information can be further evaluated, together with some medical data.

This solution would prevent the formation of an excessive over-triage. In fact, the sensitivity analysis has underlined that a reduction of some parameters weights can't cause a satisfying reduction of the red and yellow codes percentage, i.e. of the over-triage. By recalling these parameters in the last part of the emergency management process, i.e. SOP3, its role in the over-triage generation would be reduced.

However, SOP1 filter can also be modified: the sensitivity analysis shows that the addiction of some levels and the changes of some weights can reduce the red and yellow codes percentage. In particular by evaluating the presence of some life-saving instruments, i.e. the helmet and the safety belt, reduces the numerical values associate to the involved stories percentages.

It is possible to analyse the new hypothetical process with ALBA, in order to evaluate the potential reduction of over-triage by applying both a change in the Sop1 filter structure and an addiction of an evaluation algorithm in SOP3.

The input file has been modified, together with the consequences one, in order to insert the presented solutions.

The input and consequences files are reported below:

<u>Input file</u>

```
:Analysis Start
5 0. 0. 10 10 3 "Analysis" "Start" "--"

:Is the filter correctly compiled?
10 0.2 0. 48 15 3 "Filter compilation " "correct" "incorrect"

:What kind of error does the operator?
15 0.3 0. 20 35 3 "Error type" "Psychomotor" "Cognitive"

:Is the error caused by an external Distraction?
20 0.33 0. 25 48 3 "Distraction " "No" "Yes"

:Is the error caused by tiredness?
25 0.33 0. 30 48 3 "Tiredness" "No " "yes"
16 30 0. 0.

:Is the error caused by posture?
30 0.33 0. 48 48 3 "incorrect posture" "No" "Yes"

:Is the error caused by lapsus?
35 0.33 0. 40 48 3 "Lapsus" "No" "Yes"

:Is the error caused by lack of knowledge?
40 0.33 0. 45 48 3 "Lack of knowledge" "No" "Yes"
16 45 0. 0.
```

:Is the error caused by a misinterpretation?
45 0.33 0. 48 48 3 "Misinterpretation" "No" "Yes"

:Does the filter correctly calculate the triage code?
48 0.06 0. 50 49 3 "filter triage code" "correct " "incorrect"

:Is the error caused by the filter's structure (weight and question's chain)?
49 0.0001 0. 50 50 3 "filter error" "structure" "calculation"

:Does the operators consider instantaneous activation criteria?
50 0.80 0. 110 55 3 "Activation criteria" "Detected" "Undetected"
15 110 0. 0.

:Are the criteria really present?
55 0.2 0. 75 60 3 "Criteria" "Not Present" "Present"

:Is the error caused by a lack of knowledge?
60 0.33 0. 65 75 3 "Lack of knowledge" "No" "Yes"

:Is the error caused by a memory fail?
65 0.33 0. 70 75 3 "Memory fail" "No" "Yes"
16 70 0. 0.

:Is the error caused by distraction?
70 0.33 0. 75 75 3 "Distraction " "No" "Yes"

:Does the operators consider the revaluation criteria?
75 0.7 0. 110 80 3 "Revaluation criteria" "Detected" "Undetected"
10 110 0.80 0.

:Are the revaluation criteria really present?
80 0.2 0. 100 85 3 "Criteria" "Not Present" "Present"

:Is the error caused by a lack of knowledge?
85 0.33 0. 90 100 3 "Lack of knowledge" "No" "Yes"

:Is the error caused by memory fail?
90 0.33 0. 95 100 3 "Memory fail" "No" "Yes"
16 95 0. 0.

:Is the error caused by distraction?
95 0.33 0. 100 100 3 "Distraction " "No" "Yes"

:Is the revaluation forced by doctor?
100 0.95 0. 110 105 3 "Forced by doctor" "Yes" "No"
10 110 0.80 0.

:Is the revaluation forced by operator?
105 0.9 0. 110 110 3 "Forced by Operator" "Yes" "No"
10 110 0.80 0.

:Is the MSA sent on the scene?
110 0.95 0. 120 120 3 "MSA" "Sent" "Not Sent"
15 185 0. 0.
2 255 255 225 225
10 125 0.025 0.
10 145 0.025 0.
10 165 0.025 0.
10 190 0.05 0.
10 205 0.025 0.
10 260 0.01 0.
20 270 0.4 0.
20 305 0.4 0.

:SERVICE LEVEL
120 0. 0. 125 125 3 "Evaluation Start" "Personnel on scene" "---"

:Is the temperature correctly detect?
125 0.05 0. 145 130 3 "Temperature" "Correct" "Incorrect"
20 225 0.2 0.

:Is the error caused by a reading error?
130 0.80 0. 135 145 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
135 0.15 0. 140 145 3 "Instruments Usage" "Correct" "Incorrect"
16 140 0. 0.

:Is the error caused by the instrument itself?
140 0.05 0. 145 145 3 "Instrument" "Work" "Fault"

:Is the blood pressure correctly detect?
145 0.05 0. 165 150 3 "Blood pressure" "Correct" "Incorrect"
20 225 0.4 0.

:Is the error caused by a reading error?
150 0.80 0. 155 165 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
155 0.15 0. 160 165 3 "Instruments Usage" "Correct" "Incorrect"
16 160 0. 0.

:Is the error caused by the instrument itself?
160 0.05 0. 165 165 3 "Instrument" "Work" "Fault"

:Is the oximetry correctly detect?
165 0.05 0. 185 170 3 "Oximetry" "Correct" "Incorrect"
20 225 0.4 0.

:Is the error caused by a reading error?
170 0.80 0. 175 185 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
175 0.15 0. 180 185 3 "Instruments Usage" "Correct" "Incorrect"
16 180 0. 0.

:Is the error caused by the instrument itself?

180 0.05 0. 185 185 3 "Instrument" "Work" "Fault"

:Is the ultrasound present on the available vehicle?
185 0.75 0. 190 205 3 "Ultrasound" "Present" "Missing"

:Is the ultrasound analysis correctly performed?
190 0.1 0. 205 195 3 "Ultrasound" "Correct" "Incorrect"
20 225 0.5 0.

:Is the error caused by a reading error?
195 0.70 0. 200 205 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instrument usage?
200 0.25 0. 204 205 3 "Instrument usage" "Correct" "Incorrect"
16 204 0. 0.

:Is the error caused by the instrument itself?
204 0.05 0. 205 205 3 "Instrument" "Work" "Fault"

:Is the ECG exam correctly performed?
205 0.05 0. 225 210 3 "ECG" "Correct" "Incorrect"
20 225 0.6 0.

:Is the error caused by a reading error?
210 0.05 0. 215 225 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
215 0.90 0. 220 225 3 "Instruments Usage" "Correct" "Incorrect"
16 220 0. 0.

:Is the error caused by the instrument itself?
220 0.05 0. 225 225 3 "Instrument" "Work" "Fault"

:What is the global information quality?
225 0.02 0. 230 230 3 "Information quality" "Good" "Low"

20 245 0.4 0.
20 280 0.4 0.

:What is the doctor approach on patient's evaluation?
230 0.2 0. 240 235 3 "DOC Approach" "Objective" "Precautionary"
24 245 0. 0.

:Why is the DOC's approach precautionary?
235 0.5 0. 245 245 3 "DOC Why precautionary" "Legitimate worry" "Legal Protection "

:Does the DOC commit a cognitive error?
240 0.01 0. 245 245 3 "DOC Cognitive Error" "No" "Yes"
24 245 0. 0.

:Is the DOC's global evaluation correct?
245 0. 0. 255 255 3 "DOC Doctor Evaluation" "Correct" "Wrong"
20 280 0.70 0.

:SERVICE LEVEL
255 0. 0. 260 260 3 "SOP 3 Start" "data collection" "---"

:Is the communication with the scene possible?
260 0.05 0. 270 265 3 "Communication" "OK" "Error"
24 290 0. 0.

:What is the typology of performed error?
265 0.95 0. 290 290 3 "SOP3 Error type" "Fault" "Comprehension"

:What is the SOP3's approach on patient's evaluation?
270 0.2 0. 280 275 3 "SOP3 Approach" "Objective" "Precautionary"
24 290 0. 0.

:Why is the SOP3's approach precautionary?
275 0.5 0. 290 290 3 "SOP3Why Precautionary?" "Legitimate worry" "Legal Protection "

:Is there an evaluation error?
280 0.1 0. 290 285 3 "SOP3 Evaluation error" "No" "Yes"
24 290 0. 0.

:Where does the error come from?
285 0.9 0. 290 290 3 "SOP3 Source of error" "Information" "Wrong diagnosis"

:What is the global level of the SOP3's evaluation?
290 0 0. 295 295 3 "SOP3 Evaluation" "Correct" "Not Correct"
15 300 0. 0.
26 300 0. 0.

:SERVICE LEVEL
295 0 0. 300 300 3 "Hospital Choice" "-------" "---"

:Is the patient's condition correctly estimate?
300 0.1 0. 301 999 3 "Patient" "Correctly estimated" "Overestimated"
26 999 0. 0.

:Does the filter correctly calculate the triage code?
301 0.06 0. 304 302 3 "filter triage code" "correct " "incorrect"

:Does the filter's structure (weight and question's chain)?
302 0.0001 0. 304 304 3 "filter error" "structure" "calculation"

:Does the SOP3 consider the filter?
304 0.2 0. 305 305 3 'filter considered' 'yes' 'no'
2 305 0.2 0.

:What is the SOP3 approach in the final patient's condition estimation?
305 0.1 0. 315 310 3 "Approach" "Objective" "Precautionary"

:Why does the SOP3 overestimate patient's conditions?
310 0.5 0. 999 999 3 "Why precautionary?" "Legitimate worry" "Legal Protection"
26 999 0. 0.
16 999 0. 0.

:Does the SOP3 identify other structures for the patient's treatment?
315 0.05 0. 320 999 3 "Other structures" "Unidentified" "Identified"
26 999 0. 0.

:Why does the SOP3 use a precautionary approach?
320 0.05 0. 999 999 3 "Alternatives" "Unavailable" "Available"
15 999 0. 0.
26 999 0. 0.

:Over-triage
999 0. 0. 0 0 3 "Over-triage" "No" "Yes"

Consequences file

```
IF (K1.EQ.49.AND.K2.EQ.1)     XDT = XDT+XC(60)
IF (K1.EQ.49.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.15.AND.K2.EQ.2)     XDT = XDT+XC(10)
IF (k1.EQ.20.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.25.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.30.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.35.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.40.AND.K2.EQ.2)     XDT = XDT+XC(20)
```

```
IF (k1.EQ.45.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.60.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.65.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.70.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (k1.EQ.85.AND.K2.EQ.2)     XDT = XDT+XC(40)
IF (k1.EQ.90.AND.K2.EQ.2)     XDT = XDT+XC(40)
IF (k1.EQ.95.AND.K2.EQ.2)     XDT = XDT+XC(40)
IF (k1.EQ.110.AND.K2.EQ.2)    FL(1)= .TRUE.

IF (k1.EQ.130.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(7)
ELSE IF (k1.EQ.130.AND.K2.EQ.2)     THEN
XDT = XDT+XC(10)
ENDIF

IF (k1.EQ.135.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(7)
ELSE IF (k1.EQ.135.AND.K2.EQ.2)     THEN
XDT = XDT+XC(10)
ENDIF

IF (k1.EQ.140.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(7)
ELSE IF (k1.EQ.140.AND.K2.EQ.2)     THEN
XDT = XDT+XC(10)
ENDIF

IF (k1.EQ.150.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(10)
ELSE IF (k1.EQ.150.AND.K2.EQ.2)     THEN
XDT = XDT+XC(15)
ENDIF

IF (k1.EQ.155.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(10)
ELSE IF (k1.EQ.155.AND.K2.EQ.2)     THEN
XDT = XDT+XC(15)
ENDIF

IF (k1.EQ.160.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(10)
ELSE IF (k1.EQ.160.AND.K2.EQ.2)     THEN
XDT = XDT+XC(15)
ENDIF

IF (k1.EQ.170.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.170.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.175.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.175.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
```

```
ENDIF

IF (k1.EQ.180.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.180.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.195.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.195.AND.K2.EQ.2)     THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.200.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.200.AND.K2.EQ.2) THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.204.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(20)
ELSE IF (k1.EQ.204.AND.K2.EQ.2) THEN
XDT = XDT+XC(30)
ENDIF

IF (k1.EQ.210.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(34)
ELSE IF (k1.EQ.210.AND.K2.EQ.2)  THEN
XDT = XDT+XC(50)
ENDIF

IF (k1.EQ.215.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(34)
ELSE IF (k1.EQ.215.AND.K2.EQ.2) THEN
XDT = XDT+XC(50)
ENDIF

IF (k1.EQ.220.AND.K2.EQ.2.AND.FL(1)) THEN
XDT = XDT+XC(34)
ELSE IF (k1.EQ.220.AND.K2.EQ.2) THEN
XDT = XDT+XC(50)
ENDIF

IF (k1.EQ.230.AND.K2.EQ.2)     XDT = XDT+XC(20)
IF (k1.EQ.235.AND.K2.EQ.2)     XDT = XDT+XC(60)
IF (k1.EQ.240.AND.K2.EQ.2)     XDT = XDT+XC(80)
IF (k1.EQ.260.AND.K2.EQ.2)     XDT = XDT+XC(50)

IF (k1.EQ.265.AND.K2.EQ.1)  THEN
XDT = XDT+XC(50)
ELSE IF (k1.EQ.265.AND.K2.EQ.2) THEN
XDT = XDT+XC(30)
ENDIF
```

```
IF (k1.EQ.270.AND.K2.EQ.2)     XDT = XDT+XC(30)
IF (k1.EQ.275.AND.K2.EQ.2)     XDT = XDT+XC(70)

IF (k1.EQ.285.AND.K2.EQ.1) THEN
XDT = XDT+XC(100)
ELSE IF (k1.EQ.285.AND.K2.EQ.2) THEN
XDT = XDT+XC(100)
ENDIF

IF (k1.EQ.290.AND.K2.EQ.2.AND.FL(1)) THEN
XDT=XDT+XC(80)
ELSE IF (k1.EQ.290.AND.K2.EQ.2)     THEN
XDT = XDT+XC(0)
ENDIF

IF (k1.EQ.301.AND.K2.EQ.1)    FL(2)= .TRUE.
IF (k1.EQ.300.AND.K2.EQ.2)     XDT = XDT+XC(50)
IF (K1.EQ.304.AND.K2.EQ.1)     XDT = XDT+XC(20)
IF (K1.EQ.304.AND.K2.EQ.2)     XDT = XDT+XC(10)

IF (k1.EQ.310.AND.K2.EQ.2) THEN
XDT = XDT+XC(50)
ELSE IF (k1.EQ.310.AND.K2.EQ.2.AND.FL(2))  THEN
XDT = XDT+XC(60)
ENDIF

IF (k1.EQ.315.AND.K2.EQ.2) THEN
XDT = XDT+XC(60)
ELSE IF (k1.EQ.315.AND.K2.EQ.2.AND.FL(2)) THEN
XDT = XDT+XC(70)

IF (k1.EQ.320.AND.K2.EQ.2)     XDT = XDT+XC(70)
```

The analysis has been performed with the same process introduced in Chapter 4. The input file was associated to a probability cut equal to 10^{-9} for the risk analysis, whether for the calculation of the over-triage probability the selected probability cut was equal to 10^{-3}.

Input File Name	Probability Cut	Entropy	Constituents Number	Residual Probability
Solution	10^{-12}	10.53	10693476	$3.72 * 10^{-6}$
Solution 1	10^{-9}	10.50	995624	$6.18 * 10^{-4}$
Solution 2	10^{-3}	4.03	120	0.495

Table 25: data obtained by the analysis of a hypothetical modified process.

The new process would reduce the over-triage percentage up to 47%, i.e. a reduction of 16% with respect to the original system. Moreover, the CFL [Table 26] is deeply different.

CFL		Risk Percentage
1	Activation criteria undetected	60.21% %
2	Filter compilation: incorrect	23.00 %
3	Filter triage code: incorrect	6.8 %
4	DOC approach precautionary	3.07 %
5	SOP3 precautionary approach	1.69 %
6	SOP3 evaluation error	0.88 %

Table 26: CFL obtained simulating a new process, including the proposed resolution approaches.

The risk associated to the SOP3, respectively the use of a precautionary approach and the error in the evaluation of the patient's condition, are sensitively reduced. Their role in the risk generation has decreased, changing from a cumulative value equal to34.61%, to a value of 2.57%.

The risk associated to incorrect filter compilation has remained constant, but the over-triage generated in this phase can be reduced by a correct and complete work of SOP3. It's easier to intervene on the last phase of the process than on the first one: the interview process depend mostly on the layman's conditions and knowledges. The operator has to deal with agitated people that have to face an emergency situation. On the contrary, SOP3 deals with doctors or volunteer, which have been educated to face emergency situation. SOP3 can correct, together with the new insert filter, the information collected during the first interview and reduce the previous produced over-triage. The error caused by the filter structure is associated to a lower risk, but this decrease is equivalent only to circa 5%. This result reflects the fact that the filter modifications regard only the road accident category and that the modifications can't change the medical part, which is already complete and indispensable for the primary evaluation of the severity of an event.

In conclusion, an investment on these two hypothetical changes in the process would lead to a good improvement of the system, with a satisfying reduction of the over-triage. However it is important to underline that the addition of a new filter implicates the necessity to invest time, money and resource in the creation of a new algorithm but also in the personnel training. Moreover, the SOP3 personnel should be controlled in order to be sure that the mechanical result given by the algorithm is considered during the decisional process: the risk is that the operator start to ignore the filter results and continues to evaluate the patients' condition only basing on their subjective criteria.

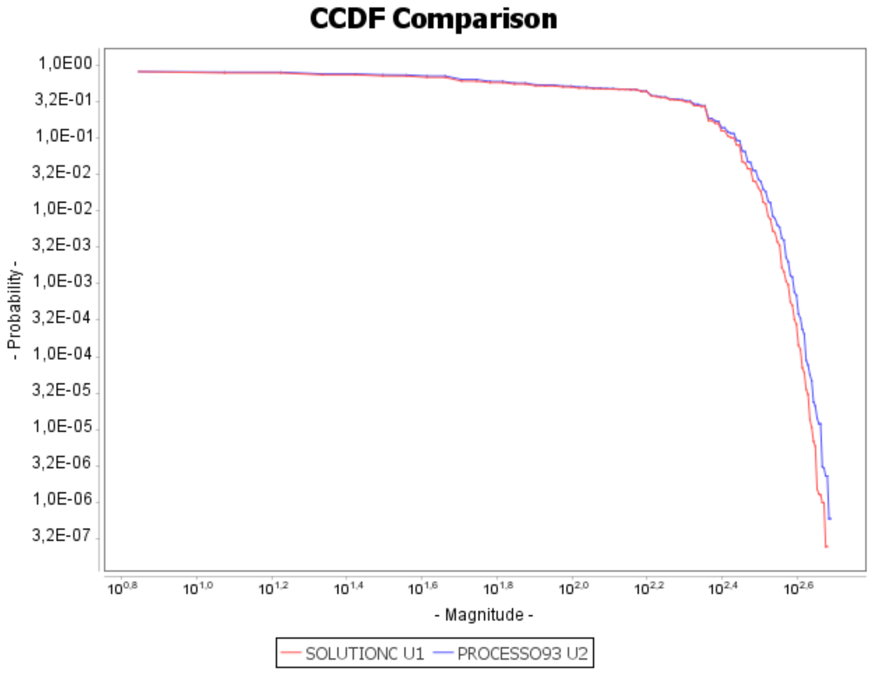


Figure 34: CCDF comparison between original process outcome (blue line) and modified process, with the addition of SOP3 filter and SOP1 filter weights changes (red line).

A modification of the SOP1 filter, on the contrary, wouldn't change the operators work, it would be an invisible change, so it wouldn't be necessary to invest on the personnel training but only on the filter structure. However the filter structure would be changed only for what concerns the weights values and distribution, together with the investment on appropriate study for a revaluation of the importance of contextual parameters.

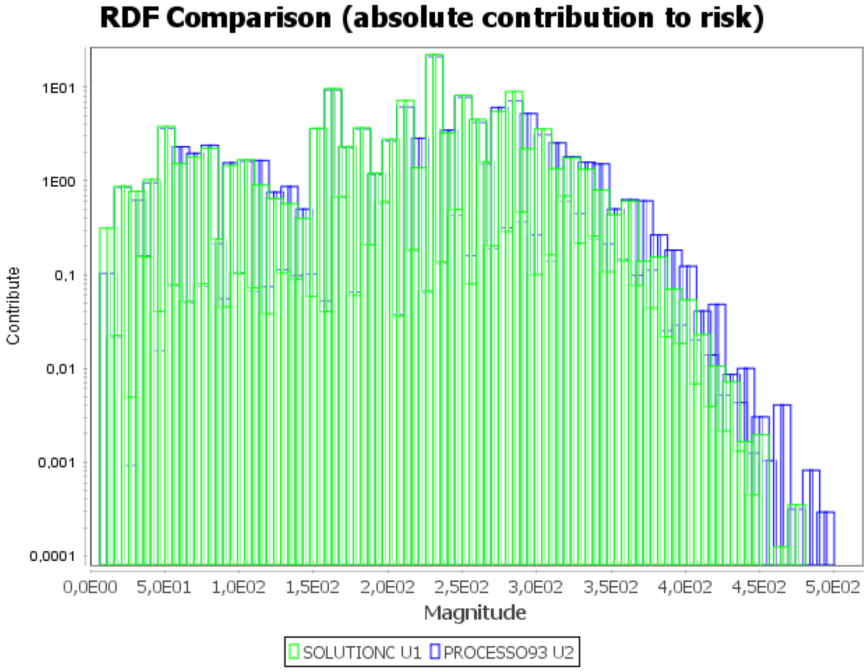


Figure 35: RDF comparison between original process outcome (blue profile) and modified process, with the addition of SOP3 filter and SOP1 filter weights changes (green profile).

Although the proposed solutions allow reducing the over-triage percentage, the risk doesn't decrease much: the risk is redistributed between the different several components, but, as shown in CCDF and RDF comparison [Figure 34, Figure 35], the overall risk level is maintained constant. The RDF shows that the beans associated to the higher magnitudes are reduced, but the risk profile shown by the CCDF comparison is similar to the original process one.

This theory is confirmed by the CFL: the un-detection of activation criteria is associated to a risk higher than 60%. This means that the risk has been readjust between the critical components already present.

One possible solution is to intervene on the activation and revaluation criteria: actually the criteria [Table 10, Table 11] are not inserted in the SOP1 filter. The operator has to recognize the activation and revaluation characteristic while he fills up the filter: this process is based on the operator memory and on the eventual consultation of the DOC 104 [IV]. In order to reduce the risk linked to this process component, it could be useful to insert the detection of these criteria within the filter. While the operator performs the interview, the system would be capable to recognize the activation and revaluation criteria: once the interview has been completed, the software would propose as an outcome the necessity to activate the ALS or to request a medical revaluation of the case, together with the triage colour associated to the patient.

The new input file would be the following one:

```
:Analysis Start
5 0. 0. 10 10 3 "Analysis" "Start" "--"

:Is the filter correctly compiled?
10 0.2 0. 48 15 3 "Filter compilation " "correct" "incorrect"

:What kind of error does the operator?
15 0.3 0. 20 35 3 "Error type" "Psychomotor" "Cognitive"

:Is the error caused by an external Distraction?
20 0.33 0. 25 48 3 "Distraction " "No" "Yes"

:Is the error caused by tiredness?
25 0.33 0. 30 48 3 "Tiredness" "No " "yes"
16 30 0. 0.

:Is the error caused by posture?
30 0.33 0. 48 48 3 "posture" "No" "Yes"

:Is the error caused by lapsus?
35 0.33 0. 40 48 3 "Lapsus" "No" "Yes"

:Is the error caused by lack of knowledge?
40 0.33 0. 45 48 3 "Lack of knowledge" "No" "Yes"
16 45 0. 0.

:Is the error caused by a misinterpretation?
45 0.33 0. 48 48 3 "Misinterpretation" "No" "Yes"

:Does the filter correctly calculate the triage code?
48 0.05 0. 50 49 3 "filter triage code" "correct " "incorrect"

:Is the error caused by the filter's structure (weight and question's chain)?
49 0.0001 0. 50 50 3 "filter error" "structure" "calculation"

:Does the system recognize activation criteria?
50 0.05 0. 65 60 3 "Act. criteria" "Detected" "Undetected"
```

15 110 0. 0.

:Is the error caused by a wrong filter compilation or by an intrinsic failure?
60 0.0001 0. 75 75 3 "error caused by" "filter incorrect" "intrinsic failure"

:Does the operator consider the pop up?
65 0.1 0. 110 66 3 'pop up' 'considered' 'ignored'

:Is the error caused by a lack of knowledge?
66 0.33 0. 67 100 3 "Lack of knowledge" "No" "Yes"

:Is the error caused by memory fail?
67 0.33 0. 68 100 3 "Memory fail" "No" "Yes"
16 68 0. 0.

:Is the error caused by distraction?
68 0.33 0. 100 100 3 "Distraction " "No" "Yes"

:Does the system recognize revaluation criteria?
75 0.05 0. 79 78 3 "Revaluation criteria" "Detected" "Undetected"
10 110 0.80 0.

:Is the error caused by a wrong filter compilation or by an intrinsic failure?
78 0.0001 0. 100 100 3 "error cause" "filter incorrect" "intrinsic failure"

:Does the operator consider the pop up?
79 0.1 0. 110 85 3 'pop up' 'considered' 'ignored'
10 110 0.80 0.

:Is the error caused by a lack of knowledge?
85 0.33 0. 90 100 3 "Lack of knowledge" "No" "Yes"

:Is the error caused by memory fail?
90 0.33 0. 95 100 3 "Memory fail" "No" "Yes"
16 95 0. 0.

:Is the error caused by distraction?
95 0.33 0. 100 100 3 "Distraction " "No" "Yes"

:Is the revaluation forced by doctor?
100 0.95 0. 110 105 3 "Forced by doctor" "Yes" "No"
10 110 0.80 0.

:Is the revaluation forced by operator?
105 0.9 0. 110 110 3 "Forced by Operator" "Yes" "No"
10 110 0.80 0.

:Is the MSA sent on the scene?

110 0.95 0. 120 120 3 "MSA" "Sent" "Not Sent"
15 185 0. 0.
2 255 255 225 225
10 125 0.025 0.
10 145 0.025 0.
10 165 0.025 0.
10 190 0.05 0.
10 205 0.025 0.
10 260 0.01 0.
20 270 0.4 0.
20 305 0.4 0.

:SERVICE LEVEL
120 0. 0. 125 125 3 "Evaluation Start" "Personnel on scene" "---"

:Is the temperature correctly detect?
125 0.05 0. 145 130 3 "Temperature" "Correct" "Incorrect"
20 225 0.2 0.

:Is the error caused by a reading error?
130 0.80 0. 135 145 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
135 0.15 0. 140 145 3 "Instruments Usage" "Correct" "Incorrect"
16 140 0. 0.

:Is the error caused by the instrument itself?
140 0.05 0. 145 145 3 "Instrument" "Work" "Fault"

:Is the blood pressure correctly detect?
145 0.05 0. 165 150 3 "Blood pressure" "Correct" "Incorrect"
20 225 0.4 0.

:Is the error caused by a reading error?
150 0.80 0. 155 165 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
155 0.15 0. 160 165 3 "Instruments Usage" "Correct" "Incorrect"
16 160 0. 0.

:Is the error caused by the instrument itself?
160 0.05 0. 165 165 3 "Instrument" "Work" "Fault"

:Is the oximetry correctly detect?
165 0.05 0. 185 170 3 "Oximetry" "Correct" "Incorrect"
20 225 0.4 0.

:Is the error caused by a reading error?

170 0.80 0. 175 185 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
175 0.15 0. 180 185 3 "Instruments Usage" "Correct" "Incorrect"
16 180 0. 0.

:Is the error caused by the instrument itself?
180 0.05 0. 185 185 3 "Instrument" "Work" "Fault"

:Is the ultrasound present on the available vehicle?
185 0.75 0. 190 205 3 "Ultrasound" "Present" "Missing"

:Is the ultrasound analysis correctly performed?
190 0.1 0. 205 195 3 "Ultrasound" "Correct" "Incorrect"
20 225 0.5 0.

:Is the error caused by a reading error?
195 0.70 0. 200 205 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instrument usage?
200 0.25 0. 204 205 3 "Instrument usage" "Correct" "Incorrect"
16 204 0. 0.

:Is the error caused by the instrument itself?
204 0.05 0. 205 205 3 "Instrument" "Work" "Fault"

:Is the ECG exam correctly performed?
205 0.05 0. 225 210 3 "ECG" "Correct" "Incorrect"
20 225 0.6 0.

:Is the error caused by a reading error?
210 0.05 0. 215 225 3 "Reading error" "No" "Yes"

:Is the error caused by a wrong instruments usage?
215 0.90 0. 220 225 3 "Instruments Usage" "Correct" "Incorrect"
16 220 0. 0.

:Is the error caused by the instrument itself?
220 0.05 0. 225 225 3 "Instrument" "Work" "Fault"

:What is the global information quality?
225 0.02 0. 230 230 3 "Information quality" "Good" "Low"
20 245 0.4 0.
20 280 0.4 0.

:What is the doctor approach on patient's evaluation?
230 0.2 0. 240 235 3 "DOC Approach" "Objective" "Precautionary"
24 245 0. 0.

:Why is the DOC's approach precautionary?
235 0.5 0. 245 245 3 "DOC Why precautionary?" "Legitimate worry" "Legal Protection "

:Does the DOC commit a cognitive error?
240 0.01 0. 245 245 3 "DOC Cognitive Error" "No" "Yes"
24 245 0. 0.

:Is the DOC's global evaluation correct?
245 0. 0. 255 255 3 "DOC Doctor Evaluation" "Correct" "Wrong"
20 280 0.70 0.

:SERVICE LEVEL
255 0. 0. 260 260 3 "SOP 3 Start" "data collection" "---"

:Is the communication with the scene possible?
260 0.05 0. 270 265 3 "Communication" "OK" "Error"
24 290 0. 0.

:What is the typology of performed error?
265 0.95 0. 290 290 3 "SOP3 Error type" "Fault" "Comprehension"

:What is the SOP3's approach on patient's evaluation?
270 0.2 0. 280 275 3 "SOP3 Approach" "Objective" "Precautionary"
24 290 0. 0.

:Why is the SOP3's approach precautionary?
275 0.5 0. 290 290 3 "SOP3Why Precautionary?" "Legitimate worry" "Legal Protection "

:Is there an evaluation error?
280 0.1 0. 290 285 3 "SOP3 Evaluation error" "No" "Yes"
24 290 0. 0.

:Where does the error come from?
285 0.9 0. 290 290 3 "SOP3 Source of error" "Information" "Wrong diagnosis"

:What is the global level of the SOP3's evaluation?
290 0 0. 295 295 3 "SOP3 Evaluation" "Correct" "Not Correct"
15 300 0. 0.
26 300 0. 0.

:SERVICE LEVEL
295 0 0. 300 300 3 "Hospital Choice" "-------" "---"

:Is the patient's condition correctly estimate?
300 0.1 0. 301 999 3 "Patient" "Correctly estimated" "Overestimated"
26 999 0. 0.

```
:Does the filter correctly calculate the triage code?
301 0.05 0. 304 302 3 "filter triage code" "correct " "incorrect"

:Does the filter's structure (weight and question's chain)?
302 0.0001 0. 304 304 3 "filter error" "structure" "calculation"

:Does the SOP3 consider the filter?
304 0.1 0. 305 305 3 'filter considered' 'yes' 'no'
20 305 0.1 0.
20 320 0.05 0.

:What is the SOP3 approach in the final patient's condition estimation?
305 0.05 0. 315 310 3 "Approach" "Objective" "Precautionary"

:Why does the SOP3 overestimate patient's conditions?
310 0.5 0. 999 999 3 "Why precautionary?" "Legitimate worry" "Legal Protection"
26 999 0. 0.
16 999 0. 0.

:Does the SOP3 identify other structures for the patient's treatment?
315 0.05 0. 320 999 3 "Other structures" "Unidentified" "Identified"
26 999 0. 0.

:Why does the SOP3 use a precautionary approach?
320 0.025 0. 999 999 3 "Alternatives" "Unavailable" "Available"
15 999 0. 0.
26 999 0. 0.

:Over-triage
999 0. 0. 0 0 3 "Over-triage" "No" "Yes"
```

The consequences file changes only in correspondence of the insertion of the new levels:

```
IF (k1.EQ.60.AND.K2.EQ.2)    XDT = XDT+XC(70)
IF (k1.EQ.60.AND.K2.EQ.1)    XDT = XDT+XC(50)
IF (k1.EQ.65.AND.K2.EQ.2)    XDT = XDT+XC(70)
IF (k1.EQ.78.AND.K2.EQ.2)    XDT = XDT+XC(60)
IF (k1.EQ.78.AND.K2.EQ.1)    XDT = XDT+XC(40)
IF (k1.EQ.79.AND.K2.EQ.2)    XDT = XDT+XC(60)
```

Level 65 and 79 are in their failure state if the operator ignores the popup: this lead to the loss of the activation or revaluation criteria. Also the system can fail in the identification of the criteria: this possibility is reflected by the conditions impose on level 60 and 78.

This new analysis lead to an over-triage percentage equal to 44%, calculated using a probability cut of 10^{-3}.

Input File Name	Probability Cut	Entropy	Constituents Number	Residual Probability
Solution B	10^{-12}	7.42	4106599	$1.48 *10^{-6}$
Solution B1	10^{-9}	7.41	381579	$2.33*10^{-4}$
Solution B2	10^{-3}	4.33	98	0.263

Table 27: results obtained from the process analysis after the modification of the activation and revaluation criteria detection

The critical components [Table 28] present reflect the adopted solution: the activation criteria are associated to a risk equal to 8.51% of the global value. The list presents a new critical component: pop up ignored. Its risk percentage is equal to 11.92%. These values reflected the importance of the human variable: even if the filters works correctly, detecting all the criteria listed in the second chapter, the concrete activation or revaluation process must be started by the operator. This means that the operator should be controlled and trained in order to maintain a constant and high attention to the possible appearance of a pop up.

CFL		Risk Percentage
1	Filter compilation: incorrect	27.84%
2	DOC approach precautionary	16.95%
3	Pop up ignored	11.92%
4	SOP3 precautionary approach	9.62%
5	Activation criteria undetected	8.51%
6	Filter triage code incorrect	6.51%
7	SOP3 Evaluation error	5.44%

Table 28: CFL related to the new proposed process with new activation and revaluation criteria detection method

This new solution allows also reducing the overall risk associated to the system.

The CCDF comparison [Figure 36] shows a reduction of the overall risk, with a reduction of the maximum magnitude and a global decrease of the probability associated to high consequences stories. The RDF comparison [Figure 37] shows that the stories associated to magnitude included between four-hundred and five-hundred have been delated. The beans profile is maintained, but has its compressed in respect to the original process results.

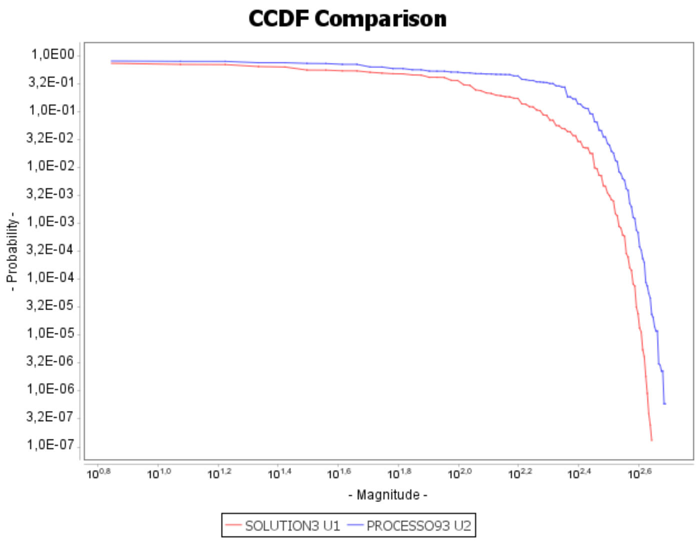


Figure 36: CCDF comparison between original process, blue line, and modified process, red line. The modifications regard both SOP3, SOP1 filter and mechanism of detection of activation and revaluation criteria.

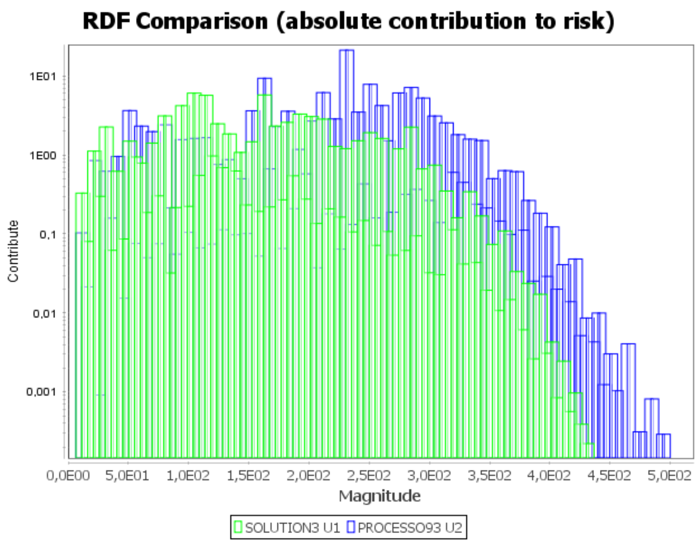


Figure 37: RDF comparison between original process, blue profile, and modified process, green profile. The modifications regard both SOP3, SOP1 filter and mechanism of detection of activation and revaluation criteria.

The modifications applied have changed the process outcomes in the region of high magnitudes. The effects on the lower magnitude are quite invisible: the beans maintain the same probability. The following figures represent a comparison between the original process and the proposed solution approaches.

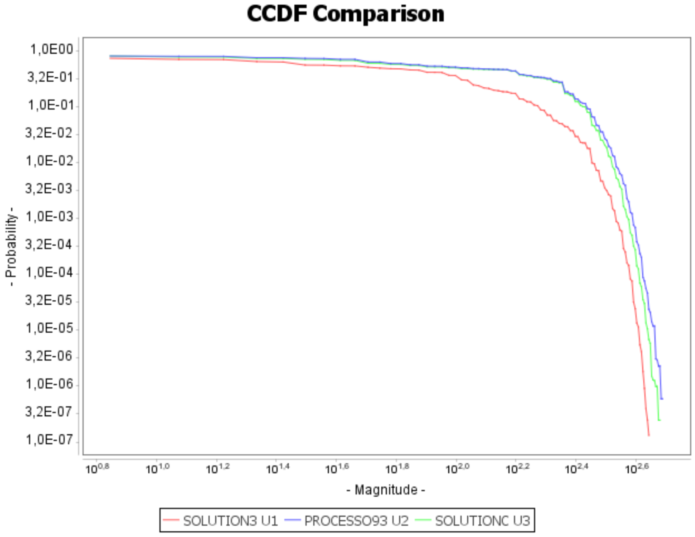


Figure 38: CCDF comparison: blue line represents the original process. The green one reflects the addition of the SOP3 filter and the modification applied to the SOP1 filter (weights change). The red line represents the further modification inherent to the activation and revaluation criteria.

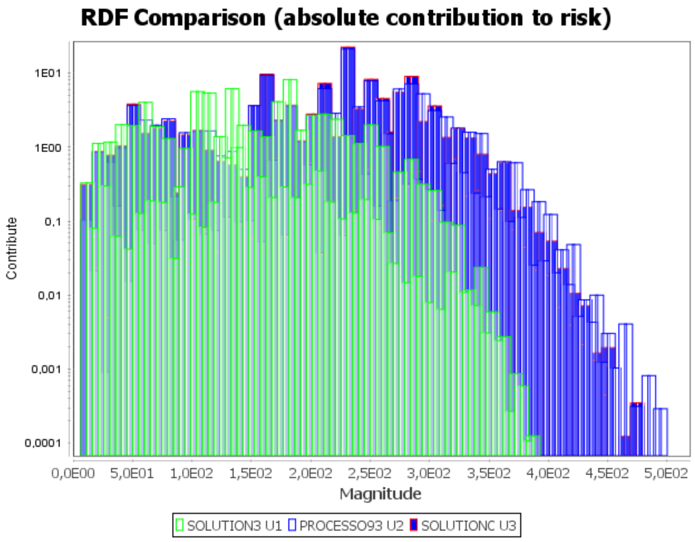


Figure 39: RDF comparison: light blue profile represents the original process. The blue one reflects the addition of the SOP3 filter and the modification applied to the SOP1 filter

(weights change). He green profile represents the further modification inherent to the activation and revaluation criteria.

The three different approaches produce a different total probability, total risk and expected damage [Table 29]. These values could be useful to comprehend how the system changes when modified.

	Original process	SOP3 filter addition + weights change	SOP3 filter addition + weights change + insertion of pop up
Total probability [p]	8.1939 E-01	8.1916 E-01	7.4567 E-01
Total risk [R]	1.2830 E+02	1.2370 E+02	1.0459 E+02
Expected damage [M]	1.5658 E+2	1.5112 E+02	1.4027 E+02
Δp	-	0.028 %	9.43%
ΔR	-	3.58%	18.48%
ΔM	-	3.48%	10.45%

Table 29: comparison of total probability, total risk and expected damage obtained from the original process and the two proposed resolution approaches

The expected damage is highly reduced adopting the second proposed approach, the same happens to the total considered risk. This means that the second approach guarantees a reduction of the maximum reachable magnitude, as well as a reduction of the global risk produced by the process itself.

In conclusion the over-triage percentage can be reduced from 63% to 44%. However not all the proposed solutions are easy to concretize.

The modification applicable to SOP1 filter, both in terms of weights and detection criteria change, don’t request a high economical investment. The internal change of weights is an invisible modification, that wouldn’t change the operators’ working procedures. The only required investment is in the software modification.

The addiction of the pop up mechanism for the detection of the activation and evaluation criteria would request, in addition to the software modification, training for the SOP1 personnel.

The operators should know how to use the pop up mechanism: it is important to underline that the pop up doesn’t actually activate the ALS intervention, but that the ultimate decision and practical activation is reserved to the operator. This is a key point in order to avoid the risk connected to the ignored notification. It is also important to monitor the operators’ work, in order to be sure that, once the mechanism has been completely comprehended, the operators lose the attention on this point and start to forget the activation of ALS or of the revaluation process.

On the contrary the insertion of the SOP3 filter would request a large investment in terms of money and time. First of all the filter should be created ex novo, basing on a study for the choice of the medical and contextual parameters that should be considered. Once the filter has been made, it would be necessary to intervene on the collection data procedure applied on the scene, in order to be sure that each doctor, but also each volunteer, is able to register all the requested data.

Furthermore a deep training for the SOP3 personnel would be necessary, in order to allow them assuming confidence with the software. As explained for the SOP1 personnel, also the SOP3 personnel should be monitor, in order to control that they considered the software outcome during the decisional process.

In conclusion the revaluation of the contextual and dynamics parameters should be based on new studies, in order to apply truthful and consistent modifications and to be consistent with the technological progress of our world. Cars and motorcycles are each day safer for the user, because of the creation of new safety instruments. For example motorcyclists wear a back protector always more frequently when riding a bike. This protection is not considered in the evaluation process, but can be useful not only for the evaluation, but also for the hospital, which would be early prepared to adequately treat the patient. Another example would be the notification of the number of airbags exploded in a car after an accident: nowadays some cars are equipped with a lot of airbag, in order to be safer for the passenger. The energy absorbed by a person in an impact is lower if he travelled on a car equipped by a lot of airbag.

The contextual parameters should be deeply studied and adjourned if necessary, in order to better respect reality.

The performed sensitivity analysis is a starting point for the revaluation of contextual and impact parameters, that can really be helpful both for the patient preliminary evaluation and for the patient's treatment. Moreover this a more specific analysis would help within the choice of the parameters to be inserted also in SOP3 filter.

This work has underlined that an improvement of the actual process is possible, but that it would request additional work and study, in order to concretize the proposed solution and to obtain a more performant process that could allow reducing the over-triage, leading to a better utilization of the trauma centre as a fundamental territorial sanitary resource.

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