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EVALUATION MODEL IN THIRD PARTY LIABILITY FOR HOSPITALS

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A chi non c’è più e mi ha voluto bene.

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Chapter 1

Introduction

Healthcare industry is currently a very common topic. It is possible to read or to hear something about it almost everywhere. There exist a great number of studies, papers and articles about all what concerns directly, or indirectly, the health system. In modern economies this sector plays a very great role, either under an economic point of view, or under a social one. It is indeed one of the world's largest and fastest growing industries, using up over 10 percent of gross domestic product of most developed countries, at such point to be considered a parameter of development strictly connected to welfare.

It is a complex system, made up of different aspects: providing goods and services to treat patients, involving a set of heterogeneous stakeholders such as treatments-providers, payers and, of course, patients. The healthcare system can not be analysed without considering law system and insurance policies. In recent years the healthcare theme has gained fame, in particular as a consequence of the emergence of many problems and scandals. Policy-makers and governments are trying to find solutions to such problems. Given this situation, we consider useful to take a deeper look at this domain from a different sight: the simulation perspective in connection to medical third party liability. We are trying to re-create a real-world process or a system in a controlled environment, based upon real data, even despite an incomplete set of information on the real situation we are investigating. It is a very powerful application that allows us to work on a parallel world very similar to the real one, starting on real assumptions, in order to foresee the future using logic algorithms.

We have decided to analyse this topic for two main reasons: firstly because of the key role played by the healthcare industry over the entire economy of every country all around the world. A second reason of interest lies on a nearest and more concrete problem: the Italian situation. In our country there is a general flee from the medical third party liability market, most of the Italian and European insurance companies have abandoned it not to assume the risk connected to what is generally called med-mal, or medical malpractice. As consequences premiums are arising because of the lack of competitors and, sadly, due to the lack of interventions of the government. Additional details will be found in the following pages.

In analysing this situation, my goal is trying to provide you with an agent-based simulation instrument, developed with a simulating software called *NetLogo*, which is able to evaluate different scenarios given different assumptions, in order to propose the optimal solution to the policy an hospital has to underwrite. It is important to say that my analysis is based on *La Città della Salute e della Scienza* di Torino data. It is really important to underline that all the information and data received from the risk management department respect the privacy of the patients.

We could split this work in two main areas: literature review is an introducing part about the theories useful for the whole work. It consists on a set of knowledges that must be taken into account in order to get a better comprehension on the subject of our model. This introductory part is covered from chapter 2 to chapter 5. The second part develops the main theme of this work and it consists in a model we developed using an agent based simulating software. It will allow us to make several considerations about the actual insurance setting governing the healthcare system. This section is covered from chapter 6 to chapter 9.
Let's give a brief description to the themes you can find in this work:

In chapter 2 there is a brief introduction on the insurance business, from the origin to our days. You can find the most important steps that occurred in the history and that led the insurance industry to play a such important role in the economy system. Finally, you can deal with asymmetric information and with the concept of deductible as tool to face the problem.

Chapter 3 is based on the inversion of the production cycle, as phenomenon strictly connected to the particular business managed by insurances. Differences between *Fair, Net and commercial premiums* are also considered. Finally there is a brief introduction to medical malpractice.

Chapter 4 is completely based on the med-mal phenomenon and its analysis with respect to the Italian situation and the USA approach.

Chapter 5 focuses on the general principles of insurance matter according to the Italian civil code and shows the difficulties and the uncertainty atmosphere that has characterized the medical malpractice problem, from the origin to the Balduzzi Decree.

Chapter 6 is an introduction to Agent-based model and it focuses on the additional possibilities provided by adopting the simulation modelling in health care domain.

Chapter 7 describes the programs we had to write in Python in order to manage properly the data received from the hospital. You can find the codes created and a brief description of them. At the end of the chapter you can find a set of graphical representations of the statistical approach adopted to estimate the distribution and the quality of risks.

Chapter 8 is the aim of the entire project. It consists in the description of the code, written with Netlogo, to estimate the premium of a third party liability for hospitals. It also explains to the user the correct way of interacting with the interface.

Chapter 9 represents the conclusion of our study and shows the results found thanks to the simulation and a final comment on the possible developments of the code.

Chapter 2

Insurance business

Generally speaking, insurance business is living a very interesting season and facing a challenging period, due to the amendments and new rules introduced by the new European Regulation Solvency II, the International Accounting Standards (IAS) and the International Financial Reporting Standards (IFRS). All these new concepts affect every line of business (medical third party liability, too) managed by an insurance company. Moreover, an insurance company always deals with the legislative environment in which it works and Italy, on late with respect to USA and the European leading countries, is facing the medical malpractice problem, which is strictly connected to the core of this work. Before speaking about the health care system, it is important to give a brief introduction to insurance business. Our will is to write an essay that can be read and understood by everybody.

Nothing will be left to the reader, some references will be cited in order to give to the expert user the possibility to go deeper into details. In the next pages you can find a brief introduction about the origin of the insurance and its evolution. We consider it as a funny and interesting way to approach an argument that otherwise could appear too technical.

2.1 Insurance time line

As Gropello and Gionta (2004) affirm the first insurance arrangements proved date back at least to ancient Greece, around 2700 - 2500 BCE and it is known as Bottomry Bonds. In that era marine loans advanced money on a ship or cargo. It would be repaid with substantial interest if the voyage succeeded, but forfeited if the ship could not reach the final destination. Even if it is scheduled as loan, it can be considered as the first example of insurance policy, as we said. It sounds very similar to the contemporary catastrophe bonds. The interest rate covered both the cost of capital and risk of loss.

Something similar was written into the Hammurabi's code, a collection of 282 laws inscribed on an upright stone pillar. Hammurabi ruled the Babylonian empire from 1792-1750 BCE. This evidence can be also considered as the first proof of the existence of medical malpractice (often referred to as med-mal) in the history of human being, it reports: "if a surgeon performs a major operation on an 'awelum' (nobleman), with a bronze lancet and caused the death of this man, they shall cut off his hands".

Direct insurance of sea risks, using premiums and so based on a very modern conception of insurance policy, started in the first half of the 14th century in Belgium but rapidly spread among Europe and in particular in Italy, as a protection against the abusive practices and the laws against usury issued by Pope Gregorio IV on every kind of risk that was transferred by a loan contract. In the same period, due to the success of the insurance on maritime transports, in Genova it was written the first reinsurance contract on July 12, 1370. It assured the trades from Genova to Sluis and in particular the insurer transferred to a third part, the reinsurer, the most dangerous part of the track, from Cadiz to Sluis, "ripigliando sichurtà". It allowed the insurer to reduce its own exposure to risks and it was directly underwritten between the insurer and the reinsurer, without the participation of the assured.

From the first half of XVI century, insurance on sea trades reached a such level of diffusion to be created, in 1552 in Siviglia, the first standard format for this kind of policy. The first known life insurance policy was written in 1583. XVII century is characterized by a large and quite fast diffusion of a new kind of insurance policy in which there is a team of insurers that covers risks. This kind of policy is known with the term of coinsurance contract.

By the end of the 17th century, sea risk insurance had evolved to a competitive process between underwriters evaluating risks and meeting at Lloyd's coffee house, the precursor to Lloyds of London, one of the biggest broker company in the world, composed by several thousands of syndicates, each one specialized in evaluating and pricing risks. The birth and development of Lloyd's syndicate was also due to the lack of possibility in adopting the reinsurance strategy because of restrictions imposed by King George II that required new techniques in pricing risks.

Mutual insurance companies acquire importance under Queen Victoria. In the same period, as consequence to the Hamburg fire of 1842, in 1846 were born the first two professional insurance companies, respectively the Kölnische Rück and the Aachener Rück. They understood that fire risk had to be managed in a completely different way in respect of the sea risks, because of the impossibility of individuating an initial and an ending moment of exposure to the risk. In Italy, the first professional insurance company was the Ausonia, founded in 1898 but effectively working since 1924.

2.2 Insurance today

Today, insurance is a major industry established throughout the world. But, what does really mean the expression insurance and what kind of insurance policies exist? The article 1882 of the Italian civil code defines as insurance contract as:

> L'assicurazione è il contratto col quale l'assicuratore, verso il pagamento di un premio, si obbliga a rivalere l'assicurato, entro i limiti convenuti, del danno ad esso prodotto da un sinistro, ovvero a pagare un capitale o una rendita al verificarsi di un veneto attinente alla vita umana.

It means that an insurance policy is a contract whereby one party, called the insurer, undertakes to compensate the other, known as the insured, for a loss relating to a particular subject, for specified consideration and limits, as a result of the occurrence of designated hazards that could produce economic losses or damages to human life.

As we perceive from the definition, an insurance policy can have a double goal:

- to refund (or to foresee) possible economic losses;
- to offer an alternative way of compensating economic needs as soon as an event concerning human life of a family member becomes concrete.

We can consider an insurance contract as an instrument of removing some aleatory, by means of transferring the risk to an insurance company that have been authorized by Italy.

As every aspect of the human life is characterized by variability it is easy to understand the reason why insurance matter has progressively moved into new fields. For example, health insurance was virtually unknown in the United States prior to 1929 and now pays for more than 10 percent of the US GDP.

Almost every kind of risk is insurable, there are really few exclusions such as events connected to nuclear or petrol contamination, as the cost directly connected to the realization of such kind of claims is very difficult to estimate and can be hardly bore by insurance companies, even considering co-assurance or re-assurance strategies.

According to David. M. Cutler and Richard Zeckhauser, lack of coverage for terrorism insurance represents instead a particular case of policy that could exist but does not. There are social and cultural reasons behind this phenomenon: the existence and the promotion of such kind of policy could appear as a legitimation or approval to that kind of acts.

Let's see a brief list of the most common kinds of insurance policies existing in the market before focusing on the medical third part liability. In Italy, as in the whole world, the insurance policies are divided into two groups according to the kind of risk underwritten.

The two branches are "Ramo Vita" and "Ramo Danni", literally they mean life and damages but they are usually translated using a different approach, they are not only two groups of risks related or not to human life but, they are categories that cover all the possible risks: life and non-life insurance policies.

Belong to Life insurance contracts that kinds of risks whose realization compromise the economic equilibrium of the insurer or other people, recalled in the policy, and that affect the human life. There are several kinds of contracts belonging to this class, that's why it has been created a set of subclasses to better classify the associated risk:

I. assurance on the length of human life;

II. marriage assurance, birth assurance;

III. assurance referred to in classes I and II, whose main benefits are directly linked to the value of units of a undertakings for collective investment in transferable securities, or the value of the assets in an internal fund or else to an index or other reference values;

IV. health insurance and insurance against the risk of dependency that are covered by permanent health insurance contracts not subject to cancellation, against the risk of serious disability resulting from accident or sickness or longevity;

V. capital redemption operations;

VI. management of group pension funds that effect payments on death or survival or in the event of discontinuance or curtailment of activity.

Belong to non-life insurance contracts that kinds of risks whose realization determines an economic loss or damage without affecting human life. Also this category is characterized by a big number of classes:

1. accident (including industrial injury and occupational diseases); fixed pecuniary benefits; benefits in the nature of indemnity; combinations of the two; injury to passengers;

2. sickness: fixed pecuniary benefits; benefits in the nature of indemnity; combinations of the two;

3. land vehicles (other than railway rolling stock): all damage to or loss of: land motor vehicles; land vehicles other than motor vehicles;

4. railway rolling stock: all damage to or loss of railway rolling stock;

5. aircraft: all damage to or loss of aircraft;

6. ships (sea, lake and river and canal vessels): all damage to or loss of: river and canal vessels; lake vessels; sea vessels;

7. goods in transit (including merchandise, baggage, and all other goods): all damage to or loss of goods in transit or baggage, irrespective of the form of transport;

8. fire and natural forces: all damage to or loss of property (other than property included in classes 3, 4, 5, 6 and 7) due to: fire; explosion; storm; natural forces other than storm, nuclear energy; land subsidence;

9. other damage to property: all damage to or loss of property (other than property included in classes 3, 4, 5, 6 and 7) due to hail or frost, and any event such as theft, other than those mentioned under 8;

10. motor vehicle liability: all liability arising out of the use of motor vehicles operating on the land (including carrier's liability);

11. aircraft liability: all liability arising out of the use of aircraft (including carrier's liability);

12. liability for ships (sea, lake and river and canal vessels): all liability arising out of the use of ships, vessels or boats on the sea, lakes, rivers or canals (including carrier's liability);

13. general liability: all liability other than those forms mentioned under numbers 10, 11 and 12;

14. credit: insolvency (general); export credit; instalment credit; mortgages; agricultural credit;

15. suretyship: suretyship (direct); suretyship (indirect);

16. miscellaneous financial loss: employment risks; insufficiency of income (general); bad weather; loss of benefits; continuing general expenses; unforeseen trading expenses; loss of market value; loss of rent or revenue; indirect trading losses other than those mentioned above; other non-trading financial loss; other forms of financial loss;

17. legal expenses: legal expenses;

18. assistance: assistance to persons who get into difficulties.

The above mentioned classification it is possible to be found in the code of private insurance, published by IVASS, the acronym of Istituto per la Vigilanza sulle Assicurazioni, the main authority for insurance matters. The set of rules was amended by the Legislative Decree n. 209 of 7 September 2005.

We decided to report this elaborated structure in order to underline an important concept, namely, medical third party liability, even if it is strictly connected to human life it is considered belonging to the non-life class, as the risk is represented by injuries or related damages. As consequence it must followed the rules imposed to non-life insurances, this is particularly important considering the reserve structure.

After introducing and focusing on the classification of the medical third party liability, let's move on talking about the two main problems affecting each insurance policy: adverse selection and moral hazard.

2.3 Adverse Selection and Moral Hazard

Since the second half of the last century, the study of the problem of asymmetric information has become important in the field of economics and insurance. Much progress has been made from both a theoretical and an empirical point of view.

Before economists took the question of information transparency into consideration, they commonly assumed the presence of complete information. The concept of complete information implies that all the information is transparent and equally known among all the possible counterparts or to the whole set of participant to the market. Conversely, the concept of asymmetric information implies that the information known to one party may be unknown or only partially known to another. This creates a sort of disequilibrium.

Between the two concepts, the asymmetric information, comes closest to describing or reflecting the real economic world. Insurance pricing is a very good example of the importance of this phenomenon. The insurer sets the premium based on statistics and actuarial data on the previous loss experience within a normal population. In the long run, the company will break even, if the risk is at the average level as presumed.

Unfortunately, people who, in fact, represent a higher than average risk level, may be able to purchase insurance coverage against their more frequent or more severe future losses at a favourable price that was originally based on the average risk. This disconnect may occur because insurers lack sufficient information on the percentage of the pool with higher risk and the exact risk levels represented, even though the insured is fully aware of the risk level. Therefore, this asymmetric information situation may lead to higher losses for the insurer.

The existence of asymmetric information normally entails two complementary problems: adverse selection and moral hazard. The term adverse selection refers to circumstances which permit an insured with higher risk to buy insurance at a premium calculated to service the average risk level. The term moral hazard refers to the tendency of insurers to exercise less precaution than they should, establishing inadequate incentives to control the risks represented by those to whom they provide coverage.

Adverse selection and moral hazard both contribute to the potential for higher losses than the insurer may have expected. In the presence of serious asymmetric information, the insurer may experience a much higher loss than expected. Therefore, the detection of possible asymmetric information, including the discovery of previously unknown risk, has the potential to benefit both the insurer and the insured.

Both the two problems have been partially mitigated by introducing some limits to the refund. The three most adopted strategies are:

- fixed deductible: is the amount of expenses that must be paid out of pocket before an insurer will pay any expenses, it represent a sort of threshold for the insurer, only the exceeding amount must be repaid. It works as a demotivating instrument against frauds because losses under this limit are completely bore by the insured;

- proportional deductible: it works very similar to the deductible with the only different that the threshold is not an amount but is expressed as percentage of the claim;

- franchise deductible: the only difference with respect to the fixed deductible is that in case the loss is higher than the threshold then the claim amount is equal to the loss, zero otherwise.

Here you can graphically observe how the different kinds of deductibles work.

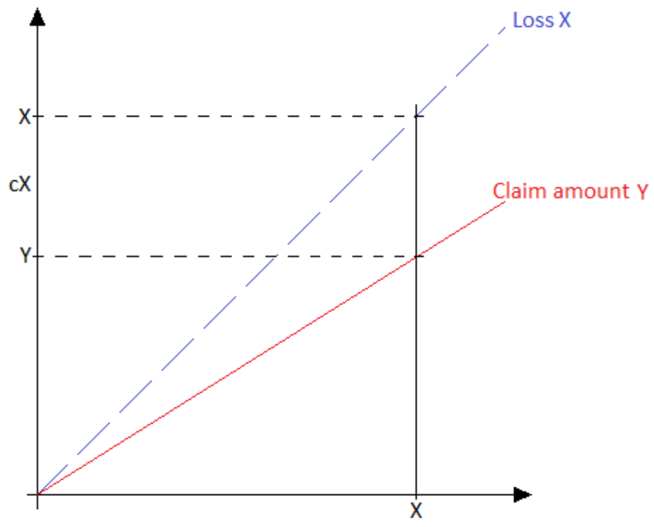

Figure 2.1: The theoretical working of a proportional deductible.

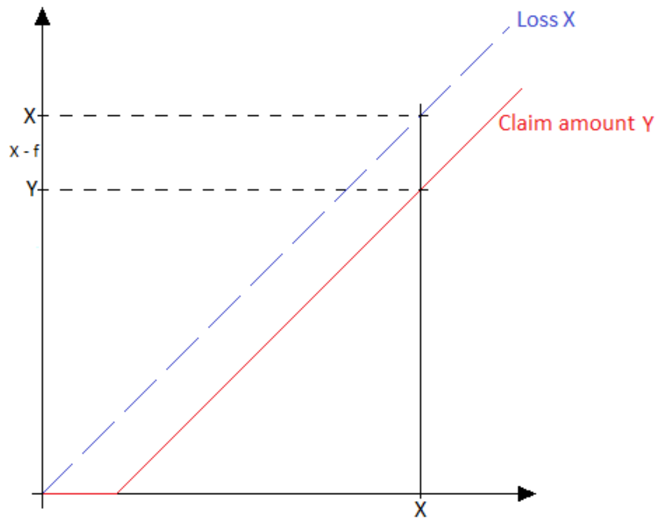

Figure 2.2: The theoretical working of a fixed deductible.

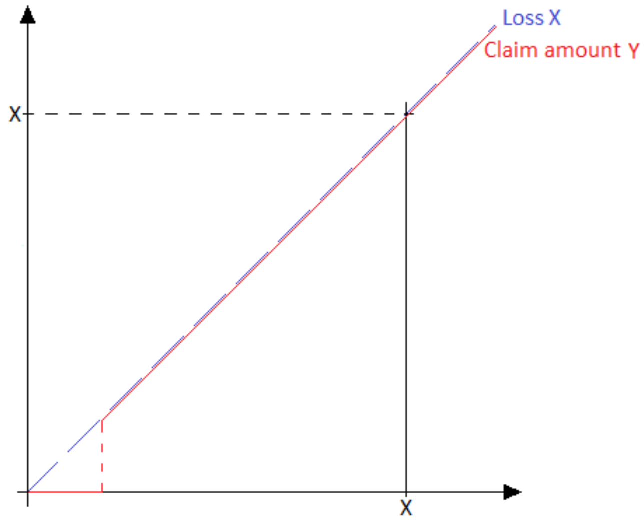

Figure 2.3: The theoretical working of a franchise deductible.

Chapter 3

Inversion of the production cycle

In this section we focus on the meaning of the expression *inversion of the production cycle* in order to identify the requirements and procedures used to compute the adequate insurance price. This will be useful to make some assumptions and considerations in our simulation model. Moreover we will introduce the crucial moments in the life of an insurance policy, focusing on the definition process of a claim.

Unlike other kinds of economies, the production cost of an insurance contract is not known in advance, but the ultimate cost will be known only in the future, and this date does not necessary correspond to the December 31. This is the meaning of inversion of the production cycle.

Correct pricing of insurance is therefore the foundation of the existence of insurance contracts and this is possible thanks to special techniques, strictly connected to actuarial mathematics, which have been developed to price all the possible kinds of insurance products. A first concept that must be defined in order to be clear to all the readers is what a rate is. This is a very easy but fundamental tool for pricing insurance policies.

A rate is the price an insurer charges for each unit of a loss exposure that is covered under a specific insurance contract, while the premium is the amount that the insured has to pay to the insurer in order to be covered against underwritten risks. The pricing of an insurance contract may be described as the set of procedures of computing the expected claims to be paid and expenses in assuming risks. Of course, the insurance company is available to cover risks only if the price guarantees a profit.

The first step is a correct identification and evaluation of the risk and a large number of homogeneous risks in the basket, to be used to calculate the expected frequency and severity of the losses. Up to now we have used premium in a very general way, let's go a bit deeper and do define the different kinds of existing premiums.

- Fair premium: it is equal to the expected value of the whole reimbursement cost that the insurer evaluate in line with the probability and the severity of the risks underwritten. It is not possible to adopt this premium as policy price due to the lack of certainty of the results. Risk of underpricing, which means under estimating the losses connected to the risks assured, can cause heavy patrimonial losses. Practically it consists in observing at the end of the year, a bigger volume of claims occurred a higher impact with respect to the estimated one at the moment of pricing risk.

- Net premium: it is obtained by adding together the fair premium and the safety loan, which can be considered as an incremental amount asked to the underwriting either to reduce the probability of under estimating risk, or to remunerate the cost of capital. This parameter is strictly connected either to the capital requirements amended by the Solvency II, or to the capitalization level required. Rating is an important element to be considered in this step. Notice that the safety loan could be negative in accordance with an aggressive subscribing politic of the insurance company.

- Finally we get the commercial premium, which is the one proposed to the underwriting, increasing the net premium of an amount equal to the fraction of the estimated expenses hold by the insurer.

As we said, it is really important to evaluate adequately the expected losses the insurer will have to repay to the insurers, to make it possible is fundamental describing all the different scenarios related to the realization of a claim:

- the occurrence year/date represents the moment in which a claim becomes concrete. It is the first realization of an covered event;

- the reporting year/date is the moment in which the insured informs the insurer of the claim, on the converse side, it is the moment in which the insurance company knows the realization and in some cases the entity of the losses;

- the closing year/date represents when the insurance company ends to deal with the claim. It could be paid back to the insured or it could have produced no effect, e.g. losses are evaluated to be under the threshold imposed by the deductible;

- the re-opening year/date represents the moment in which the insurer decides of changing the previous results or the moment in which is informed by insurer of the will in producing a different effect because of new information arrival.

3.1 Introduction to medical malpractice

As the core of this work is the medical third part liability, we have decided to focus on a very important concept, the medical malpractice, also called med-mal, already mentioned in the previous text. At the origin of this term there is the Latin expression of "mala praxis".

It represents a set of incorrect practices adopted by a doctor or physician, from which follow dangers and risks for the life of the patient. As written in the report published from ANIA (2014) the term has been kept alive from Sir William Blackstone, an English jurist, judge and Tory politician of the 18th century thanks to his several publications of the Laws of England. In Italy the same concept is expressed with the terms "malasanità" or "malasalute".

What stood accused is doctors' inexperience or the disorganization of the hospitals paid, sometimes a very high price, by those who commit to their care. A problem whose importance is growing in the latest years and, for certain profiles, it takes over the features of a real emergency.

According to a survey made in 2006 by the European Commission, the Eurobarometer put Italy at the top of the list of the countries whose citizens give importance to the medical malpractice news. In Italy this kind of phenomena are classified into two main categories: *eventi avversi* and *eventi sentinella*. Here we use the Italian terms not to make confusion with the *adverse events* or *sentinel events* that is the correspondent terminology used all over the world but whose definitions vary from country to country.

In Italy either *eventi avversi* or *eventi sentinella* are defined by the Government, in particular by the Department of Health, as follows:

> Evento avverso: Evento inatteso correlato al processo assistenziale e che comporta un danno al paziente, non intenzionale e indesiderabile. Gli eventi avversi possono essere prevenibili o non prevenibili. Un evento avverso attribuibile ad errore è "un evento avverso prevenibile".

It could be translated by referring to the Medicines for Human Use (Clinical Trials) Regulations (2004) as amended, interpret an adverse event to be any untoward medical occurrence in a subject to whom a medicinal product has been administered, including occurrences which are not necessarily caused by or related to that product.

In general the Italian definition has a larger extension than the one just reported, it also considers as adverse events all that unexpected events, arisen during the health treatment, that produces unintentional and not desirable damages to the patient. Generally speaking, an adverse event can be any incident that happens to an individual and therefore they can be classified as preventable or not preventable depending on the presence or absence of human mistakes. Here you can find the definition of *evento sentinella* given by the Department of Health:

> Evento sentinella: Evento avverso di particolare gravità, potenzialmente indicativo di un serio malfunzionamento del sistema, che può comportare morte o grave danno al paziente e che determina una perdita di fiducia dei cittadini nei confronti del servizio sanitario. Per la loro gravità, è sufficiente che si verifichi una sola volta perché da parte dell'organizzazione si renda opportuna
>
> a) un'indagine immediata per accertare quali fattori eliminabili o riducibili lo abbiamo causato o vi abbiano contribuito e
>
> b) l'implementazione delle adeguate misure correttive.

From the above definition it is clear that each evento sentinella has its roots in the evento avverso, with a difference in the severity of injuries. The importance of considering and monitoring the evento sentinella can be traced back to the negative impact that its manifestation plays among the society. As a consequence, it is sufficient that such an event happens once to start an investigation on the causes and possible solutions. The model that the health facility has to send to the department of health can be found in the appendix A. The department of health moves a step on and makes a list of 16 events that must be considered as eventi sentinella and that satisfy the definition. Here you can find the whole content of the list[1]:

[1] From the Italian website of the Department of Health, www.salute.gov.it :

1. Procedura in paziente sbagliato;
2. Procedura chirurgica in parte del corpo sbagliata (lato, organo o parte);
3. Errata procedura su paziente corretto;
4. Strumento o altro materiale lasciato all'interno del sito chirurgico che richiede un successivo intervento o ulteriori procedure;
5. Reazione trasfusionale conseguente ad incompatibilità AB0;
6. Morte, coma o grave danno derivati da errori in terapia farmacologica;
7. Morte materna o malattia grave correlata al travaglio e/o parto;
8. Morte o disabilità permanente in neonato sano di peso >2500 grammi non correlata a malattia congenita;

1. Wrong-patient procedure;
2. Wrong-site and wrong-side procedures;
3. Wrong-procedure on right patient;
4. Unintended retention of a foreign body;
5. Transfusion error;
6. Inpatient drug overdose;
7. Maternal death or severe injury in labor or childbirth;
8. Perinatal death or permanent disability in sane newborn with weight > 2500g not correlated to congenital illness;
9. Death or serious injury after fall;
10. Suicide realization or attempt in hospital;
11. Criminal event;
12.

Referring to the same regulation as before, we can say that the Italian definition of evento sentinella has a wider extension than the serious adverse event (SAE), which means any adverse event that satisfies at least one of the following characteristics:

- Results in death;
- Is life-threatening;

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9. Morte o grave danno per caduta di paziente;
10. Suicidio o tentato suicidio di paziente in ospedale;
11. Violenza su paziente;
12. Atti di violenza a danno di operatore;
13. Morte o grave danno conseguente ad un malfunzionamento del sistema di trasporto (intraospedaliero, extraospedaliero);
14. Morte o grave danno conseguente a non corretta attribuzione del codice triage nella Centrale operativa 118 e/o all'interno del Pronto Soccorso;
15. Morte o grave danno imprevisti conseguente ad intervento chirurgico;
16. Ogni altro evento avverso che causa morte o grave danno al paziente.

- Requires hospitalization or prolonged or existing hospitalization;
- Results in persistent or significant disability or incapacity;
- Consists of a congenital anomaly or birth defect;
- Anything the Investigator deems to be of clinical significance.

The Medicine for Human Use (Clinical Trials) Regulations (2004) and the European Clinical Trials Directive 2001/20/EC affirm that a serious adverse event refers to an event where the individual subject was put at risk of harm at the time of the event. It is not a serious adverse event if it has not occurred, yet might occur. A hypothetical situation is not a serious adverse event. Just observing the two lists one notices that in Italy the borders of the evento sentinella are wider, they in fact also include, among others, damages suffered during the transportation by ambulance, or due to an incorrect evaluation of risk in the triage phase, suicides and near misses suicides committed by patients during hospitalization and violence carried out by the staff.

Chapter 4

Med-mal data

In this chapter we will present some data about the medical malpractice problem. The first section will analyse the Italian situation, while the second part will offer a brief look on the same subject but faced from other developed countries.

4.1 Italy

From an investigation made in 2011 by Riccardo Tartaglia, director of Centro Gestione Rischio Clinico e Sicurezza del Paziente of Tuscany, and based on the situation of 5 hospitals but extended to whole country, results that 5,2% of patients which correspond to almost 500 thousand people suffer from an adverse event and, among them, 45 thousand people would die.

This investigation has to be managed with attention because its results are based on a very small set of data, although the percentage is in line with international studies in this field. According to an estimate conducted by the Politecnico of Milan, more than 320 thousand patients over 8 millions have reported injuries (near to 4%). Since there is no information on the damages, we have to imagine them on a scale, from minor severity up to death.

Moreover, to get some additional information on the medical malpractice, it is possible to read the report that the department of health regularly publishes. On April, 2015 has been uploaded the 5th report on the eventi sentinella, with the final purpose of informing and monitoring the problem, coherently with the European Directive 24/2011 and in line with the Agreement of March 20, 2008 and transposed into the Ministerial Decree of December 11, 2009, known as SIMES (Sistema Informativo per il Monitoraggio degli Errori in Sanità).

The period covered goes from September 2005 to December 2012 and in the tables below you can find the results of the 1918 sentinel events monitored.

Type of event	#	%
Morte o grave danno per caduta di paziente	471	24.6
Suicidio o tentato suicidio di paziente in ospedale	295	15.4
Ogni altro evento avverso che causa morte o grave danno al paziente	275	14.3
Atti di violenza a danno di operatore	165	8.6
Strumento o altro materiale lasciato all'interno del sito chirurgico che richieda un successivo intervento o ulteriori procedure	159	8.29
Morte o grave danno imprevisto conseguente ad intervento chirurgico	135	7.04
Morte o disabilità permanente in neonato sano di peso >2500 grammi non correlata a malattia congenita	82	4.28
Morte, coma o gravi alterazioni funzionali derivati da errori in terapia farmacologica	79	4.12
Reazione trasfusionale conseguente ad incompatibilità AB0	72	3.75
Morte materna o malattia grave correlata al travaglio e/o parto	55	2.87
Errata procedura su paziente corretto	32	1.67
Morte o grave danno conseguente ad inadeguata attribuzione del codice triage nella centrale operativa 118 e/o all'interno del pronto soccorso	27	1.41
Procedura chirurgica in parte del corpo sbagliata (lato, organo o parte)	26	1.36
Procedura in paziente sbagliato	16	0.83
Morte o grave danno conseguente ad un malfunzionamento del sistema di trasporto (intraospedaliero, extraospedaliero)	15	0.78
Violenza su paziente in ospedale	14	0.73

Table 4.1: Classification of the Eventi Sentinella with respect to the tipology of risks suffered during the period 2005-2012 in Italy.

Specialties	#	%
Medicina generale	261	13.61
Ostetricia e ginecologia	207	10.79
Chirurgia generale	205	10.69
Psichiatria	152	7.92
Ortopedia e traumatologia	116	6.05
Astanteria	115	6
Cardiologia	44	2.29
Recupero e riabilitazione	44	2.29
Non specificato	221	11.52
Altro	553	28.84

Table 4.2: Classification of the Eventi Sentinella with respect to the medical specialties during the period 2005-2012 in Italy.

The last part of the report is a discussion on the data under analysis and what is really important to observe is that the monitoring and reporting strategy adopted

Place of occurrence	#	%
Reparto di degenza	753	39.26
Sala operatoria	359	18.72
Bagni	130	6.78
Ambulatorio	104	5.42
Domicilio	72	3.75
Corridoio	62	3.23
Terapia intensiva	54	2.82
Ambulanza	39	2.03
Scale	23	1.2
Non specificato	53	2.76
Altro	269	14.03

Table 4.3: Classification of the Eventi Sentinella with respect to place of occurrence during the period 2005-2012 in Italy.

Outcome	#	%
Morte	683	35.61
Trauma maggiore conseguente a caduta di paziente	305	15.9
Reintervento chirurgico	203	10.58
Trasferimento ad una unità semintensiva o intensiva	101	5.27
Stato di malattia che determina prolungamento della degenza o cronicizzazione	91	4.74
Reazione trasfusionale conseguente ad incompatibilità AB0	43	2.24
Disabilità permanente	34	1.77
Richiesta di trattamenti psichiatrici e psicologici specifici in conseguenza di tentativi di suicidio o violenza subita nell'ambito della struttura	28	1.46
Coma	24	1.25
Rianimazione cardio respiratoria	13	0.68
Altro	393	20.49

Table 4.4: Classification of the Eventi Sentinella with respect to the outcomes during the period 2005-2012 in Italy.

is not sufficient to discover all the sentinel events that really happened. Despite a persistent phenomenon of under reporting, it is noted for 2012 a substantial increasing trend in the number of reports compared to 2011: it passes from 407 reports to 466 and, moreover, only 19 over 29 regions of Italy have been considered.

Comparing the different areas of Italy, it emerges that the number and the typology of the reports has a very high variability. From the insurance point of view these data show the importance of analysing each single case in order to exactly quantify the amount of preventable events. There exists a high correlation in between sentinel events and claim reimbursements, it will be possible to verify it in the second part of this work.

As the perimeter of the potential errors is quite extended, an important point could be discovering the percentage of the events whose responsibility is in the hands of the doctor or the health facility. In Italy what has to be considered as med-mal is not so clear, mainly due to the different pronunciations of the judiciary, that have moved the borders of obligations over time and the activism of lawyers that have contributed to rise up the amount of claim reimbursements, either in terms of volume or in terms of monetary sums.

According to ANIA (Associazione Nazionale Imprese di Assicurazione), refund requests are about 30 thousand per year and the time necessary to get the sentence can last many years. According to a European investigation of 2013, Italy is the worst country in Europe under the efficiency point of view concerning the expected time for a sentence in the civil courts.

Country	at 1/1/2010	New cases	Closed cases	at 12/31/2010
Italy	4 263 961	2 399 530	2 834 879	3 828 612
Spain	1 362 790	1 940 277	1 816 559	1 438 719
France	1 318 782	1 793 299	1 764 255	1 347 826
Germany	803 757	1 581 762	1 586 654	798 865
Romania	462 023	1 073 669	963 742	571 950
Russia	450 306	13 649 662	13 627 319	472 649
Poland	344 160	819 861	778 641	385 035
Portugal	372 085	314 317	320 267	366 135

Table 4.5: Evolution of the number of sentences in the European civil courts.

In Italy the situation of medical third part liability is quite confused because of the lack of a unique and specific rule. This is a direct consequence to a period of monetary losses suffered by the insurances, difficulties in the actuarial computations, a certain grade of subjectivity in the estimation of the refunds and a legislative environment in continuous development towards an increasing evaluation of human suffering and injuries, were the main causes of the exit of the Italian insurance companies from the market of the medical third part liability. Nowadays there are three different models adopted by the health facilities, respectively known as Insured model, Self-insured retention strategy or a Mix between the two. Let's analyse them:

- Insured model: in this kind of model the health facility, in particular the hospital, decides of transferring all the risk bore to the insurer, by paying the premium of the policy. In this setting we observe the insured being completely safe because at worst he will be called to pay only a very small part of the refunds, in terms of deductibles. Conversely, this situation of relative safety has a very high price because the bigger is the risk underwritten by the insurer, the higher is the premium asked in order to bear that risk.

- Self-insured retention: with the adoption of a total retention strategy, we assist to the lack of an underwriting policy in favour of a complete self-insurance setting. As consequence, the hospital will not pay any kind of premium and it will be necessary to manage in a different way the money saved, in order to guarantee the solvability of the hospitals when it will be called to pay back all the claims happened. In this kind of situation is fundamental improving an optimal allocation of the capital into a guarantee fund that have to be modelled according to the evolution of the reserves and considering the obligations towards the aggrieved party.

- Mixed model: this strategy is a mix between the two previous methods of managing risk. It is characterized by the introduction of one or more thresholds that define the accountability of the claim amount. Generally, the first threshold is a deductible, under which all the amount has to be paid by the hospital, while the excess is covered by the insurance company.

Opening date / Closing date	1990	1993	1999	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
2010						**1**	**1**	**5**	**4**	**9**	**15**	**17**	**22**					**74**
Civil court									2	2	5	2	2					13
Deal						1	1	4	2	6	9	14	19					56
Penal court								1		1	1	1	1					5
2011			**1**	**2**	**1**	**2**	**1**	**5**	**4**	**3**	**10**	**17**	**26**	**30**				**102**
Civil court						1	1	2			1	5	1	2				13
Deal			1	2	1	1		2	4	3	9	12	21	27				83
Penal court								1					4	1				6
2012					**1**	**1**	**1**	**1**	**1**	**6**	**4**	**3**	**9**	**22**	**24**			**73**
Civil court													1					1
Deal					1	1	1	1	1	6	4	3	7	22	23			70
Penal court													1		1			2
2013		**1**		**1**		**4**	**2**	**4**	**1**	**1**	**8**	**6**	**4**	**14**	**29**	**36**		**111**
Civil court											1	1		2		1		5
Deal		1		1		4	2	4	1		7	4	3	12	27	34		100
Penal court										1		1	1		2	1		6
2014	**1**					**2**	**2**	**1**				**3**	**2**	**3**	**7**	**19**	**6**	**46**
Deal	1					2	2	1				3	2	3	7	16	4	41
Penal court																3	2	5
Total	**1**	**1**	**1**	**3**	**2**	**10**	**7**	**16**	**10**	**19**	**37**	**46**	**63**	**69**	**60**	**55**	**6**	**406**

Table 4.6: Dispute resolution for those claims that require broker's intervention by creating a reserve.

Opening date Closing date	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
2010		**1**		**4**	**4**		**12**	**12**	**14**				**47**
Civil court				1			2						3
Deal		1		3	4		10	12	13				43
Penal court									1				1
2011			**1**	**1**	**1**	**1**	**4**	**4**	**9**	**10**			**31**
Civil court								1					1
Deal			1	1	1	1	4	3	9	8			28
Penal court										2			2
2012	**1**				**2**	**3**	**2**	**5**	**1**	**14**	**16**		**44**
Deal	1				2	3	2	5	1	14	16		44
2013							**1**	**1**	**1**		**4**	**3**	**10**
Civil court											1		1
Deal							1	1	1		3	2	8
Penal court												1	1
2014									**1**				**1**
Deal									1				1
Total	**1**	**1**	**1**	**5**	**7**	**4**	**19**	**22**	**26**	**24**	**20**	**3**	**133**

Table 4.7: Dispute resolution for those claims that require broker's intervention in refunding the claim amount.

4.2 USA

In USA the medical malpractice problem has a longer historical background than in Italy and nowadays it represents one of the most developed countries facing this matter. That's why we are referring to USA, in order to learn the strategies adopted to face the problem. The first malpractice crisis occurred in the USA in the decade between 1970 and 1980. Beginning in 1975, many states enacted changes in tort law; perhaps most notable was California's Medical Injury Compensation Reform Act, also known with its acronym MICRA. MICRA set a 250,000$ cap on noneconomic damage awards along with other changes in tort law. A dozen other states adopted similar forms of tort reform in the 1970s which are very well explained by Morrisey *et al.* (2007).

The second crisis occurred almost ten years later. Posner (1986) reports that malpractice premiums increased by 20–40 percent overall in 1984 and by 50–100 percent in some areas. In particular, a number of states enacted caps on noneconomic damages or revisited their earlier statutes.

The most recent crisis began with steep premium increases in 2002. Medical Liability Monitor (2005) reported increases of 10–49 percent, depending upon specialty, in 2003 and 7–25 percent in 2004 after several years when increases were little more than the rate of inflation.

The economic theory of torts and tort reform has been well summarized by Danzon (2000). The intent of tort law is to provide incentives for providers to deliver optimally efficient care.

In the following pages we will represent the American situation adopting as reference text one of the most known report in the American literature about medical malpractice: To Err is Human, published by the Institute of Medicine in 1999. From this report it is clear that medical malpractice is a challenging problem for the whole health care system but, it is also evident that USA has moved important steps to contain the phenomenon.

In the report, the terms error and adverse event will be used according to following definition:

> *An error is defined as the failure of a planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning). An adverse event is an injury caused by medical management rather than the underlying condition of the patient. An adverse event attributable to error is a preventable adverse event. Negligent adverse events represent a subset of preventable adverse events that satisfy legal criteria used in determining negligence (i.e., whether*

the care provided failed to meet the standard of care reasonably expected of an avergage physician qualified to take care of the patient in question).

Two large studies, one conducted in Colorado and Utah using 1992 data and the other in New York using 1984 data, found that adverse events occurred in 2.9 and 3.7 percent of hospitalizations, respectively. It is also evident that in Colorado and Utah hospitals, 6.6 percent of adverse events led to death, as compared with 13.6 percent in New York hospitals. Moreover, both the studies found that the proportion of hospital admissions experiencing an adverse event, defined as injuries caused by medical management, were 2.9 and 3.7 percent, respectively. The proportion of adverse events attributable to errors, the so-called preventable adverse events, was 58 percent in New York and 53 percent in Colorado and Utah.

Preventable adverse events are a leading cause of death in the USA. Considering these two percentages as correct and homogeneous to the rest of the States, it is possible to obtain a range of the number of deaths due to this cause. When extrapolated to the over 33.6 million admissions to hospitals in 1997, the results of these two studies imply that at least 44 000 and perhaps as many as 98 000 Americans die in hospitals each year as a result of medical errors. Comparing this number with the deaths attributable to motor vehicle accident, breast cancer or AIDS in the same period, we can easily understand the severity of the subject. The comparison is shown graphically.

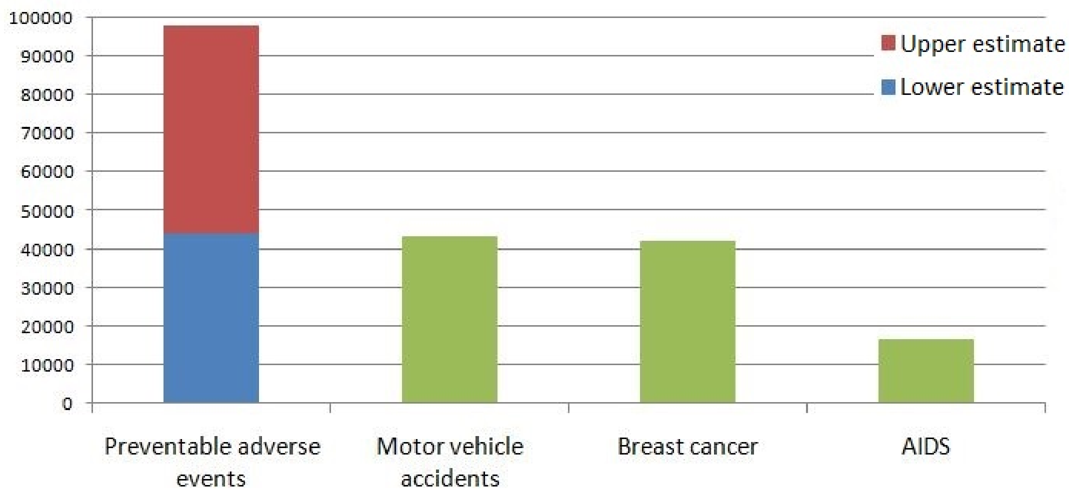

Figure 4.1: Comparison between some leading causes of death in the USA. Preventable adverse events are represented by a lower estimate and an upper one due to the parameter adopted in the extrapolation.

Notice that adopting the lower estimate as reference point we would obtain that deaths due to medical errors exceed the number attributable to the 8th-leading cause of death. In terms of lives lost, patient safety is as important issue as worker safety. Every year, over 6 000 Americans die from workplace injuries. Medication errors alone, occurring either in or out of the hospital, are estimated to account for over 7 000 deaths annually, one out of 131 outpatient deaths and one out of 854 inpatient deaths.

If we consider the same problem under an economic point of view, instead of a quantitative sight, we discover that the total national costs (including lost income, lost household production, disability, health care costs) are estimated to be between 37.6 billion dollars and 50 billion dollars for adverse events and between 17 billion dollars and 29 billion dollars for preventable adverse events. Health care costs account for over one-half of the total costs. Even when using the lower estimates, the total national costs associated with adverse events and preventable adverse events represent approximately 4 percent and 2 percent, respectively, of national health expenditures in 1996.

Chapter 5

Legislative Environment

Health insurance is common to most of the countries all over the world, but the mechanism for obtaining assurance differs from country to country. In most countries, health insurance is universal: it means that everyone is entitled to coverage. Sometimes we can find some particular exclusions, such as Germany, where temporary workers do not receive health insurance, but they comprise a small part of the population. In some nations, such as Canada, the financing is done through taxation: people pay an income and the proceeds are used by the government to purchase health insurance. In other countries, the financing is through private insurance: so the citizens themselves or the employers contribute to health insurance companies, which then provide insurance for the insured. In this kind of countries the universality of insurance is not guaranteed. Italy finance health insurance through general taxation and provide services publicly, even if in the last few decades some hospitals have been set up as private trusts. In the following pages it will be possible to read a brief analysis on the Italian legislative system. The structure of the chapter is divided into two parts: the former is an introduction and wants to appear as a picture of the actual situation, the latter is richer in details but the references to the Italian code are in the original language.

5.1 Introduction

Recent legislative initiatives, such as the decree-law 138/2011[1] and the so-called Balduzzi law[2] have sparked debate over the medical malpractice in Italy, focusing on the third party liability for health facilities. To better understand all the problems referring to the insurance policies of third party liability it is necessary to consider the evolution of clinical risk. The main issues that marked either the medical profession or the insurance behaviour can be quickly resumed as follows:

- scientific progress of medicine and more and more sophisticated technologies have created new typologies of risk and uncertainty and, consequently, new responsibilities. It seems a paradox but in the past medical error was considered as something hardly inevitable, because of a profession subject to human fallibility, while nowadays the adverse event is not tolerable;
- an increasing tendency to resort to judicial authority when expectations are dashed;
- strong pressure from the media to amplify in a sensationalist way cases of medical liability, resulting in a growing distrust of medical profession;
- enlargement of the system protections recognized in favour of the patient, resulting into an increasing number of controversies managed by the civil Courts.

As consequence, Italy is facing a deep crisis in the insurance sector, especially concerning to medical and health facilities, due to the increment in the cost of claim refunds and its impact on the insurance premiums.

Italian insurance companies have progressively abandoned the market of medical third party liability to foreign companies. In this context, after years characterized by the lack of intervention from the Government, we are assisting to a difficult tentative of changing the trend by means of the above mentioned decrees.

[1]D.Lgs. 13 agosto 2011, n.138 (convertito in legge, con modificazioni, dall'art.1, comma 1, L.14 settembre 2011, n.148) *Ulteriori misure urgenti per la stabilizzazione finanziaria e per lo sviluppo.* All'art.3, comma 5, lett.e) è previsto: *a tutela del cliente, il professionista è tenuto a stipulare idonea assicurazione per rischi derivanti dall'esercizio dell'attività professionale. Il professionista deve rendere noti al cliente, al momento dell'assunzione dell'incarico, gli estremi della polizza stipulata per la responsabilità professionale e il relativo massimale. Le condizioni generali delle polizze assicurative di cui al presente comma possono essere negoziate, in convenzione con i propri iscritti, dai Consigli nazionali e dagli enti previdenziali dei professionisti.*

[2]D.Lgs. 13 settembre 2012, n.158 (convertito in legge, con modificazioni, dall'art.1, comma 1, L.8 novembre 2012, n.189) *Disposizioni urgenti per promuovere lo sviluppo del Paese mediante un più alto livello di tutela della salute.* L'art.3 è rubricato *Responsabilità professionale dell'esercente e professioni sanitarie.*

5.2 General Principles

According to the Italian civil code, the insurance contracts we are describing are amended by the art.1917, comma 1, that enshrines:

> *Nell'assicurazione della responsabilità civile l'assicuratore è obbligato a tenere indenne l'assicurato di quanto questi, in conseguenza del fatto accaduto durante il tempo dell'assicurazione, deve pagare a un terzo, in dipendenza della responsabilità dedotta nel contratto.*

As we can notice the borders of this formulation are very wide and the direct consequence is that a particular attention must be paid either to the clauses that denote the objects covered, or to the limits of the policy.

In 1999 the Italian Court of Cassation introduced a leading sentence in our legal system: by the law n.589/1999, the relationship between patient and health system is modified into a particular kind of contract whose nature is defined as "social contact". In the very same moment that someone asks for help to a physician (or to a hospital), the latter accepts to take care of him, according to the Supreme Court this is the heart of the implicit contract existing between the two counterparts: physician and patient. As direct consequence it is given to the patient the right to ask for a refund in case of either injuries or bad results.

> *L'obbligazione del medico dipendente dal servizio sanitario per responsabilitá professionale nei confronti del paziente, ancorché non fondata sul contratto, ma sul contatto sociale ha natura contrattuale. Consegue che relativamente a tale responsabilitá i regimi della ripartizione dell'onere della prova, del grado della colpa e della prescrizione sono quelli tipici delle obbligazioni da contratto d'opera intellettuale professionale.*

Before this intervention, the Legislator tried to discipline an insurance obligation of the health facilities to cover, by means of an insurance policy, the medical employees. The art.29 of D.P.R. 27 marzo 1969, n.130, enacted:

> *Le amministrazioni ospedaliere devono garantire l'ente e il personale dipendente, mediante adeguata polizza di assicurazione per la responsabilità civile, dalle eventuali conseguenze derivanti da azioni giudiziarie promosse da terzi, ivi comprese le spese di giudizio relativamente alla loro attività di servizio ospedaliero, senza diritto di rivalsa, salvo i casi di colpa grave o dolo.*

The previous discipline has changed over time and not it is considered out of date. It has been discussed for a long time also the art.3, comma 59 of the financial law of 2008, that affirms:

> *È nullo il contratto di assicurazione con il quale un ente pubblico assicuri i propri amministratori per i rischi derivanti dall'espletamento di compiti istituzionali connessi con la carica e riguardanti la responsabilità per danni cagionati allo Stato o a enti pubblici e la responsabilità contabile. I contratti di assicurazione in corso alla data di entrata in vigore della presente legge cessano di avere efficacia alla data del 30 giugno 2008. In caso di violazione della presente disposizione, l'amministratore che pone in essere o che proponga il contratto di assicurazione e il beneficiario della copertura assicurativa sono tenuti al rimborso, a titolo di danno erariale, di una somma pari a dieci volte l'ammontare dei premi complessivamente stabiliti nel contratto medesimo.*

Therefore, all the managers and the medical employees too, due to an extension of the mentioned article, interested in being covered from the risk of negligence had to pay for en extra individual insurance contract. Before 2008, the health facilities had the possibility of adding the so-called *rinuncia alla rivalsa* in the insurance policy in order to keep safe managers or medical employees whose negligence was ascertained.

Let's now focus on the two articles, mentioned in the first paragraph of this chapter due to their implications on the actual situation. The D.Lgs. 13 agosto 2011, n.138 (convertito in legge, con modificazioni, dall'art.1, comma 1, L.14 settembre 2011, n.148) established *a tutela del cliente [...] di stipulare idonea assicurazione per i rischi derivanti dall'esercizio dell'attività professionale [...] e di rendere noti al cliente, al momento dell'assunzione dell'incarico, gli estremi della polizza stipulata per la responsabilità professionale ed il relativo massimale.*

Aware that what prompted concerns only doctors who perform as professionals, we decided to focus on it because of two interesting matters concerning the article:

- the principles behind the precept are directed to provide protection to customers, forcing the professionals to underwrite insurance policy;
- the obligation to provide information needs to be regulated with a new and specific law not to increase the number of litigations in the civil Courts because of the lack of minimal requirements in the mentioned article.

Art.3, comma 2, of the decree-law of 13 settembre 2012, n.158 converted into law 8 novembre 2012, n.189 (the so-called Balduzzi Decree, from the name of the

Minister of Health in charge at the time of its enactment) has to be pointed out because of the relevant impact on the medical third party liability. This article, according to *Relazione illustrativa al provvedimento di legge*, would offer a possible solution to the phenomenon of defensive medicine, consisting in a relevant increasing cost for the health care system and as consequence, it represents also a problem connected to the medical third party liability due to its impact on the average premiums paid.

Defensive medicine refers to the practice of recommending a diagnostic test or treatment that is not necessarily the best option for the patient, but an option that mainly serves the function to protect the physician against the patient as potential plaintiff. Defensive medicine is a reaction to the rising costs of malpractice insurance premiums and patients' biases on suing for missed or delayed diagnosis or treatment but not for being over diagnosed.

What is really important is considering this Decree as the first intervention of the Government in this field, after years of silence. However the Legislator's choice is too limited and an intervention with wider borders is hopefully waited for. This law containing *Disposizioni urgenti per promuovere lo sviluppo del Paese mediante un più alto livello della salute* has generated some problems, in particular we refer to art.3, comma 2:

> *Art.3 - Responsabilità professionale dell'esercente le professioni sanitarie [...] 2. Con decreto del Presidente della Repubblica, adottato ai sensi dell'articolo 17, comma 1, della legge 23 agosto 1988, n.400, (da emanare entro il 30 giugno 2013) [...] anche in attuazione dell'articolo 3, comma 5, lettera e), del decreto-legge 13 agosto 2011, n.138, convertito con modificazioni dalla legge 14 settembre 2011, n.148, al fine di agevolare l'accesso alla copertura assicurativa agli esercenti le professioni sanitarie, sono disciplinati le procedure e i requisiti minimi e uniformi per l'idoneità dei relativi contratti, in conformità ai seguenti criteri [...]*

This regulatory is not ready yet[3]. Morever, thanks to this Decree we assist to the introduction of *buone pratiche* whose meaning is best practice, which is a form of program evaluation in public policy in order to guarantee the protection of the physician from a possible plaintiff.

> *L'esercente la professione sanitaria che nello svolgimento della propria attività si attiene a linee guida e buone pratiche accreditate dalla co-*

[3]The Department of Health has proposed a scratch of the regulatory for the professional third party liability, according to Balduzzi Decree. It is possible to read it on the website www.quotidianosanita.it looking for *Rc professionale. Pronto il regolamento. Arriva il fondo rischi sanitari. Durata minima 3 anni e forti limiti al recesso.*

> *munità scientifica non risponde penalmente per colpa lieve. In tali casi risulta comunque fermo l'obbligo di cui all'articolo 2043 del codice civile. Il giudice, anche nella determinazione del risarcimento del danno, tiene debitamente conto della condotta di cui al primo periodo.*

The problem of the assumption is that the Decree does not identify neither the guide lines nor the best practices that must be adopted, leaving the arbitrage upon the judge of the trial.

Chapter 6

Introduction to Agent-based model

6.1 Simulation modelling in health care domain

This chapter has the purpose of introducing the reader into the world of simulation modelling in health care domain in order to inform him/her about the importance of such kind of tool for different kinds of inquiries. We will show the long tradition and the historical background of these kinds of applications, to understand in a better way the area in which we will work by constructing a model of our own.

Use of simulation plays a central role in assisting decision maker in the field of health care, as Kirchhof and Meseth (2012) point out. This is due to the intrinsic uncertainty that permeates every aspect of human life such as health care needs. Computer modelling and simulation tools allow the user of creating an environment very similar to the real one, based on evidences and rational rules able to recreate complex systems in order to conduct analysis like testing some possible scenarios or estimating the impact of introducing changes into the model. This is a competitive alternative to the trial-and-error process or to empirical research as it emerges in Fone *et al.* (2003).

Moreover, Heath *et al.* (2009) state that simulation methods have long been used to model elements belonging to health care system to reach different goals depending on the modeller's level of understanding of the system to be simulated. In particular it is suggested to split the simulations into three categories:

- When the level of understanding is high, a simulation can be used as a *predictor* because the machine is able to produce clear predictions about the system's behaviour under defined conditions.

- If the level of understanding can be considered as medium, a simulation model plays the role of *mediator*, which provides insight into the behaviour of the system without offering a complete representation of that behaviour.

- If the level of understanding is low, the use of a simulation model can be limited to the role of *generator* to support the generation of hypothesis and theories about the system behaviour, but not in a precise manner.

Even though the high degree of possible use of the simulation tool, there still exist a very poor adoption of this instrument in the role of assisting decision maker. In this sense, there is a surprising result obtained by Eldabi (2009) according to which only few studies conducted in the health care domain are supported by simulation tools when the subject is a real-life problem. In the following graph there is the result of his cross-sectoral study. This work is aimed at showing the prevalence of theoretical work in contrast to practical applications in healthcare simulation. The bar is split in three categories (A,B and C), whose dimensions represent the percentage of each category within health care domain. The first category includes those articles inspecting real problem with real stakeholders. The second one contains papers addressing real-life problems without engagement for real stakeholders. The last category is filled by entirely theoretical papers.

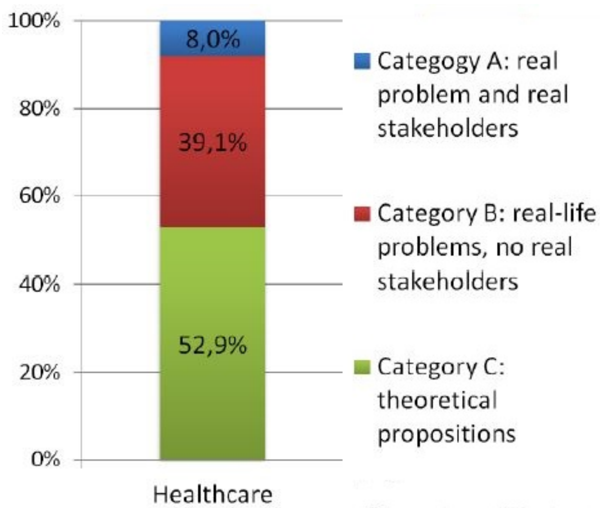

Figure 6.1: Cross-sectoral comparison of simulations in the health care domain.

A further step can be done in order to evaluate either the quality or the value of computer simulation modelling in population health and healthcare delivery. There exists a study made by Fone *et al.* (2003) which helps us in doing it properly. The authors carried out a systematic review of world literature from 1980 to 1999. Papers were included within such review if containing two elements: a computer simulation model of individuals in a stochastic system and a setting related to population health or health service delivery. Among all the papers, 182 met the inclusion criteria only. Moreover, they found out that, even if the quality of papers is variable, it is improving over time. So, although the lack of implementation is one of the most characteristic problem associated to modelling, still the potential of simulation tools in providing aid to policy development is clear.

Finally, RIGHT (Research Into Global Healthcare Tool) which is a collaborative research venture between six UK universities, whose main aim is to assess the feasibility of applying to decision making in healthcare some of the most successful modelling and simulation methods. The type of modelling taken into account by such project is the one based on a structured approach to understand, and possibly solving, a real-world problem by developing a simplified version of the real world. The projects dealt by RIGHT are 342 research works, whose publication dates range from 1952 to 2007. The 82% of the papers has been published after 1990. It is clear that most of studies has been undertaken in North America and Europe. This represents the first result of such review.

An other important emerging outcome concerns the analysis of publications. First of all they have been divided into six categories, according to the type of modelling prevailing, which are: qualitative modelling, mathematical modelling, statistical modelling, statistical analysis, simulation and other, which is a residual class. A smaller but significant number employ mathematical modelling, very few belong to the residual category. It is interesting to notice that where qualitative methods are used, they are very often a subsidiary method, while where mathematical methods are used, they almost represent the primary instrument.

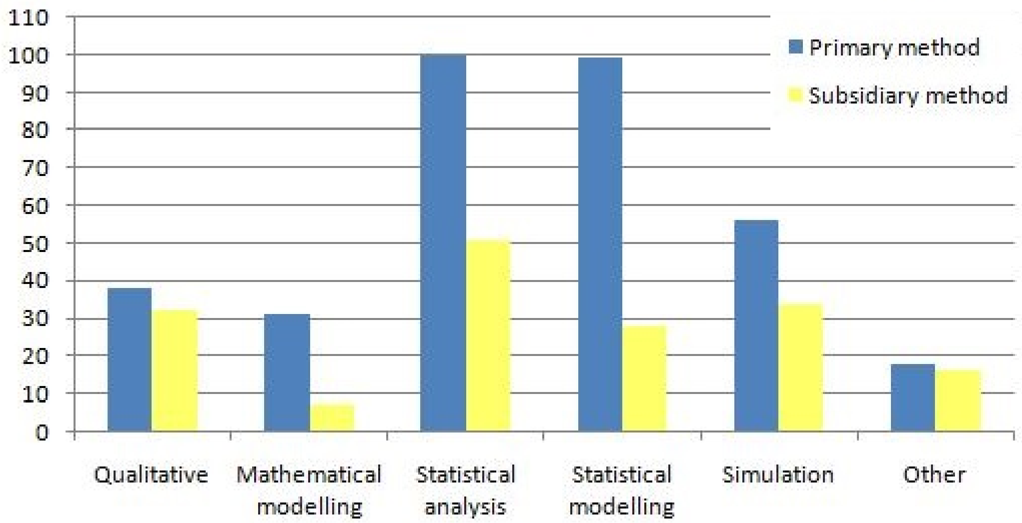

Figure 6.2: Classification of research works according to the prevailing type of modelling.

The level of implementation is the last point the research project has focused its attention on. The extent to which the model has actually been used in practice for its stated purpose represents a key aspect of any study. Each modelling study was rated according to a three-level scale of implementation:

- Suggested: it means that the author has theoretically proposed it;
- Conceptualized: it means that the model has been discussed with a client organization;
- Implemented: the model is used in practice.

According to these classes the articles have been rated as follows: Suggested(50%), Conceptualized (44.7%) and Implemented (5.3%). The emerging situation is quite negative, almost one out of twenty research works in health-care domain is actually used in practice.

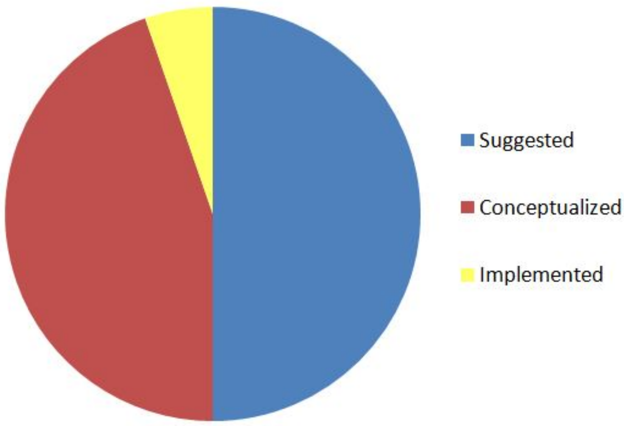

Figure 6.3: Modelling studies split into a three-level scale of implementation.

As Boero *et al.* (2015) points out, although in economics, even in recent times, there are many examples of fruitful integration of empirical data and theory development, it is also quite usual to find evidence of a over-strict separation between theory and data. This setting is naturally based on a double consideration: from one perspective this rigid classification leads to theoretical developments that rely more on theoretical consistency than on empirical salience, while, from the opposite perspective, evidence from empirical studies is often not studied in depth because it can not be harmonized with pre-existing theories. Among the many causes of this phenomenon is the lack of flexibility in the tools traditionally used in economics. To a certain degree, common formalism in economics do not always support the linkage with empirical data, and in empirical analysis relying on equation-based models, like most econometric models, there is difficulty in identifying clear causal relationships and other challenges beyond causality. The technical limitations of traditional tools in economics oblige researchers who adopt them to give uo a degree of realism, and to accept compromises whose consequences are difficult to evaluate.

Generally speaking, Agent-based models (ABMs) avoid this trade-off by allowing a large degree of integration between theoretical and empirical knowledge. With this new kind of tool it is possible to use empirical knowledge in theoretical analysis, allowing researchers both to leave intact the loop of scientific discovery that goes back and forth between theory and data, and to properly address the different kinds of applied research questions posed by contemporary world. The extensive adoption of the ABMs to social and natural phenomena could really play an important role towards the comprehension of the relationship between the variables considered. This is possible because agent-based approach has a positive impact either on the explanation of phenomena and on theory development, or on applied and predictive analyses. This is possible because the language adopted is not a limit any more as the case of equation-based models. Another crucial aspect of ABMs is that the level of heterogeneity between the agents characterizing a phenomenon can reach surprisingly high degree of freedom, in the sense that agents can be modelled one by one, with completely different behaviour and characteristics, while the equation-based models are bound to a very low level of heterogeneity because of the difficulty of representing all the possible behaviours by equations. As Boero *et al.* (2015, p. 8) write:

> *ABMs can provide more realism in modelling economic phenomena. ABMs can thus improve the analysis of economic phenomena for both positive and normative aims, and by means of both theoretical and applied research. In particular, ABMs provide the ability to more accurately model the causal mechanisms determining economic phenomena. They are formal tools, and they allow for a great level of empirical validation, thus enabling more accurate what-if analyses to be conducted.*

6.2 From complexity to agents

The roots of the application of agent-based models in social sciences, via the complexity view, can be found, according to Boero *et al.* (2015) in the paper *More is different* of Anderson's (1972), where it is written:

> *The reductionist hypothesis may still be a topic for controversy among philosophers, but among the great majority of active scientists I think it*

> *is accepted without question.*
> *(...) The main fallacy in this kind of thinking is that the reductionist hypothesis does not by any means imply a "constructionist" one: The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe.*
> *(...) The constructionist hypothesis breaks down when confronted with the twin difficulties of scale and complexity. The behavior of large and complex aggregates of elementary particles, it turns out, is not to be understood in terms of a simple extrapolation of the properties of a few particles. Instead, at each level of complexity entirely new properties appear, and the understanding of the new behaviors requires research which I think is as fundamental in its nature as any other.*

From this extract emerges that the real world, as also the social phenomena and the economic ones, can be considered as a very complex net populated by different agents, each one with its own characteristics and economics as a science has been simply ignoring the details for about 200 years.

Now let us clarify what agent-based models (ABMs) are, according to Axtell and Epstein's (2006) definition:

> *Compactly, in agent-based computational models a population of data structures representing individual agents is instantiated and permitted to interact. One then looks for systematic regularities, often at the macro-level, to emerge, that is, arise from the local interactions of the agents. The shorthand for this is that macroscopic regularities "grow" from the bottom-up. No equations governing the overall social structure are stipulated in multi-agent computational modeling, thus avoiding any aggregation or misspecification bias. Typically, the only equations present are those used by individual agents for decision-making. Different agents may have different decision rules and different information; usually, no agents have global information, and the behavioral rules involve bounded computational capacities – the agents are "simple". This relatively new methodology facilitates modeling agent heterogeneity, boundedly rational behavior, non-equilibrium dynamics, and spatial processes. A particularly natural way to implement agent-based models is through so-called object-oriented programming.*

Another way of viewing to ABMs is that of considering them as tools useful to produce knowledge, as in Axelrod and Tesfatsion (2005):

Simulation in general, and ABM in particular, is a third way of doing science in addition to deduction and induction. Scientists use deduction to derive theorems from assumptions, and induction to find patterns in empirical data. Simulation, like deduction, starts with a set of explicit assumptions. But unlike deduction, simulation does not prove theorems with generality. Instead, simulation generates data suitable for analysis by induction. Nevertheless, unlike typical induction, the simulated data come from a rigorously specified set of assumptions regarding an actual or proposed system of interest rather than direct measurements of the real world. Consequently, simulation differs from standard deduction and induction in both its implementation and its goals. Simulation permits increased understanding of systems through controlled computational experiments.

Chapter 7

Data collection

In this chapter we will present all the data received from *La città della Salute e della Scienza* di Torino about the adverse events they dealt with from the second half of 2005 to march, 2015. I collected these information thanks to the possibility of accessing to their database. The first step was to convert the original Lotus file into a new format in order to manage all the information contained in a more effective way. I decided to adopt a .txt format before adopting a spreadsheet layout because of the necessity of "cleaning" the original sample. Here you can find an example of data in .txt format to understand the entire set of information I had for each adverse event. Additionally we have to consider that the sample was composed by 959 adverse events.

```
Categoria:
Selezione:
Corpi Estranei:
Danni:
Ustioni:
Difetti Estetici:
Lesioni Nervi:
Procedura:
Procedura Diagnostica:
Correlate Intervento:
Correlate Trattamento:
Emotrasfusioni:
HIV:
RST:
Sacca Emazie:
Legionella:
```

Apergius:

Pseudomonas:

Infezioni:

DTS:

DV:

DT:

Altro:

NC:

DO:

Original Mod Time: 22/07/2010 18:20:35

Progressivo: 0482

Operatore: *Dato sensibile omesso*

Data Caricamento: 29/10/2010

Data Compilazione: 21/09/2010

Area Funzionale: Altri Servizi

Altri Servizi:

Qualifica Operatore: Infermiere Professionale

Anzianita: più di 5 anni

Note Aggiuntive: relazione allegata

Tipo Prestazione: Ricovero Ordinario

Altro Prestazione:

Luogo: sala operatoria neurochirurgia

Data Evento:

Descrizione Evento: in fase di monitoraggio post-risveglio di una paziente sottoposta ad embolizzazione di aneurisma cerebrale, non veniva effettuato monitoraggio strumentale (ruolo limitato solamente visivi: escursione respiratoria, colorito cute)

Fattori Paziente:

Altro Paziente:

Fattori Personale: Presa una scorciatoia - regole non seguite

Altro Personale:

Fattori Sistema: Mancata / inadeguata comunicazione, Mancanza / inadeguadezza attrezzature

Altro Sistema:

Altri Fattori:

Come Prevenire: adeguata comunicazione da parte dell'anestesista, che avrebbe permesso di preparare materiale e procedure (secondo quanto predisposto da LG interne sull'assistenza post-anestesiologica)

```
Fattori:  Individuazione precoce , Buona assistenza
Fattori Altri:
Cartella Clinica:  No
Comunicato Paziente:  No
Livello1:  Livello 1
Livello2:
Livello3:
Livello4:
Livello5:
Livello6:
Livello7:
Livello8:
Riaccadimento:  Frequente (più di 5 eventi l’anno)
Ulteriori Indagini:
Altre Indagini:
Azioni Intraprese:  Si
Quali:  l’evento sarà oggetto di analisi e comunicazione di Servizio
ai Dirigenti Medici della SC
Risorse:  No
Costi:  No
Organizzazione:  No
Degenza:  No
Procedure:  No
Reparti:  Si
Descrizione Reparti:
Errore Diagnosi:
Esecuzione:
Somministrazione:
Infezioni:
Altro:
```

We decided to deal only with a partition of the information contained in the original file in order to manage in a proper way the data. Therefore, we wrote two small programs using Python language with two different goals:

- First program’s objective was obtaining the exact number of adverse events and introducing some special characters to delimit the extension of each adverse event. We reached the goal editing the original database by introducing a counter before each adverse event. The code is in the next page:

```
arch=open("./Database","r")

mod_arch=open("./arch_with_ID.txt","w")

record = 0
count = 2

for line in arch:
    if line.split() == []: count = count + 1
    if count == 2:
        count = 0
        record = record + 1
        print >> mod_arch, "*** "+str(record)
    else: print >> mod_arch, line,

arch.close()
mod_arch.close()
```

- Second goal's was reducing the amount of data without loosing any relevant information. Here is the code:

```
arch=open("./arch_with_ID.txt","r")
f_arch=open("./final_arch.txt","w")

section=""
level=0
date=""
date_c=0
date_e=0
label=""
for line in arch:
    if line.find("***") != -1:
        if section != "":
            if date_e==1:
                section=section+date_event
            else:
                if date_c==1:
                    section=section+date_comp
            if words>1:
                section=section+service
            else:
                section=section+"ND,"
            if    level != 0: section=section+level+label
            else:             section=section+"LevelUnknown"
            print >> f_arch, section
            section=""
            date=""
            date_c=0
            date_e=0
            label=""

        section=section+str(int(line.split()[1]))+","
```

```
    if (line.find("Livello ") != -1 and len(line.split()) >1):
         level=line.split()[2]

    if line.find("caduta") != -1:
        label=",Caduta"

    if date_c==0:
       if (line.find("Data_Compilazione:") != -1 and len(line.split()) > 1):
          date_comp=line.split()[1]+","
          date_c=1
       else:
           if (line.find("Data_Compilazione:") != -1 and len(line.split()) == 1):
              date_comp="ND,"
              date_c=1

    if line.find("Tipo_Prestazione:") != -1:
        words=len(line.split())
        service=""
        if words > 1:
         for i in range(1,words):
             service = service+line.split()[i]
         service=service+","

    if date_e==0:
       if (line.find("Data_Evento:") != -1 and len(line.split()) > 1):
          date_event=line.split()[1]+","
          date_e=1

arch.close()
f_arch.close()
```

Brief description of the codes As we noticed that in the database each single event was preceded by two empty lines, giving the reader the possibility of recognizing the a defined adverse event, we decided to take advantage of this frame.

Therefore, our program is able to read the contents of the database line by line and recognizing when there are two consecutive empty lines. The logic adopted in doing this operation consists in asking the program to split each line of the database into its characters, when the vector is empty it means that the line observed is empty, too.

Every two consecutive empty lines, we increase the record variable by a unit, this value represent the ID of the event. Before introducing the ID number, we printed some star characters to add a more visible delimiter.

The second program has a different structure, we could think of it like a train that goes from A to B but, during its course can grow in length by adding new wagons. Obviously, A is the initial delimiter, from which on a new adverse event starts, while B is the following delimiter, that represents either the end of the information correlated to the adverse event analysed, or the starting point of a new event. Going back to the previous paragon, what is the train is the value of the variable `section`, which starts from A as only locomotive (it is an empty char variable) and reaches B with additional char information: the ID number of the adverse event, the inception date (or the upload date or ND in case dates are no available), medical specialty, the severity level of the adverse event according to the AIMS standards[1] and an additional label for the falls.

In this way we just have to print the value of the `section` variable before considering the successive adverse event to obtain all the information needed for our purposes. The additional label for the falls is due to the fact that, starting from 2014, this kind of adverse event should be managed into a different database[2]. Therefore, the label will help us by pointing out all the events that need to be transferred in addition to a second database, which is composed by only falls. Thanks to these two programs, we have been able to represent all information contained in the data in a very effective way, that we are going to show for the sake of completeness.

[1]AIMS standards define 8 severity levels as follows:

- Level 1: Near miss event characterized by a dangerous situation, potentially serious events not occurred.
- Level 2: Near miss event characterized by a dangerous situation, potentially serious events occurred but intercepted before happening.
- Level 3: it represents the events with no effect.
- Level 4: it is characterized by events with low negative impact.
- Level 5: it is composed by all those events that produce moderate damages.
- Level 6: belong to this class all the events considered in between moderate and significant severity.
- Level 7: it is characterized by all the events that procure significant damages to the patient.
- Level 8: the most dangerous class of risk, it is formed by all the events that affect the patient with extreme outcomes like death or permanent disability.

[2]In our analysis we will deal with several databases; each one containing the details for a specific class of events. Up to now we have always referred to the larger database which is composed by all the adverse events with the exceptions of: falls, dental avulsions, acts of violence and lost dentures

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	5	32	25	13	4	12	8	2	146
Ricovero ordinario	36	78	142	103	65	56	14	14	508
Intervento chirurgico	9	18	12	15	15	12	8	1	90
Prestazione ambulatoriale	9	9	13	12	7	15	3	1	69
Non dichiarato	7	13	3	10	5	3	0	3	44
Ricovero day hospital	4	12	30	25	18	8	3	2	102
Total	115	162	225	178	114	106	36	23	959

Table 7.1: Adverse events split according to category and severity level. Data represent the adverse events going from 10/2003 to 03/2015.

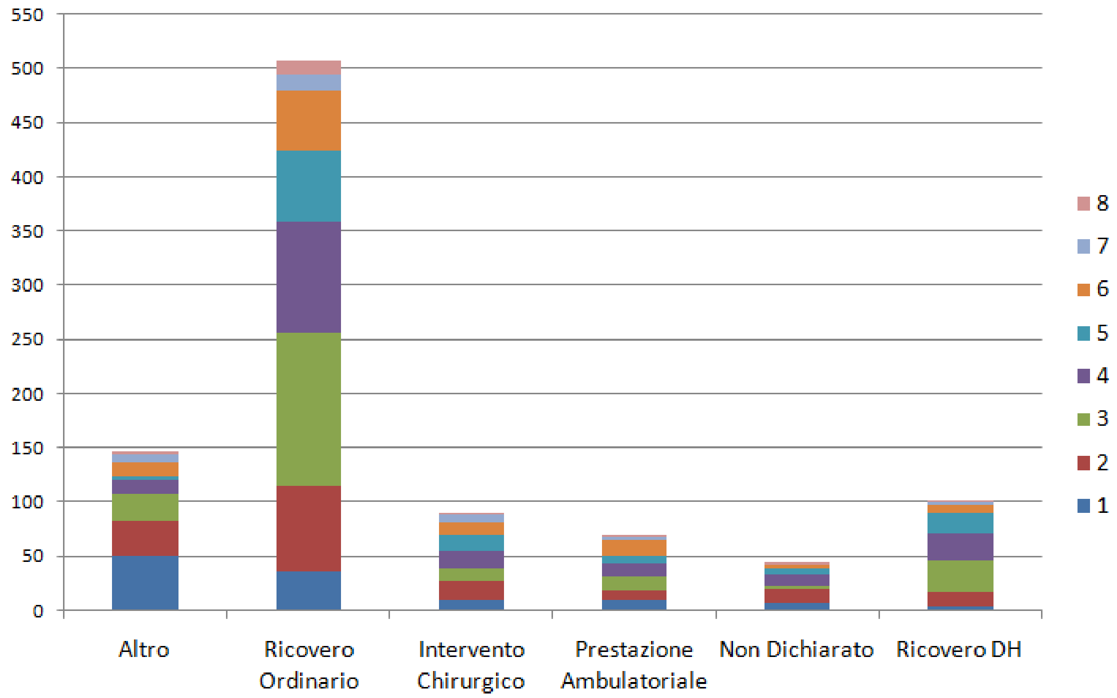

Figure 7.1: Graphical representation of table 7.1. Severity levels appear with different colours.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	1	8	4	1	0	3	2	0	19
Ricovero ordinario	4	0	1	9	3	10	1	1	29
Intervento chirurgico	0	2	1	0	2	3	4	0	12
Prestazione ambulatoriale	1	2	3	1	0	2	0	0	9
Non dichiarato	1	1	0	1	0	1	0	0	4
Ricovero day hospital	1	1	0	1	0	4	0	0	7
Total	8	14	9	13	5	23	7	1	80

Table 7.2: Adverse events split according to category and severity level. Data represent the adverse events of 2005.

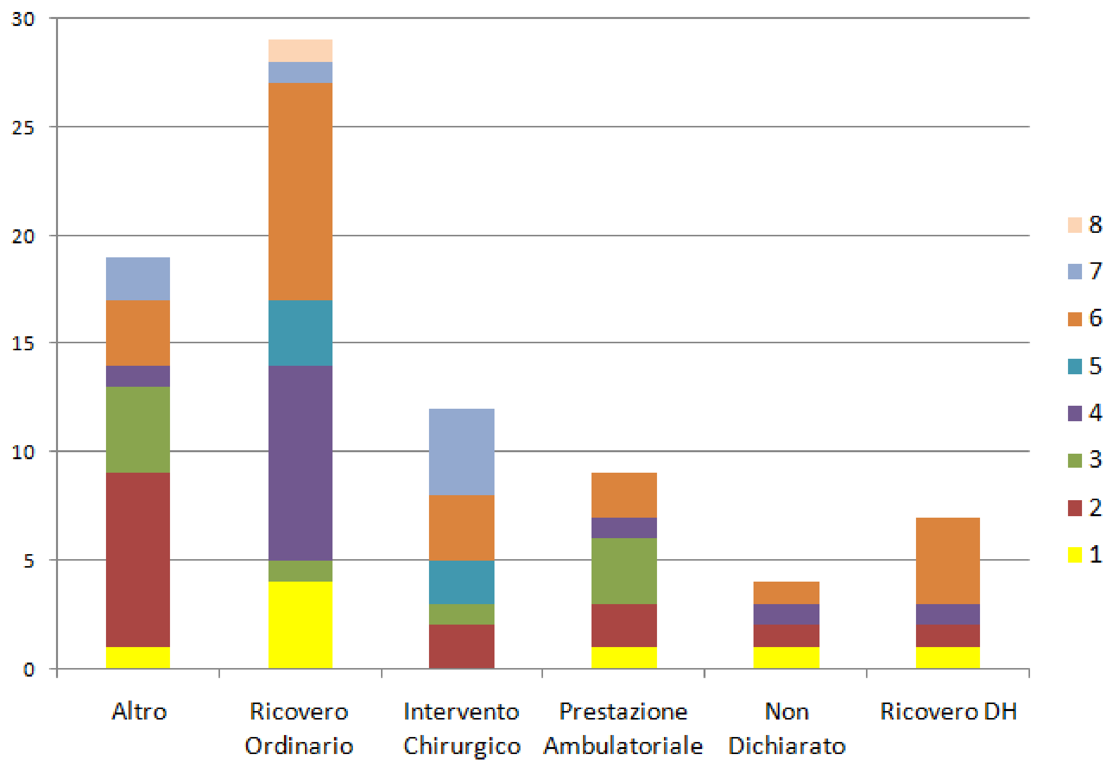

Figure 7.2: Graphical representation of table 7.2. Absolute frequency of the adverse events with inception year 2005, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	3	4	1	0	1	1	0	0	10
Ricovero ordinario	8	2	4	3	1	4	1	5	28
Intervento chirurgico	1	3	1	3	2	3	0	1	14
Prestazione ambulatoriale	1	3	0	1	2	2	1	1	11
Non dichiarato	1	0	0	0	1	0	0	0	2
Ricovero day hospital	0	1	2	2	2	1	0	1	9
Total	14	13	8	9	9	11	2	8	74

Table 7.3: Adverse events split according to category and severity level. Data represent the adverse events of 2006.

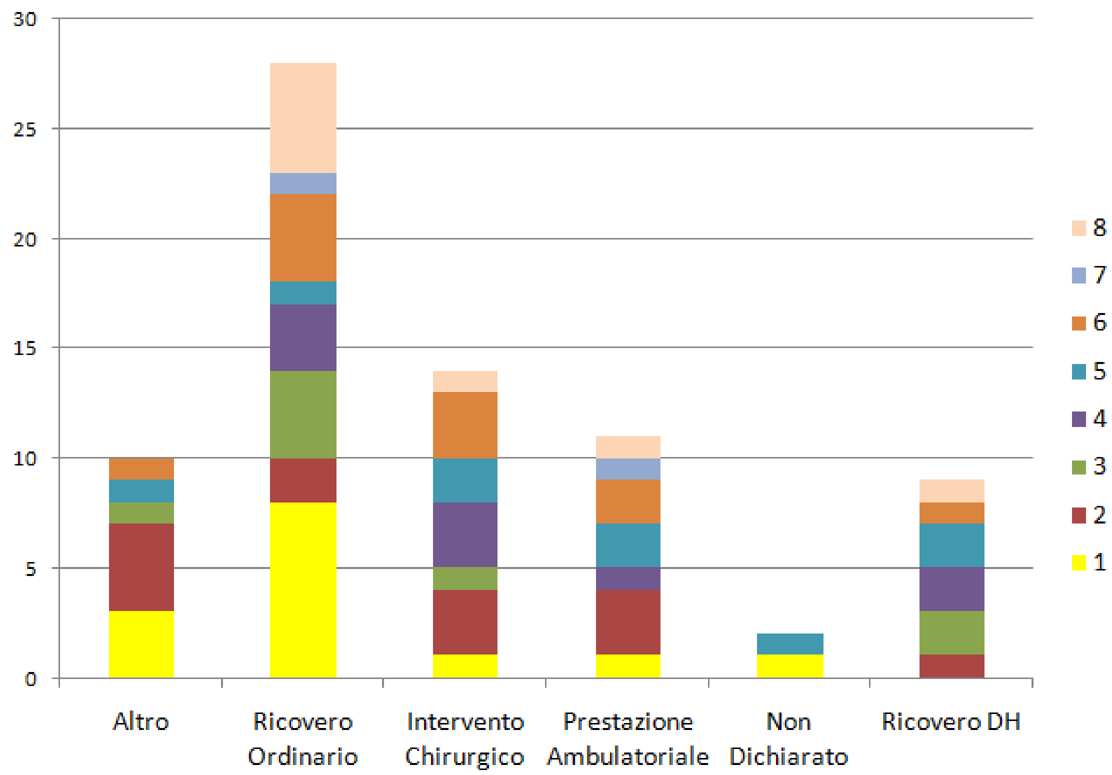

Figure 7.3: Graphical representation of table 7.3. Absolute frequency of the adverse events with inception year 2006, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	0	3	0	5	0	3	0	0	11
Ricovero ordinario	4	17	7	14	4	9	0	1	56
Intervento chirurgico	0	1	1	2	4	2	0	0	10
Prestazione ambulatoriale	3	0	1	1	0	1	1	0	7
Non dichiarato	1	3	0	2	0	0	0	0	6
Ricovero day hospital	0	2	2	3	0	1	0	0	8
Total	8	26	11	27	8	16	1	1	98

Table 7.4: Adverse events split according to category and severity level. Data represent the adverse events of 2007.

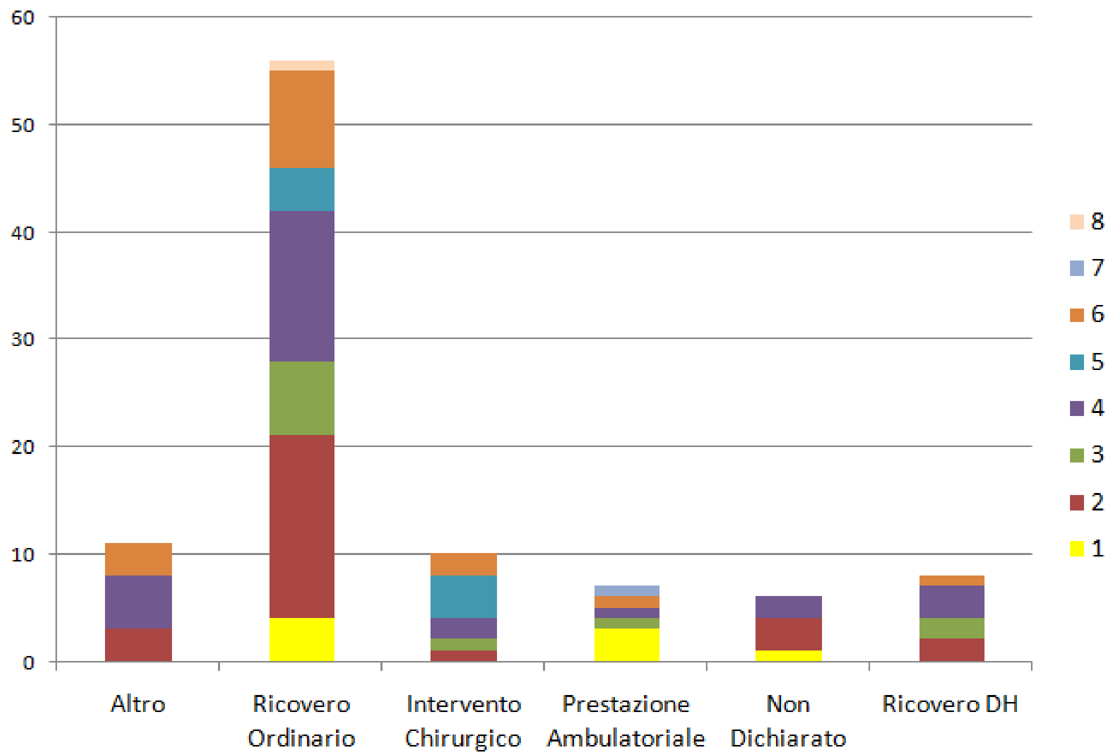

Figure 7.4: Graphical representation of table 7.4. Absolute frequency of the adverse events with inception year 2007, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	35	3	1	0	0	2	1	1	43
Ricovero ordinario	8	5	1	9	6	7	0	1	37
Intervento chirurgico	2	0	0	1	1	0	0	0	4
Prestazione ambulatoriale	1	0	0	0	2	4	0	0	7
Non dichiarato	3	1	0	0	1	0	0	0	5
Ricovero day hospital	1	2	3	1	5	0	0	0	12
Total	50	11	5	11	15	13	1	2	108

Table 7.5: Adverse events split according to category and severity level. Data represent the adverse events of 2008.

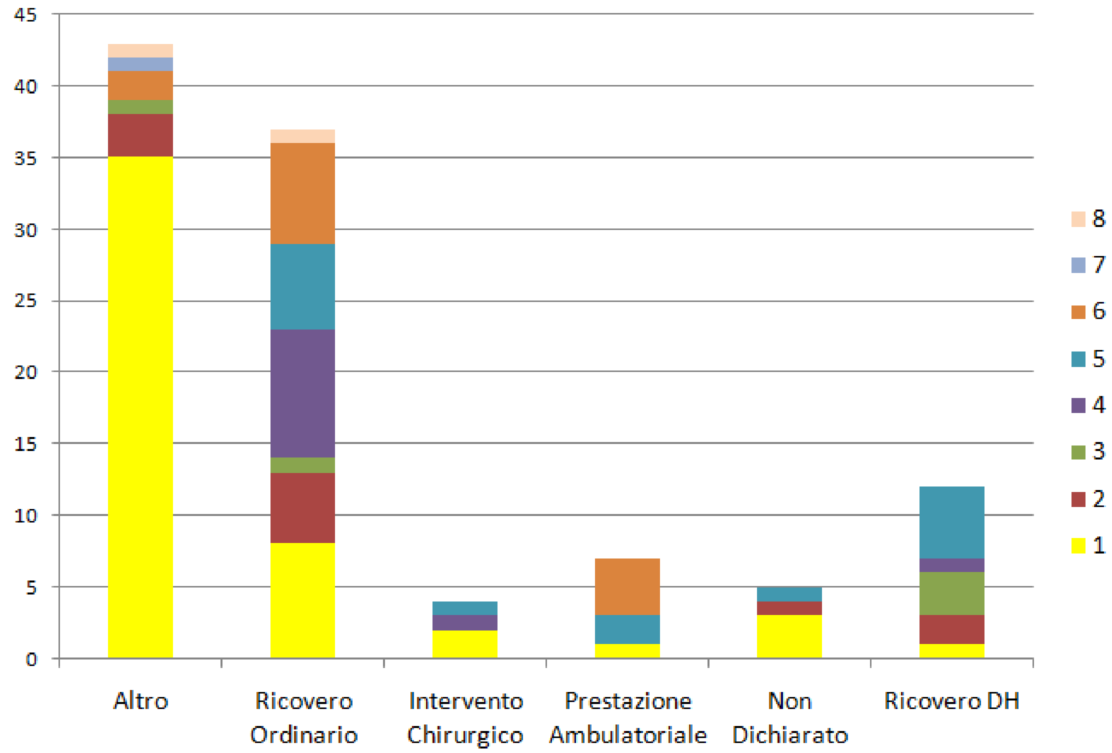

Figure 7.5: Graphical representation of table 7.5. Absolute frequency of the adverse events with inception year 2008, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	1	1	0	0	1	0	3	0	6
Ricovero ordinario	3	7	14	7	10	6	0	1	48
Intervento chirurgico	3	5	0	3	1	0	1	0	13
Prestazione ambulatoriale	0	0	1	0	1	3	0	0	5
Non dichiarato	0	2	1	2	1	0	0	3	9
Ricovero day hospital	0	0	3	6	4	2	2	0	17
Total	7	15	19	18	18	11	6	4	98

Table 7.6: Adverse events split according to category and severity level. Data represent the adverse events of 2009.

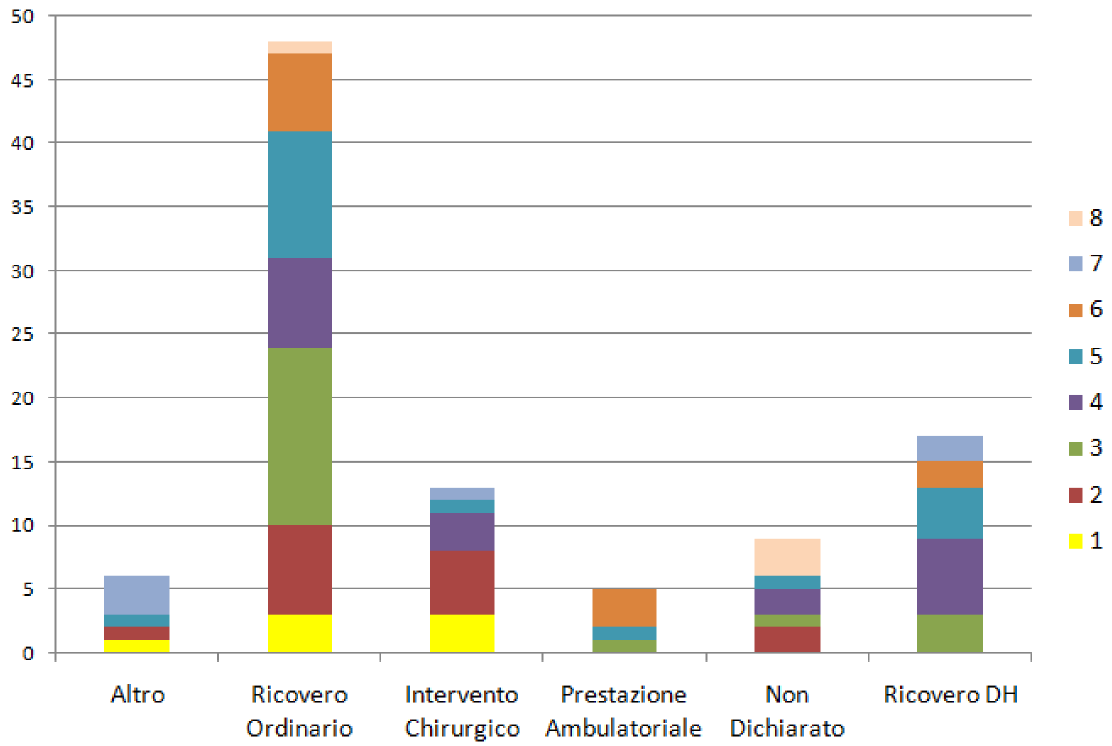

Figure 7.6: Graphical representation of table 7.6. Absolute frequency of the adverse events with inception year 2009, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	0	4	6	2	0	1	0	0	13
Ricovero ordinario	2	7	9	14	10	6	3	0	51
Intervento chirurgico	0	3	4	4	2	1	1	0	15
Prestazione ambulatoriale	2	3	2	3	0	0	0	0	10
Non dichiarato	0	4	2	4	2	0	0	0	12
Ricovero day hospital	2	3	9	3	0	0	1	0	18
Total	6	24	32	30	14	8	5	0	119

Table 7.7: Adverse events split according to category and severity level. Data represent the adverse events of 2010.

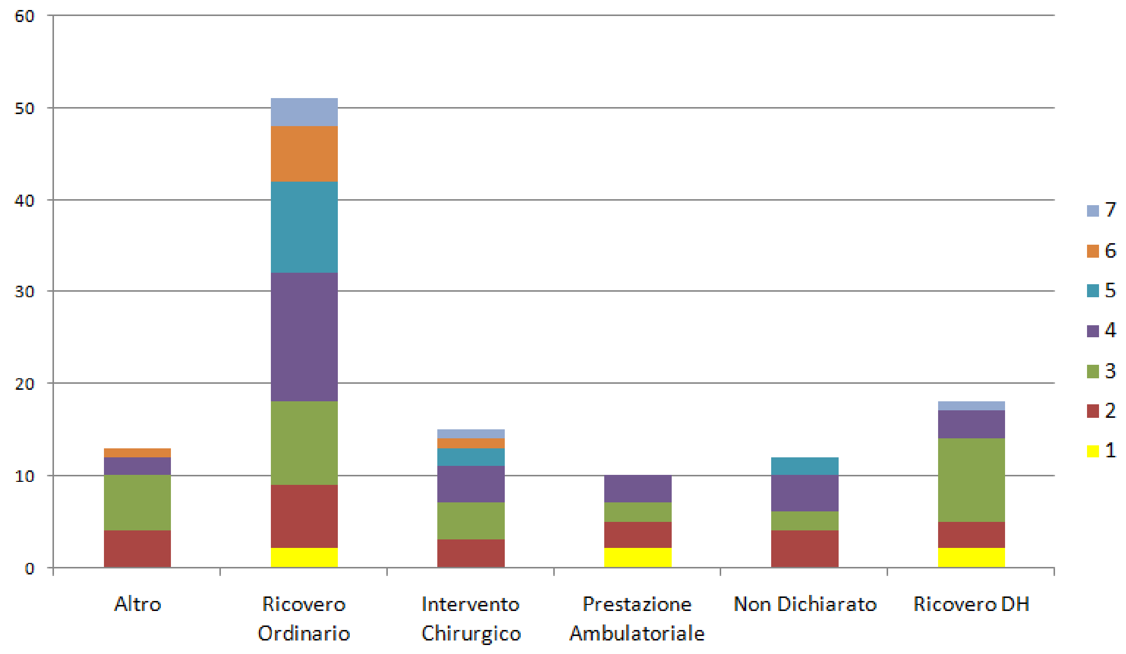

Figure 7.7: Graphical representation of table 7.7. Absolute frequency of the adverse events with inception year 2010, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	4	7	2	3	1	1	0	0	18
Ricovero ordinario	1	10	29	14	12	4	3	5	78
Intervento chirurgico	0	3	2	2	1	1	0	0	9
Prestazione ambulatoriale	1	0	3	0	1	0	0	0	5
Non dichiarato	1	1	0	0	0	0	0	0	2
Ricovero day hospital	0	0	4	4	0	0	0	0	8
Total	7	21	40	23	15	6	3	5	120

Table 7.8: Adverse events split according to category and severity level. Data represent the adverse events of 2011.

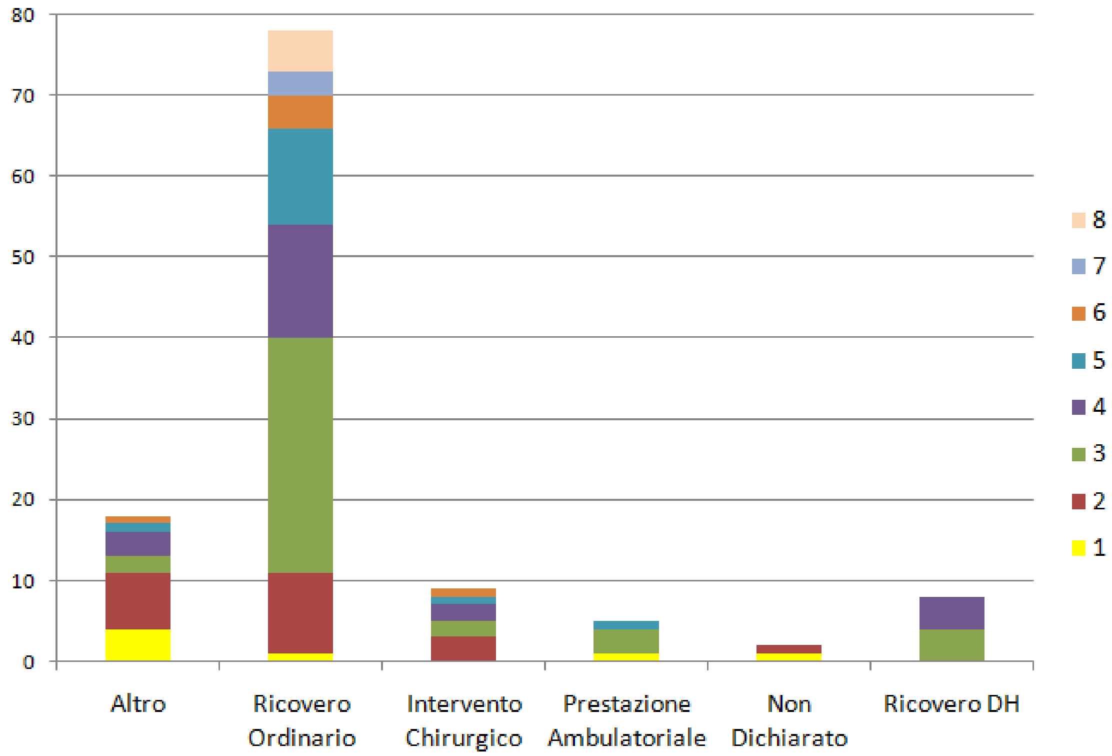

Figure 7.8: Graphical representation of table 7.8. Absolute frequency of the adverse events with inception year 2011, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	0	0	5	1	0	1	1	0	8
Ricovero ordinario	0	7	24	17	8	3	1	0	60
Intervento chirurgico	0	0	2	0	0	2	0	0	4
Prestazione ambulatoriale	0	0	3	3	0	1	0	0	7
Ricovero day hospital	0	1	1	3	2	0	0	1	8
Total	0	8	35	24	10	7	2	1	87

Table 7.9: Adverse events split according to category and severity level. Data represent the adverse events of 2012.

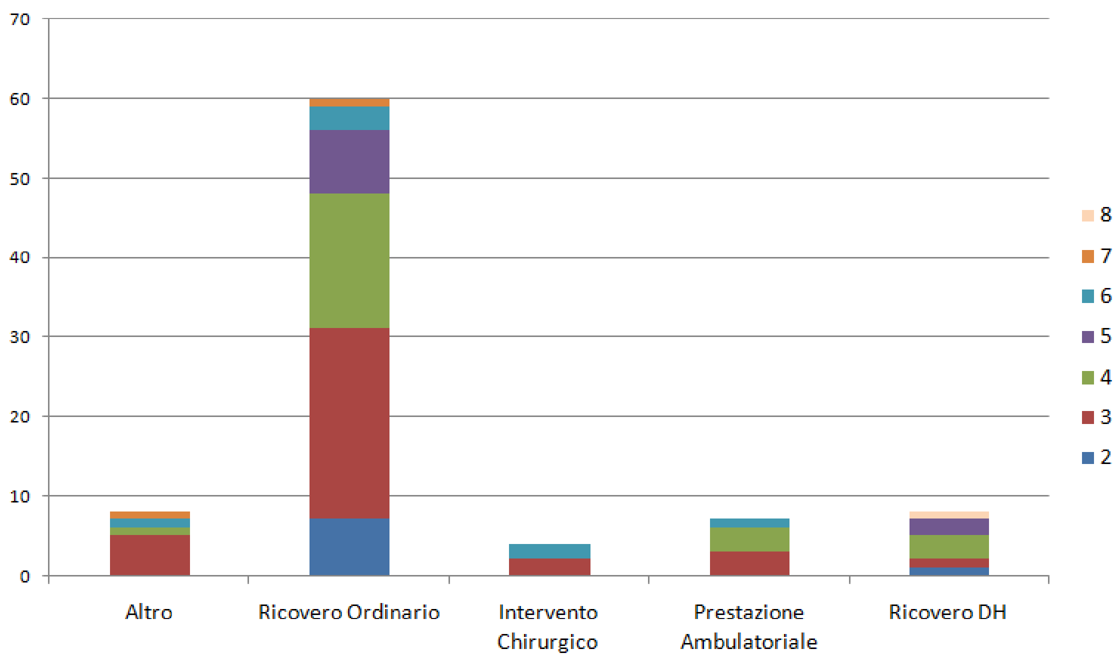

Figure 7.9: Graphical representation of table 7.9. Absolute frequency of the adverse events with inception year 2012, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	2	1	2	0	1	0	1	0	7
Ricovero ordinario	4	12	26	6	8	2	0	0	58
Intervento chirurgico	0	0	1	0	2	0	2	0	5
Prestazione ambulatoriale	0	1	0	1	0	0	1	0	3
Non dichiarato	0	0	0	4	0	0	0	0	1
Ricovero day hospital	0	2	3	0	1	0	0	0	6
Total	6	16	32	8	12	2	4	0	80

Table 7.10: Adverse events split according to category and severity level. Data represent the adverse events of 2013.

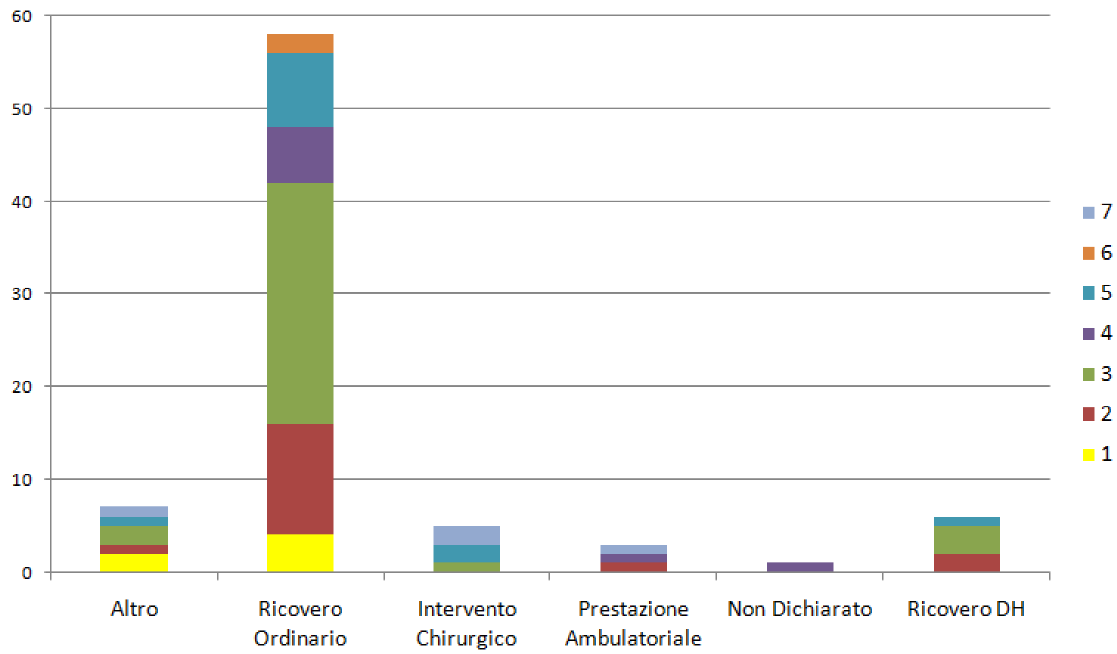

Figure 7.10: Graphical representation of table 7.10. Absolute frequency of the adverse events with inception year 2013, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	3	0	1	1	0	0	0	0	5
Ricovero ordinario	1	9	19	6	2	4	0	0	41
Prestazione ambulatoriale	0	0	0	2	0	0	0	0	2
Non dichiarato	0	1	0	0	0	0	0	0	1
Ricovero day hospital	0	0	3	1	3	0	0	0	7
Total	4	10	23	10	5	4	0	0	56

Table 7.11: Adverse events split according to category and severity level. Data represent the adverse events of 2014.

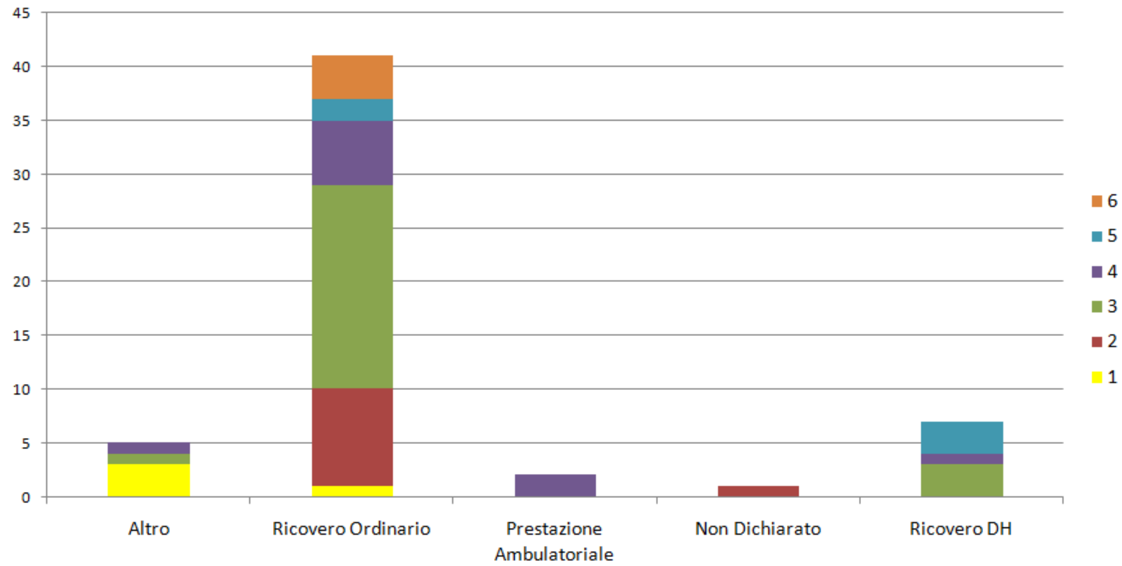

Figure 7.11: Graphical representation of table 7.11. Absolute frequency of the adverse events with inception year 2014, split in classes.

	Severity level								
Type of event	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Altro	0	0	1	0	0	0	0	0	1
Ricovero ordinario	0	1	1	3	1	0	0	0	6
Ricovero day hospital	0	0	0	1	1	0	0	0	2
Total	0	1	2	4	2	0	0	0	9

Table 7.12: Adverse events split according to category and severity level. Data represent the adverse events of the first three months of 2015.

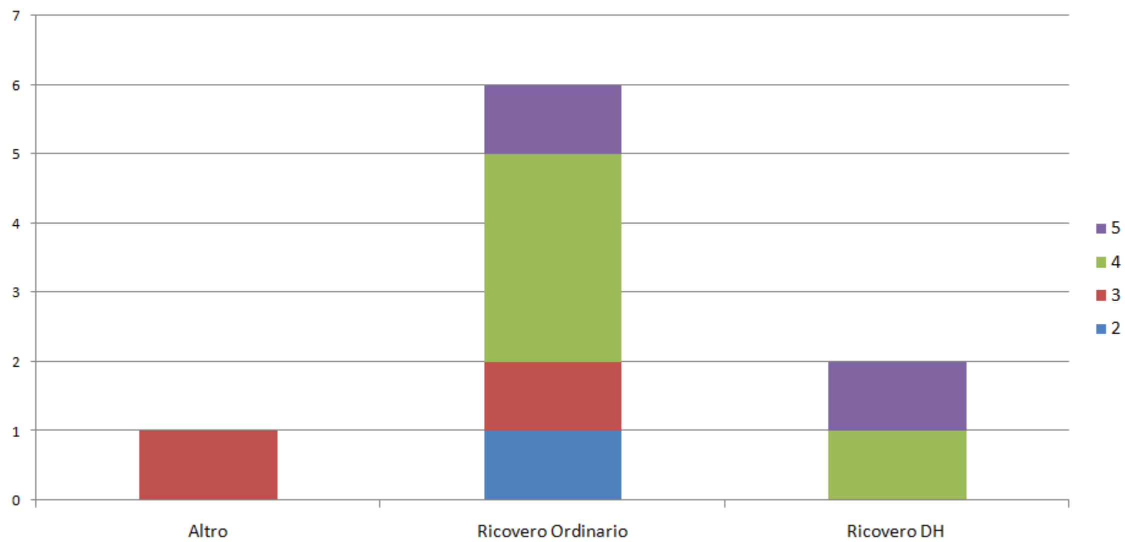

Figure 7.12: Graphical representation of table 7.12. Absolute frequency of the adverse events of the first three months of 2015, split in classes.

Severity level	#
1	115
2	162
3	225
4	178
5	114
6	106
7	36
8	23

Table 7.13: Adverse events split according to severity level, from 10/2003 to 03/2015.

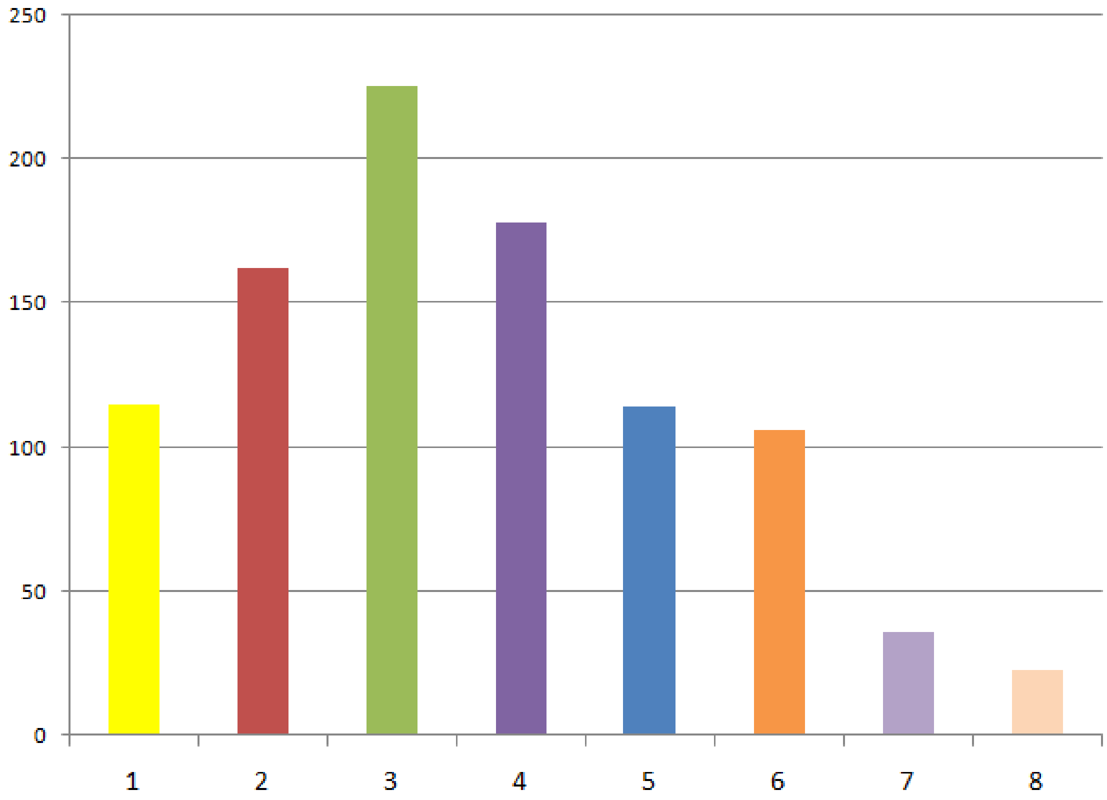

Figure 7.13: Graphical representation of table 7.13. Adverse events split according to severity level, from 10/2003 to 03/2015.

Month	#
Jan	63
Feb	61
Mar	49
Apr	45
May	47
Jun	43
Jul	40
Ago	53
Sep	65
Oct	67
Nov	58
Dec	55
Whole year	646

Table 7.14: Monthly partition of the falls recorded during 2014.

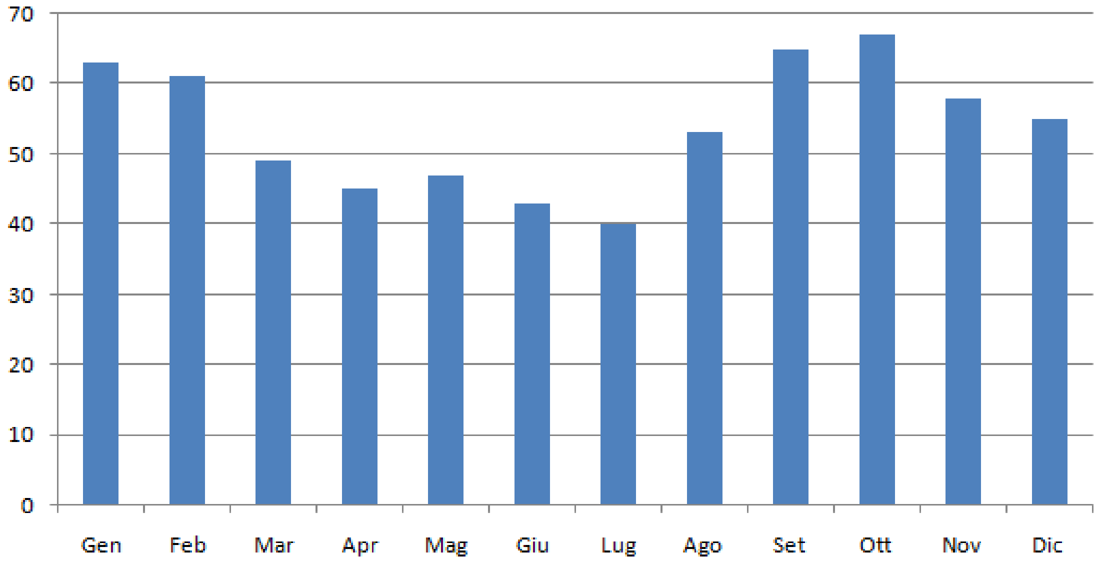

Figure 7.14: Graphical representation of table 7.14. Distribution of falls happened in 2014 over time.

Event	First aid	Psychiatry	Medicine	Surgery	Total
Acts of violence	4	4	24	0	32
Lost dentures	0	0	1	1	2

Table 7.15: Data from a different database. Violences and lost dentures.

Thanks to Dr. Emanuele Patrini, I had the possibility of managing the data owned by the broker agency that assists *La città della Salute e della Scienza di Torino* in what concerns the insurance matters. I will show the aggregate analysis I used in order to obtain information about the exposure to risks and the interventions the insurance has been obliged to perform according to the working contract.

Reporting date / Inception date	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total amount
2010		**5465,6**		**388292,44**	**364700**		**1177322,43**	**698286,79**	**407367,23**				**3041434,46**
Closed		5465,6		388292,44	364700		1177322,43	696786,79	12668				2645235,23
Closed under deductible								1500	4360				5860
Partially paid									390339,23				390339,23
2011			**75000**	**177184,5**	**176822,6**	**80772,5**	**257566,62**	**66425,41**	**778904,26**	**740784,11**			**2353460**
Closed			75000	177184,5	176822,6	80772,5	257566,62	66425,41	778404,26	740284,11			2352460
Closed under deductible									500	500			1000
2012	**100**				**94389,44**	**102305,98**	**319804**	**33814,68**	**15000**	**706466**	**409537,86**		**1681417,96**
Closed	100				94389,44	102305,98	319804	33814,68	15000	706466	404537,86		1676417,96
Closed under deductible											5000		5000
2013							**7015,04**	**112053,6**	**16000**		**35142,6**	**23350**	**193561,24**
Closed							7015,04	112053,6	16000		35142,6	15350	185561,24
Closed under deductible												8000	8000
2014									**30000**				**30000**
Closed									30000				30000
Total amount	**100**	**5465,6**	**75000**	**565476,94**	**635912,04**	**183078,48**	**1761708,09**	**910580,48**	**1247271,49**	**1447250,11**	**444680,46**	**23350**	**7299873,66**

Figure 7.15: Sums paid by the broker with respect to the inception date and the reporting date.

Reporting date / Inception date	1990	1993	1999	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total amount
2010						**6000**	**51020**	**121980**	**110960**	**521324,8**	**1166229,24**	**1280859**	**547127,5**					**3805500,51**
In progress						6000	51020	121980	110960	521324,8	1166229,24	1280859	397127,5					3655500,51
Partially paid													150000					150000
2011			**60000**	**303000**	**151694**	**159142,05**	**1000000**	**463626,08**	**30000**	**24573**	**641518,32**	**1542142**	**976088,81**	**1346695,5**				**6698480**
In progress			60000	303000	151694	159142,05	1000000	463626,08	30000	24573	641518,32	1542142	976088,81	1346695,5				6698480
2012					**85900**	**10000**	**1299999**	**15000**	**150000**	**2993000**	**33300**	**900000**	**682328,5**	**3505000**	**1586299**			**11260826,5**
In progress					85900	10000	1299999	15000	150000	2993000	33300	900000	682328,5	3505000	1586299			11260826,5
2013		**100**		**3500**		**75000**	**2550000**	**1326000**	**150000**	**35000**	**176000**	**99999**	**334999**	**527000**	**2553997**	**3399500**		**11231095**
In progress		100		3500		75000	2550000	1326000	150000	35000	176000	99999	334999	527000	2553997	3399500		11231095
2014	**140000**					**115000**	**260000**	**50000**		**0**	**0**	**430000**	**90000**	**240000**	**2555000**	**3450000**	**1704999**	**9034999**
In progress	140000					115000	260000	50000		0	0	430000	90000	240000	2555000	3450000	1704999	9034999
Total amount	**140000**	**100**	**60000**	**306500**	**237594**	**365142,05**	**5161019**	**1976606,08**	**440960**	**3573898**	**2017047,56**	**4253000**	**2630543,81**	**5618695,5**	**6695296**	**6849500**	**1704999**	**42030901,01**

Figure 7.16: Amount reserved by the broker with respect to the inception date and the reporting date.

Average refunds for category Year	Damages to things	Death	Injuries	Total amount
2010	**900**	**66648**	**2937,5**	**11456,85714**
Caduta Accidentale		66648	2500	34574
Danni a cose	1500			1500
Errore anestesiologico			1450	1450
Errore diagnostico			3900	3900
Furto/smarrimento	300			300
2011	**900**	**178500**	**23533,83889**	**30150,455**
Caduta Accidentale			1791,875	1791,875
Danni a cose	900			900
Errore Chirurgico			40471,48571	40471,48571
Errore diagnostico			117000	117000
Errore terapeutico			4486,85	4486,85
Infezione		178500		178500
2012	**940**	**390000**	**39292,63633**	**49053,72156**
Caduta Accidentale			829	829
Errore Chirurgico		390000	46009,16526	63208,707
Errore da parto/ cesareo			71624,54	71624,54
Errore diagnostico			16055,71	16055,71
Errore terapeutico			1625	1625
Furto/smarrimento	940			940
Infezione			18742,6	18742,6
2013		**91510,2**	**70287,99727**	**71642,60596**
Avulsione dentaria			2850	2850
Caduta Accidentale			7786,757143	7786,757143
Danni a persona			8300	8300
Errore anestesiologico			12800	12800
Errore Chirurgico		48715,3	103365,2116	98160,4581
Errore da parto/ cesareo			103876	103876
Errore diagnostico		177100	300	88700
Errore procedura invasiva			10764,89	10764,89
Errore terapeutico			194235	194235
Infezione			35000	35000
2014			**53150,435**	**53150,435**
Caduta Accidentale			3000	3000
Danni a persona			21250	21250
Errore Chirurgico			54207,83909	54207,83909
Errore da parto/ cesareo			73015,54	73015,54
Errore diagnostico			11338,45	11338,45
Errore terapeutico			119853,1	119853,1
Infezione			62368,6	62368,6
Infortunio			9903	9903
2015			**38365,39667**	**38365,39667**
Errore Chirurgico			21250	21250
Errore procedura invasiva			72596,19	72596,19
Total amount	**910**	**151613,1**	**49514,18041**	**52706,36969**

Figure 7.17: Average refunds with respect to closing year, kind of error and outcome.

Average reserves for category Year	Damages to things	Death	Injuries	Total amount
2010	**1500**	**157723,7436**	**33894,08738**	**51425,68257**
Caduta Accidentale		151380	4300	17670,90909
Errore anestesiologico			2000	2000
Errore Chirurgico		35411,125	30363,98	30975,75515
Errore da parto/ cesareo			151992,7867	151992,7867
Errore diagnostico		354998,34	38800	129142,3829
Errore procedura invasiva			45665,5	45665,5
Errore terapeutico			38775,5	38775,5
Errore Trasfusionale		150000		150000
Furto/smarrimento	1500			1500
Infezione		275720	37427,09167	97000,31875
Livello di Servizio		30500	21010	25755
2011	**2500**	**148509,3443**	**54873,20452**	**65671,37255**
Caduta Accidentale			5897,39375	5897,39375
Danni a cose	3000			3000
Errore anestesiologico			3000	3000
Errore Chirurgico		111923,3125	92500,86667	96290,6122
Errore da parto/ cesareo		800420		800420
Errore diagnostico		45636,75	61214,03357	59266,87313
Errore terapeutico		200000	18779,09	36901,181
Furto/smarrimento	2000			2000
Infezione		46025,41	39404,90909	40423,44769
2012	**3075**	**348915,9375**	**140119,9833**	**155705,9236**
Aggressione	300			300
Caduta Accidentale			2666,666667	2666,666667
Danni a cose	3500			3500
Danni a persona			4166,666667	4166,666667
Errore assistenziale		150000		150000
Errore Chirurgico		300000	74700	82746,42857
Errore da parto/ cesareo			100000	100000
Errore diagnostico			12700	12700
Errore procedura invasiva		250000	824999,5	633333
Errore terapeutico		250664,25	525412,5	470462,85
Furto/smarrimento	5000			5000
Infezione		529999,6667	23600	213499,875
Infortunio			10000	10000
Livello di Servizio			5000	5000
Non identificato			10000	10000

Figure 7.18: Average reserves with respect to closing year (up to 2012), kind of error and outcome.

Average reserves for category Year	Damages to things	Death	Injuries	Total amount
2013		**194166,5833**	**90725,47959**	**102009,9636**
Avulsione dentaria			2000	2000
Caduta Accidentale			3900	3900
Danni a persona			21666,66667	21666,66667
Dispositivo difettoso			17500	17500
Errore anestesiologico			10000	10000
Errore assistenziale		50000		50000
Errore Chirurgico		262500	20516,61111	44714,95
Errore da parto/ cesareo			843333,3333	843333,3333
Errore diagnostico		233333	175714,2857	185882,2941
Errore farmacologico			5000	5000
Errore procedura invasiva			20000	20000
Errore terapeutico		175000	23038,38462	43299,93333
Infezione			14400	14400
Infortunio			14000	14000
Livello di Servizio		90000	5000	61666,66667
Macchinario difettoso			30000	30000
Materiale difettoso			30000	30000
Non identificato			2500000	2500000
2014		**269374,875**	**85972,22222**	**119318,1591**
Caduta Accidentale		25000	17000	18333,33333
Danni a persona			60000	60000
Errore Chirurgico		105000	34285,71429	43125
Errore da parto/ cesareo		99999	30000	64999,5
Errore diagnostico		1000000	34000	195000
Errore prevenzione			150000	150000
Errore terapeutico		110000	440000	330000
Infezione		600000	85000	188000
Non identificato			20000	20000
Total amount	**2530**	**209253,1604**	**79853,05165**	**94989,806**

Figure 7.19: Average reserves with respect to closing year (from 2012 on), kind of error and outcome.

Specialty / Year	2010	2011	2012	2013	2014	Total
Anatomia patologica			5000			5000
Anestesia e Rianimazione	2000	3000		4666,666667		3800
Cardiochirurgia		83675,16667	155000	151500	200000	133003,1875
Cardiologia	117501,92		350905		150000	161818,78
Chirurgia dei trapianti			110000			110000
Chirurgia d'urgenza	114964,9233					114964,9233
Chirurgia Generale	64455,04063	93984,9597	109833,3333	51019,92	133750	82939,17362
Chirurgia maxillo facciale				15000		15000
Chirurgia oncologica		6186,5				6186,5
Chirurgia plastica	21701,16667		10250	29750	40000	24460,35
Chirurgia vascolare			41500		650000	345750
Day hospital/Day surgery			150000			150000
DEA/ Pronto Soccorso	8000	33602,80167	11960	51533,33333	47500	36126,19457
Dermatologia	105102		25000	150000	7500	59020,4
Direzione amministrativa			5000		25000	15000
Ematologia	51020			30000		37006,66667
Gastroenterologia e Endoscopia			250000	3000		126500
Malattie endocrine					600000	600000
Malattie Infettive e tropicali			1299999			1299999
Medicina Generale	251350	37888,88889	5000	117000		75293,75
Medicina Nucleare				1000		1000
Medicina Trasfusionale	150000			5000		77500
Nefrologia			50000	5000		27500
Neurochirurgia		15000	14000	20000	67500	33000
Neurologia			1200000	5000		602500
Neuropsichiatria infantile				1300000		1300000
Neuroradiologia					30000	30000
Non identificato			44144,7	18249,75	366666,6667	116143,5417
Oculistica e Oftalmologia	15000					15000
Odontoiatria e stomatologia			10000	5000	15000	7500
Oncologia			2000	55000	50000	42400
Ortopedia e Traumatologia	37180,425	63760,05786	26150	11187,5	32222,22222	38421,47349
Ostetricia e ginecologia	98195,672	192667,2083	571249,875	540463,5455	124285,5714	352218,3408
Otorinolaringoiatria	17900		270000	5000		110825
Pediatria e patologia neonatale			50000	49999,75		49999,8
Radiologia	10000	58104,10545			10000	50703,47385
Residuale manicomiale					10000	10000
S.S.U.Em. 118	30500		10000		325000	223416,6667
Struttura/Parti Comuni	3500	5374,017647	3642,857143	5000	30000	5163,292857
Traumatologia					1500000	1500000
Unità Spinale				5000		5000
Urologia	21063,75			200000		80709,16667
Total	**51425,68257**	**65671,37255**	**154257,8973**	**101828,1364**	**163999,9818**	**101415,2198**

Figure 7.20: Evolution of reserves over time with respect to the specialty.

Chapter 8

Simulation code

In this section we introduce the code created in order to simulate the estimated price of a medical third party liability for a public hospital.

```
globals[num_event_gen
        reserves
        tot_paid
        calendar
        deduct
        hosp_paid
        ins_paid
        Premium
        y_Hosp_paid
        y_Ins_paid
        yy_Hosp_paid
        yy_Ins_paid
        yyy_Hosp_paid
        yyy_Ins_paid
        hist_reserves
        part_hist_reserves]

breed [claims claim]
breed [adverse_events adverse_event]

claims-own [level
            inception
            reporting
            amount
```

```
            accounting_type
            p_reserve
            p_paid
            p_partial
            partial_reserve
            partial_paid]

adverse_events-own [inception
                    level
                    prob_claim]
```

In this very first part of the code we have to define all the variables we are going to use in the simulation. On the top part it is possible to observe the *globals*. This particular kind of variable can assume only one value, and every agent can access it. You can think of global variables as belonging to the observer context. We will describe each single variable in the following pages analysing the code. *Breed* determines a set of agents that behave differently. Moreover, being an *agentset*, it does not own a predetermined order but, on the contrary, it's always in a random order.

As NetLogo User Manual reports, randomness helps you keep your model from treating any particular *turtles*, *patches* or *links* differently from any others. In order to define a *breed* it is necessary to put into square brackets the name of the whole set and the name of the single component. In our code we will work with *adverse_events* and *claims*. The former represents the set of adverse events happened in a period, while the latter is a subset of the first set in the sense that it consists in all those adverse events being reported to the hospital as claims to be refund. Finally we define all the variables that characterize the two breeds and that allow us to add specific information to each agent in accordance to its breed. Their meanings will be analysed together with their code later on.

```
;; World

to setup
  clear-all
  reset-ticks
  set hist_reserves []
  set part_hist_reserves []
  set calendar ["jan" "feb" "mar" "apr" "may" "jun" "jul" "ago"
                "sep" "oct" "nov" "dec"]
```

```
  ask patches [set pcolor white]
  set-default-shape adverse_events "person"
  set-default-shape claims "x"
  claims_init
  num_events
  graph_ad
end
```

In this brief extract it is possible to observe how the setup button works when pushed by the user at the beginning of the simulation. Firstly it deletes all the possible results obtained in previous simulations and set the clock function, called *ticks* in NetLogo, to zero. Then we define two variables as empty vectors: *hist_reserves* will be filled by the value assumed by the reserves at every tick as *part_hist_reserves* but only for the first 36 ticks, which correspond to three years: a tick is thought to be equivalent to one month of the real world.

Calendar is a list of twelve elements, each one representing the abbreviation of a month. Then we act on the graphical side of the simulation by turning to white all the patches of the *world* window and by setting the default shapes of both the breeds. The last three lines of code are used to call and to active some functions. This strategy has the purpose of leaving the code easy and lighter to reading. Here we analyse one-by-one the three functions just mentioned:

```
to claims_init
  create-claims 6 [set hidden? true
                   setxy 5 5
                   set size 5
                   set label-color black]
end
```

This function creates six claims that will be useful in a second moment when we will managing the graphic aspect. You have to notice that all these agents are not visible, it means that they do not appear in the world window even if they exist at the coordinates (5 5). The idea, that we will find behind the entire code, is to create a virtual parking area which we can access to find and to give order to the existing agents. Then we set the size of the hidden image representing the claim (notice that we set a X for the claims in the setup procedure), finally we order to write the label using the black colour.

```
to num_events
  ifelse Event_generator = true
```

```
    [if Distribution_choice = "Poisson"
      [set num_event_gen random-poisson Mean_generator
      if num_event_gen < 5 [set num_event_gen 5]]
     ifelse Distribution_choice = "Exponential"
      [set num_event_gen round random-exponential Mean_generator
      if num_event_gen < 5 [set num_event_gen 5]]
     [set num_event_gen round random-normal
                                Mean_generator Dev_std_generator
      if num_event_gen < 5 [set num_event_gen 5]]
  create-adverse_events num_event_gen [set inception ticks
                                       set hidden? true
                                       set label-color black
                                       setxy 0 0]]
  [set num_event_gen round random-normal 74.333 10.800
  create-adverse_events num_event_gen [set inception ticks
                                       set hidden? true
                                       set label-color black
                                       setxy 0 0]]
  set_level
end
```

This is the second function called by the setup button and it is a very important piece of code for the whole program: it is responsible of determining, at each tick, the number of adverse events to be created. It is made up of different *ifelse* alternatives that allow the user to choose among a Normal, Exponential or Poisson distribution if the switch *Event_generator* in the interface is ON, otherwise a Normal distribution with fixed parameters is automatically assumed to fit the adverse events. When the user chooses to act directly to the distribution function he/she has the possibility of modifying the sliders *Mean_generator* and *Dev_std_generator*, but notice that there is a lower bound of five adverse events that must be created. This limit does not affect the validity of the simulation but prevents some errors to occur.

On the other hand, if the user prefers not to act on the distribution function then he/she will indirectly choosing to adopt a normal distribution with mean 74.333 and standard deviation of 10.800 in line with the historical observations of *La città della Salute e della Scienza di Torino* and considering an additional amount for the trend, acting on the mean value. Finally we create as many adverse events as the random number obtained from the probability distribution function and we set the *inception* variable equal to the value of *ticks* to have memory of its inception date. The other stings of code, as previously mentioned, only need to hide these agents, moving them to (0 0) and setting the label colour to black. The last line of code recall the function *set_level* that we are going to introduce.

```
to set_level
  ask adverse_events with [inception = ticks]
    [let threshold random-float 1
     ifelse threshold < Prob_level_1 / 100 [set level 1]
     [ifelse threshold < (Prob_level_1 + Prob_level_2) / 100
      [set level 2]
     [ifelse threshold < (Prob_level_1 + Prob_level_2 + Prob_level_3)
       / 100 [set level 3]
     [ifelse threshold < (Prob_level_1 + Prob_level_2 + Prob_level_3 +
       Prob_level_4) / 100 [set level 4]
     [ifelse threshold < (Prob_level_1 + Prob_level_2 + Prob_level_3 +
       Prob_level_4 + Prob_level_5) / 100 [set level 5]
     [ifelse threshold < (Prob_level_1 + Prob_level_2 + Prob_level_3 +
       Prob_level_4 + Prob_level_5 + Prob_level_6) / 100 [set level 6]
     [ifelse threshold < (Prob_level_1 + Prob_level_2 + Prob_level_3 +
       Prob_level_4 + Prob_level_5 + Prob_level_6 + Prob_level_7)
       / 100 [set level 7][set level 8]]]]]]]]
  prob_transition
end
```

From the analysis of the data collected it is possible to deduce that risks are managed in accordance with the classification made by the AIMS. It consists in 8 different levels of severity, from near misses events up to death. We decided to let the user free to directly modify the probabilities according to which the adverse events are classified into the above mentioned 8 levels. This freedom has been thought in order to let either the hospital or the insurer to study the impact of possible preventive measures on the premium price. Once the user has set the different probabilities he/she has the possibility to verify the inputs are correct by giving a look to the *Control* monitor: it must show 100.

The idea adopted to attribute the correct *level* of severity to each adverse event is based on the possibility of splitting the interval [0 1] into sub intervals whose length is proportional to the inputs. Notice that level is a variable owned by both the breeds, in order not to change its value in the case an adverse event turns to claim. Finally, the level of severity depends on the random number extracted from the interval (0 1) with respect to the sub intervals created. This algorithm is computed once the adverse event is created. The last line of code recalls a function whose goal is attributing each adverse event the probability of turning into claim basing the choice on the severity level.

```
to prob_transition
ask adverse_events [if level = 1 or level = 2 and inception = ticks
                      [set prob_claim 0]
                     if level = 3 or level = 4 and inception = ticks
                      [set prob_claim Prob_transition_green / 1200]
                     if level = 5 or level = 6 and inception = ticks
                      [set prob_claim Prob_transition_yellow / 1200]
                     if level = 7 or level = 8 and inception = ticks
                      [set prob_claim Prob_transition_red / 1200]]
end
```

Near misses events, whose level of severity is 1 or 2 in accordance with AIMS rules, never turn into claims by definition, while the other adverse events turn into request of reimbursement with different impact that can be modify by the user acting on the sliders *Prob_transition_green*, *Prob_transition_yellow* and *Prob_transition_red*. We decided to adopt the colours green, yellow and red either for the transition probabilities, or the representing shapes in the world window, as reference to the severity level usually assigned by the triage in the real world. In the code you can notice that each transition probability is divided by 1200 to transform the value of the slider, considered as annual, into a monthly probability because of the horizon covered by the tick. Finally, we can analyse the last function directly called in the setup algorithm.

```
to graph_ad
  act_comp_res
  if ticks > 0 and precision (ticks / 12) 2 = int (ticks / 12)
         [ask adverse_events [set hidden? true
                               setxy 0 0]
          ask claims [set hidden? true
                      setxy 5 5]
                      year_summary]
  ask patch 11 (-4 - 7 * ((ticks - 1) - int ((ticks - 1) / 12) * 12))
     [set plabel-color white]
  ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                  inception = ticks]
```

```
   [setxy 3 -4
    set size 5
    set shape "flag"
    set hidden? false
    set color black
    set label year + int (ticks / 12)]
ask patch 11 (-4 - 7 * (ticks - int (ticks / 12) * 12))
   [set plabel-color black
    set plabel item (ticks - int (ticks / 12) * 12) calendar]
ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                 inception = ticks]
   [setxy 15 (-4 - 7 * (inception - int (inception / 12) * 12))
    set size 5
    set hidden? false
    set color blue
    set label count adverse_events with [level = 1 or level = 2]]
ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                 inception = ticks]
   [setxy 45 (-4 - 7 * (inception - int (inception / 12) * 12))
    set size 5
    set hidden? false
    set color green
    set label count adverse_events with [level = 3 or level = 4]]
ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                 inception = ticks]
   [setxy 75 (-4 - 7 * (inception - int (inception / 12) * 12))
    set size 5
    set hidden? false
    set color yellow
    set label count adverse_events with [level = 5 or level = 6]]
ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                 inception = ticks]
   [setxy 105 (-4 - 7 * (inception - int (inception / 12) * 12))
    set size 5
    set hidden? false
    set color red
    set label count adverse_events with [level = 7 or level = 8]]
ask one-of claims with [xcor = 5]
```

```
    [setxy 60 (-4 - 7 * (ticks - int (ticks / 12) * 12))
     set hidden? false
     set color green
     set label count claims with [level = 3 or level = 4]]
  ask one-of claims with [xcor = 5]
    [setxy 90 (-4 - 7 * (ticks - int (ticks / 12) * 12))
     set hidden? false
     set color yellow
     set label count claims with [level = 5 or level = 6]]
  ask one-of claims with [xcor = 5]
    [setxy 120 (-4 - 7 * (ticks - int (ticks / 12) * 12))
     set hidden? false
     set color red
     set label count claims with [level = 7 or level = 8]]
end
```

This section of the code has the main purpose of creating an adequate graphical aspect that is able of showing the evolution of agents, keeping a distinction between the two breeds: adverse events and claims. The concept of evolution over time is obtained by adopting a linear structure of the agents moving from the upper part of the window to the bottom, jumping at each tick. Moreover, the *calendar* vector is linked to ticks in order to observe time increasing. This is also in line with the introduction of a *flag* icon on the left side at the top which shows the starting year that the user inserted in the *year* input. The very first line of code recalls a function whose working is not directly linked to the graphical question and that it will be analysed in the following pages.

The second line is an *if* command that allows us to hide all the agents and to introduce at the bottom an additional line of agents, each one with the information referring to the previous tick. This strategy has been adopted no to waste the information of the previous year, in fact every 12 ticks a new year starts and we need to restart the agents from the top. The function *year_summary*, as we will see, reproduces the same passages of *graph_ad* but at the end of the window and considering a previous tick. As we can observe, *graph_ad* is built by reproducing the same block and changing few instructions, e.g. the abscissa, the colour, the level of severity and the breed. This is done to keep the code very easy and immediate to be understood.

```
to year_summary
  ask one-of adverse_events with [xcor = 0 and ycor = 0 and
```

```
                                                inception != ticks]
   [setxy 15 (-4 - 7 * 14)
    set size 5
    set hidden? false
    set color blue
    set label count adverse_events with [level = 1 or level = 2 and
                                                inception < ticks]]
ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                inception != ticks]
   [setxy 45 (-4 - 7 * 14)
    set size 5
    set hidden? false
    set color green
    set label count adverse_events with [level = 4 or level = 3 and
                                                inception < ticks]]
ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                inception != ticks]
   [setxy 75 (-4 - 7 * 14)
    set size 5
    set hidden? false
    set color yellow
    set label count adverse_events with [level = 6 or level = 5 and
                                                inception < ticks]]
ask one-of adverse_events with [xcor = 0 and ycor = 0 and
                                                inception != ticks]
   [setxy 105 (-4 - 7 * 14)
    set size 5
    set hidden? false
    set color red
    set label count adverse_events with [level = 7 or level = 8 and
                                                inception < ticks]]
ask one-of claims with [xcor = 5]
    [setxy 60 (-4 - 7 * 14)
     set size 5
     set hidden? false
     set color green
     set label count claims with [level = 3 or level = 4 and
                                                inception < ticks]]
```

```
  ask one-of claims with [xcor = 5]
      [setxy 90 (-4 - 7 * 14)
       set size 5
       set hidden? false
       set color yellow
       set label count claims with [level = 5 or level = 6 and
                                                   inception < ticks]]
  ask one-of claims with [xcor = 5]
      [setxy 120 (-4 - 7 * 14)
       set size 5
       set hidden? false
       set color red
       set label count claims with [level = 7 or level = 8 and
                                                   inception < ticks]]
end
```

As previously mentioned, the *year_summary* function is very similar to the *graph_ad* code, with the big difference that the information showed by labels refer to the past, while the *graph_ad* is in line with the tick value. Another difference, due to the different use of this particular information, is in the fixed coordinates adopted to show the agents, these are not linked any more to the remainder.

```
to go
   tick
   basket
   transition_claims
   num_events
   cash_setting
   claims_amount
   graph_ad
   monitor
   insurance_method
   premium_comp
   time_effect_on_ad_events
   first_year_hosp
   second_year_hosp
   third_year_hosp
end
```

This set of instructions is automatically activated every time the *go* button is clicked. Some of them have already been analysed because mentioned in the setup command. Considering that the *graph_ad* is recalled after increasing the tick value, this will help us in describing the *act_comp_res* that we have left for a second moment.

```
to basket
  ask adverse_events [set shape "person"
                      setxy 0 0
                      set hidden? true]
                      ask claims [setxy 5 5
                      set hidden? true]
end
```

This very simple function corresponds to what was previously referred to using the concept of parking area. It only needs to put together all the adverse events at the coordinates (0 0) being hidden. The same reasoning is done for the claims, whose parking area is in (5 5). This strategy allow us preventing the possibility of having holes in the graph due to the change of breed of an adverse event to a claim. This is due to the choice of adopting the very easy *one-of* methodology as starting point of representing the adverse events in the graph, moreover it is important to set once more their shape to prevent the error of having an agent represented by the *flag* shape.

```
to transition_claims
  ask adverse_events [let threshold random-float 1
                      if threshold < prob_claim [set breed claims
                                                 set reporting ticks
                                                 set size 5]]
end
```

This brief piece of code is fundamental in our analysis. It manages the transformation of an adverse event into a claim in accordance with the transition probability we set. To get the result we created a temporary variable called *threshold* which assumes a random value in (0 1) interval. If the transition probability is smaller than the random variable then we set the breed from *adverse_events* into *claims* and set the *reporting* variable equal to the value of the current tick. This new variable is owned only by the claims and represents the reporting date, that is the moment in which the hospital is informed by the patient suffering from an adverse event to ask for a refund.

```
to cash_setting
  ifelse Homogeneity_in_accounting = false
    [ask claims [set p_reserve Prob_reserve
                 set p_paid Prob_paid
                 set p_partial Prob_partial]]
    [ask claims [set p_reserve 4.8
                 set p_paid 95
                 set p_partial 0.2]]
acc_type
end
```

Cash_setting is responsible of attributing to each claim three different probabilities: the probability of being reserved, the probability of being paid and the probability of being partially paid. The user has the possibility of setting these probabilities by acting on the correspondent sliders after switching on the *Homogeneity_in_accounting* switch, or to use the default setting which is based on the analysis made by Di Perna *et al.* (2010). In the last line we recall the function we are going to explain.

```
to acc_type
  ask claims with [accounting_type = "Partially paid"]
    [let threshold random-float 1
     ifelse threshold < Prob_paid / 100 [
       set accounting_type "Paid"
       set reporting ticks]
    [set accounting_type "Partially paid"]]
     ask claims with [accounting_type != "Paid"
                      and accounting_type != "Partially paid"]
    [let threshold random-float 1
     ifelse threshold < Prob_reserve / 100 [
       set accounting_type "Reserve"]
    [ifelse threshold < ((Prob_paid + Prob_reserve) / 100) [
       set accounting_type "Paid"
       set reporting ticks]
    [set accounting_type "Partially paid"
     set reporting ticks]]]
end
```

Thanks to this function we define the accounting aspect of each claim among three possible alternatives: *Paid*, *Reserve* and *Partially paid*. Notice that claims which have already been paid, have to be considered as closed claims. A further implementation of this program could be the introduction of the possibility of a closed claim to be reopened. Claims that are not completely paid can assume either the accountancy of reserve, or being partially paid. The difference is that reserved claims are sent to reserve for the entire amount and have the possibility of being paid in the future, either in part or completely, while partially paid claims, being a mix between the two main options, are split in two parts according to the value of the slider *Partial_percentage_paid*, one is paid and the other is sent to reserve. Notice that what is paid can not change accountancy and also that every time a change happened the reporting date is set to be equal to the value of ticks at that moment.

Finally, we can observe that the strategy adopted to assign the accounting type is based on the comparison between the extraction of a random number from the interval (0 1) and the probabilities set from the user by the interface before running the simulation.

```
to claims_amount
  if Average_claim_amount = "Broker database" [
    if count claims with [level = 3 or level = 4 and
                          reporting = ticks and amount = 0] > 0 [
      ask claims with [level = 3 or level = 4 and reporting = ticks
                       and amount = 0]
        [ifelse accounting_type != "Reserve"
          [set amount random-normal 6362.55 4252.519
           if amount < 0 [set amount amount * (- 1)]]
          [set amount random-normal 5034.33 3495.56
           if amount < 0 [set amount amount * (- 1)]]]]
    if count claims with [level = 5 or level = 6 and
                          reporting = ticks and amount = 0] > 0 [
      ask claims with [level = 5 or level = 6 and reporting = ticks
                       and amount = 0]
        [ifelse accounting_type != "Reserve"
          [set amount random-normal 38460.14 37723.1
           if amount < 0 [set amount amount * (- 1)]]
          [set amount random-normal 64428.22 39775.89
           if amount < 0 [set amount amount * (- 1)]]]]
    if count claims with [level = 7 or level = 8 and
                          reporting = ticks and amount = 0] > 0 [
```

```
      ask claims with [level = 7 or level = 8 and reporting = ticks
                       and amount = 0]
        [ifelse accounting_type != "Reserve"
          [set amount random-normal 124385 47538.79
           if amount < 0 [set amount amount * (- 1)]]
          [let threshold random-float 1
           ifelse threshold < 0.99
             [set amount random-normal 383469.6 267583.4
              if amount < 0 [set amount amount * (- 1)]]
             [set amount random-normal 2000000 250000]]]]]

  if Average_claim_amount = "ANIA database"
    [ask claims with [level != 0 and amount = 0
                      and reporting = ticks][set amount 29422]]

  if Average_claim_amount = "New impacts" [
    if count claims with [level = 3 or level = 4 and
                          reporting = ticks and amount = 0] > 0 [
      ask claims with [level = 3 or level = 4 and reporting = ticks
                       and amount = 0][set amount Low_impact]]
    if count claims with [level = 5 or level = 6 and
                          reporting = ticks and amount = 0] > 0 [
      ask claims with [level = 5 or level = 6 and reporting = ticks
                       and amount = 0][set amount Medium_impact]]
    if count claims with [level = 7 or level = 8 and
                          reporting = ticks and amount = 0] > 0 [
      ask claims with [level = 7 or level = 8 and reporting = ticks
                       and amount = 0][set amount High_impact]]]
end
```

This section is the central point of the whole simulation. We associate each claim to its foreseen economic expenditure in accordance with three fundamental parameters: *Average_claim_amount*, *accounting_type* and *level*. The user has the possibility of choosing the assumptions on which the costs are estimated, in particular, if the user sets the *Average_claim_amount* equal to *Broker database* then mean and standard deviation are calculated starting from the database the broker gave us. In order to keep the distinction between the three different levels of severity and before estimating the economic impacts of claims, we assumed to keep the expenditures split in three categories adopting the following rule: 12.500€is considered the maximum amount referred to a low impact severity claim, 125.000€is the maximum amount for a medium impact severity claim, finally the high impact severity claims are characterized by an amount bigger than 125.000€. Basing our estimation on the previous assumptions, it is possible to observe the mean and standard deviation computed for each level of severity in the code. Notice that an additional parameter considered in the estimation was the accountancy of the claim. The reason is that claims characterized by a big economic exposure are generally put into reserves and so we expected different values in terms of mean and standard deviation between *paid* and *reserved* claims. We found that reserved claims with medium or high severity have an expected value double than the paid ones. Moreover we introduced an additional probability to those claims with heavy impact to be considered as outliers, in the sense that their claim amount is far from the average. This is done to keep trace of that very rare injuries that produce a really high economic refund.

On the other hand, if the user set *Average_claim_amount* equal to *Ania database*, he/she simply applies the same cost to all the claims in accordance to the average amount reported in Dossier ANIA (2014). Finally, the user has the possibility of acting directly to the costs of claims by introducing as input the prices he/she wants to consider. A possible implementation in the code could be done in order to give the possibility to the user of acting also on the distribution of payments. Notice that in case the amount is negative it is automatically multiplied by -1 to get a positive value, in fact, even if costs are generally considered as negative amounts, our program is based on the assumption the *amount* is a positive variable.

```
to act_comp_res
  ask claims with [amount != 0 and level = 3 or level = 4
                   and accounting_type = "Reserve"][
    let threshold random-float 1
    ifelse threshold < (low_lv_prob_being_paid / 1200)
                       + (time_effect / 1200 * (ticks - reporting))
      [set accounting_type "Paid"
       set reporting ticks][trend]]
  ask claims with [amount != 0 and level = 5 or level = 6
                   and accounting_type = "Reserve"][
    let threshold random-float 1
    ifelse threshold < (med_lv_prob_being_paid / 1200)
                       + (time_effect / 1200 * (ticks - reporting))
```

```
      [set accounting_type "Paid"
       set reporting ticks][trend]]
  ask claims with [amount != 0 and level = 7 or level = 8
                  and accounting_type = "Reserve"][
    let threshold random-float 1
    ifelse threshold < (high_lv_prob_being_paid / 1200)
                      + (time_effect / 1200 * (ticks - reporting))
      [set accounting_type "Paid"
       set reporting ticks][trend]]
  ask claims with [amount != 0 and level = 3 or level = 4
                  and accounting_type = "Partially paid"][
    let threshold random-float 1
    ifelse threshold < (low_lv_prob_being_paid / 1200)
                      + (time_effect / 1200 * (ticks - reporting))
      [set accounting_type "Paid"
       set reporting ticks][trend_partial]]
  ask claims with [amount != 0 and level = 5 or level = 6
                  and accounting_type = "Partially paid"][
    let threshold random-float 1
    ifelse threshold < (med_lv_prob_being_paid / 1200)
                      + (time_effect / 1200 * (ticks - reporting))
      [set accounting_type "Paid"
       set reporting ticks][trend_partial]]
ask claims with [amount != 0 and level = 7 or level = 8
                and accounting_type = "Partially paid"][
    let threshold random-float 1
    ifelse threshold < (high_lv_prob_being_paid / 1200)
                      + (time_effect / 1200 * (ticks - reporting))
      [set accounting_type "Paid"
       set reporting ticks][trend_partial]]
end
```

Starting from the consideration that a reserved claim sooner or later will be paid, the aim of these lines of code is to increase the probability for a reserved claim of being paid when ticks go on. We decided to leave the user the possibility of modifying this parameter by changing the value of the slider *time_effect*. To get the result we decided to consider this parameter as an additional probability to be added to *prob_being_paid*. Of course, the value set as input by the slider is considered uniformly distributed over time and it is assumed to be annual.

The code seems to be difficult but after a deeper sight it is possible to notice that the same procedure has been adopted either for the claims whose accountancy is *reserve*, or for the *partially paid* claims. The only difference consists in the function called to manage the amount until the claim is not paid. If the claim turns into *paid* then the reporting date is set equal to the tick value. The following lines of code referred to the two functions just mentioned and, as they are very similar each other, their working is analysed together.

```
to trend
  if reporting != ticks [
    set amount (amount * (1 + (Evolution_refund / 1200)))]
end

to trend_partial
  if reporting = ticks [
    set partial_reserve amount * (1 - Partial_percentage_paid / 100)
    set partial_paid amount * Partial_percentage_paid / 100 ]
  if reporting != ticks [
    set partial_reserve (partial_reserve * (1
                         + (Evolution_refund / 1200)))]
end
```

Both the functions try to reflect a very well known phenomenon consisting in the evolution of refunds over time. As we saw in details in the first part of this work, it is generally noticed an increasing in price evaluation for a claim reported in the past and not yet closed. We decided to replicate this problem by increasing the value of the reserved amount just multiplying it for the *Evolution_refund* coefficient. The user has the possibility of varying it during the simulation.

```
to monitor
  set tot_paid sum [amount] of claims with
                 [amount != 0 and partial_paid + partial_reserve = 0
                 and accounting_type != "Reserve"]
             + sum [partial_paid] of claims with
                 [accounting_type = "Partially paid"]
             + sum [partial_paid + partial_reserve] of claims with
                 [accounting_type = "Paid"
                  and partial_paid + partial_reserve != 0]
```

```
  set reserves sum [amount] of claims with
                   [accounting_type = "Reserve"]
             + sum [partial_reserve] of claims with
                   [accounting_type = "Partially paid"]
  set hist_reserves (lput reserves hist_reserves)
  if ticks < 36 [
    set part_hist_reserves (lput reserves part_hist_reserves)]
end
```

In this extract you can see how we computed the variables *tot_paid* and *reserves*, respectively. The former is the sum of paid plus partially paid claims (relatively to the paid percentage) for all the claims occurred, while the latter is the amount of the claims whose accountancy is *reserve*. In the last part of the code, we filled the vector *hist_reserves* with the value of the reserves previously computed, while a partition of it with respect to the first 36 values is called *part_hist_reserves*. This additional vector will be used to estimate the amount of the premium to be paid based on 3-year interval.

```
to insurance_method
  if Insurance_model = "Totally insured" [
    set deduct 5000
    ask claims with [reporting = ticks and accounting_type = "Paid"
                     and amount >= 5000]
      [set Hosp_paid Hosp_paid + 5000]
    ask claims with [reporting = ticks and accounting_type = "Paid"
                     and amount < 5000]
      [set Hosp_paid Hosp_paid + amount]
    ask claims with [reporting = ticks and accounting_type = "Paid"
                     and amount >= 5000]
      [set Ins_paid Ins_paid + amount - 5000]]

  if Insurance_model = "Totally retained"[
    ask claims with [reporting = ticks and accounting_type = "Paid"]
      [set Hosp_paid tot_paid]]

  if Insurance_model = "Mix method"[
    set deduct Deductible
    ask claims with [reporting = ticks and accounting_type = "Paid"
                     and amount >= Deductible]
```

```
      [set Hosp_paid Hosp_paid + Deductible]
    ask claims with [reporting = ticks and accounting_type = "Paid"
                     and amount < Deductible]
      [set Hosp_paid Hosp_paid + amount]
    ask claims with [reporting = ticks and accounting_type = "Paid"
                     and amount >= Deductible]
      [set Ins_paid Ins_paid + amount - Deductible]]
end
```

These lines of code allow to the user of choosing between the three different kinds of insurance methodology to be applied in order to evaluate the premium. In accordance to the Italian law, health facilities have the opportunity to choose between a totally insured structure, a completely retained model or a mix between the two, as we already mentioned in the introduction part of this work. If the user set *Insurance_model* equal to *Totally insured* then it will be applied a deductible equal to 5.000€. The value has been obtained from the analysis of the actual insurance policy covering *La città della Salute e della Scienza di Torino*. On the other hand, if the user set the *Insurance_model* equal to *Totally retained*, he/she is deciding not to underwrite an insurance policy, then the effect will be a complete retention of risks and costs. Finally, there is the possibility of setting *Insurance_model* equal to *Mix method* to change the deductible amount, in order to pass a part of risks to the insurer and consequently, reducing the premium price.

```
to first_year_hosp
  if Insurance_model = "Totally insured" [
    set deduct 5000
    ask claims with [inception <= 12 and reporting = ticks
                     and accounting_type = "Paid" and amount >= 5000]
      [set y_Hosp_paid y_Hosp_paid + 5000]
    ask claims with [inception <= 12 and reporting = ticks
                     and accounting_type = "Paid" and amount < 5000]
      [set y_Hosp_paid y_Hosp_paid + amount]
    ask claims with [inception <= 12 and reporting = ticks
                   and accounting_type = "Paid" and amount >= 5000]
      [set y_Ins_paid y_Ins_paid + amount - 5000]]

  if Insurance_model = "Totally retained"[
    ask claims with [inception <= 12 and reporting = ticks
                     and accounting_type = "Paid"]
```

```
      [set y_Hosp_paid y_Hosp_paid + amount]]

  if Insurance_model = "Mix method"[
    set deduct Deductible
    ask claims with [inception <= 12 and reporting = ticks
               and accounting_type = "Paid" and amount >= Deductible]
      [set y_Hosp_paid y_Hosp_paid + Deductible]
    ask claims with [inception <= 12 and reporting = ticks
               and accounting_type = "Paid" and amount < Deductible]
      [set y_Hosp_paid y_Hosp_paid + amount]
    ask claims with [inception <= 12 and reporting = ticks
               and accounting_type = "Paid" and amount >= Deductible]
      [set y_Ins_paid y_Ins_paid + amount - Deductible]]
end
```

This function is thought to replicate a reporter for the total amount paid either by the insurer, or by the hospital for the risks occurred in the first year. This is necessary to create the basis on which estimating the premium price. In accordance to the *Insurance_model* chosen, we applied three different formulas. The following lines of code express the very same concept to the claims having an inception date occurred in between the second and third year.

```
to second_year_hosp
  if Insurance_model = "Totally insured" [
    set deduct 5000
    ask claims with [inception > 11 and inception <= 23
                     and reporting = ticks
                     and accounting_type = "Paid" and amount >= 5000]
      [set yy_Hosp_paid yy_Hosp_paid + 5000]
    ask claims with [inception > 11 and inception <= 23
                     and reporting = ticks
                     and accounting_type = "Paid" and amount < 5000]
      [set yy_Hosp_paid yy_Hosp_paid + amount]
    ask claims with [inception > 11 and inception <= 23
                     and reporting = ticks
                     and accounting_type = "Paid" and amount >= 5000]
      [set yy_Ins_paid yy_Ins_paid + amount - 5000]]

  if Insurance_model = "Totally retained"[
```

```
    ask claims with [inception > 11 and inception <= 23
             and reporting = ticks and accounting_type = "Paid"]
      [set yy_Hosp_paid yy_Hosp_paid + amount]]

  if Insurance_model = "Mix method"[
    set deduct Deductible
    ask claims with [inception > 11 and inception <= 23
                and reporting = ticks
                and accounting_type = "Paid" and amount >= Deductible]
      [set yy_Hosp_paid yy_Hosp_paid + Deductible]
    ask claims with [inception > 11 and inception <= 23
                and reporting = ticks
                and accounting_type = "Paid" and amount < Deductible]
      [set yy_Hosp_paid yy_Hosp_paid + amount]
    ask claims with [inception > 11 and inception <= 23
                and reporting = ticks
                and accounting_type = "Paid" and amount >= Deductible]
      [set yy_Ins_paid yy_Ins_paid + amount - Deductible]]
end

to third_year_hosp
  if Insurance_model = "Totally insured" [
    set deduct 5000
    ask claims with [inception > 23 and inception <= 35
                     and reporting = ticks
                     and accounting_type = "Paid" and amount >= 5000]
      [set yyy_Hosp_paid yyy_Hosp_paid + 5000]
    ask claims with [inception > 23 and inception <= 35
                     and reporting = ticks
                     and accounting_type = "Paid" and amount < 5000]
      [set yyy_Hosp_paid yyy_Hosp_paid + amount]
    ask claims with [inception > 23 and inception <= 35
                     and reporting = ticks
                     and accounting_type = "Paid" and amount >= 5000]
      [set yyy_Ins_paid yyy_Ins_paid + amount - 5000]]

  if Insurance_model = "Totally retained"[
    ask claims with [inception > 23 and inception <= 35
```

```
                and reporting = ticks and accounting_type = "Paid"]
      [set yyy_Hosp_paid yyy_Hosp_paid + amount]]

  if Insurance_model = "Mix method"[
    set deduct Deductible
    ask claims with [inception > 23 and inception <= 35
                and reporting = ticks
                and accounting_type = "Paid" and amount >= Deductible]
      [set yyy_Hosp_paid yyy_Hosp_paid + Deductible]
    ask claims with [inception > 23 and inception <= 35
                and reporting = ticks
                and accounting_type = "Paid" and amount < Deductible]
      [set yyy_Hosp_paid yyy_Hosp_paid + amount]
    ask claims with [inception > 23 and inception <= 35
                and reporting = ticks
                and accounting_type = "Paid" and amount >= Deductible]
      [set yyy_Ins_paid yyy_Ins_paid + amount - Deductible]]
end

to premium_comp
  set Premium (((Ins_paid * (1 + Safety_margin_on_paid / 100)
       + max hist_reserves * (1 + Safety_margin_on_reserves / 100))
       * (1 + CoC / 100)) * (1 + Taxes / 100))
end
```

The analysis of the previous extract reduces to the last function, as we said. *Premium_comp* is the formula of a very big approximation of a premium in the case the hospital want to be covered against all the claims happened until that moment. Its analysis leads to nonsense because of the lack of a temporal background but allows the user to realize the magnitude of the amounts considered.

```
to time_effect_on_ad_events
  ask adverse_events with [level = 3 or level = 4
                           and inception < ticks - 1]
    [ifelse (prob_claim - prob_transition_green / 120000) > 0
      [set prob_claim (prob_claim - prob_transition_green / 120000)]
      [set prob_claim 0]]
  ask adverse_events with [level = 5 or level = 6
                           and inception < ticks - 1]
```

```
    [ifelse (prob_claim - prob_transition_yellow / 120000) > 0
      [set prob_claim (prob_claim - prob_transition_yellow / 120000)]
      [set prob_claim 0]]
  ask adverse_events with [level = 7 or level = 8
                          and inception < ticks - 1]
    [ifelse (prob_claim - prob_transition_red / 120000) > 0
      [set prob_claim (prob_claim - prob_transition_red / 120000)]
      [set prob_claim 0]]
end
```

In the real world it is possible to notice, also due to limit imposed by the Legislator, that from the inception date to the reporting date exist a gap that is never bigger than ten years. This function reduces the probability of an adverse event of being denounced when time increases. The reduction is amended to the user that has the possibility if setting it by sliders with respect to the level of severity. Adverse events with high severity impact have a higher probability of being revealed to the hospital.

Finally we can analyse the code used in order to evaluate the premium of a medical third party liability:

```
((y_Ins_paid + yy_Ins_paid + yyy_Ins_paid) / 3
* (1 + Safety_margin_on_experience / 100)
+ max part_hist_reserves * 0.5
* (1 + Safety_margin_on_reserves / 100))
* (1 + Taxes / 100)
```

These lines of code are written directly into the reporter section of a monitor in the interface. The parameters I considered to evaluate the premium are essentially the mean value of the amount spent by the insurer during the first three years plus an additional increment, whose value depends on the *Safety_margin_on_experience* parameter previously set by the user. This variable reflects a safety margin on the effective costs, so it can be considered as an approximation of the so called *loading safety*. In order to price a premium that considers also the exposure to possible outliers or to particularly serious claims, I decided to add the half of the maximum exposure in terms of reserve,s multiplied for an additional loading safety. Finally I considered the taxation.

In the following paragraph I will briefly explain how to interact with the tool.

8.1 Interface

Let's analyse the interface of the simulation program. It could be useful to give a look at the pictures shown in the following pages, especially the one referring to the simulation aspect before running. On the left side of the world window there is the whole set of switches and sliders affecting the probability distribution of adverse events. The two monitors show respectively the number of events created at that tick and a monitor that allows the user to control that the probabilities sum up 100. On the right side there are all the sliders, switches, monitors and graphs dealing with the evolution, transition, cost and accountancy of claims. We decided to use this separation to make the distinction between adverse events and claims easier to remember. At the bottom of the screen there are three buttons: *setup*,*go* and *go forever*. Setup button has to be pushed after setting all the parameters but before running the simulation for the first time. After clicking it, the world window assumes the following aspect: The information contained in the window can be

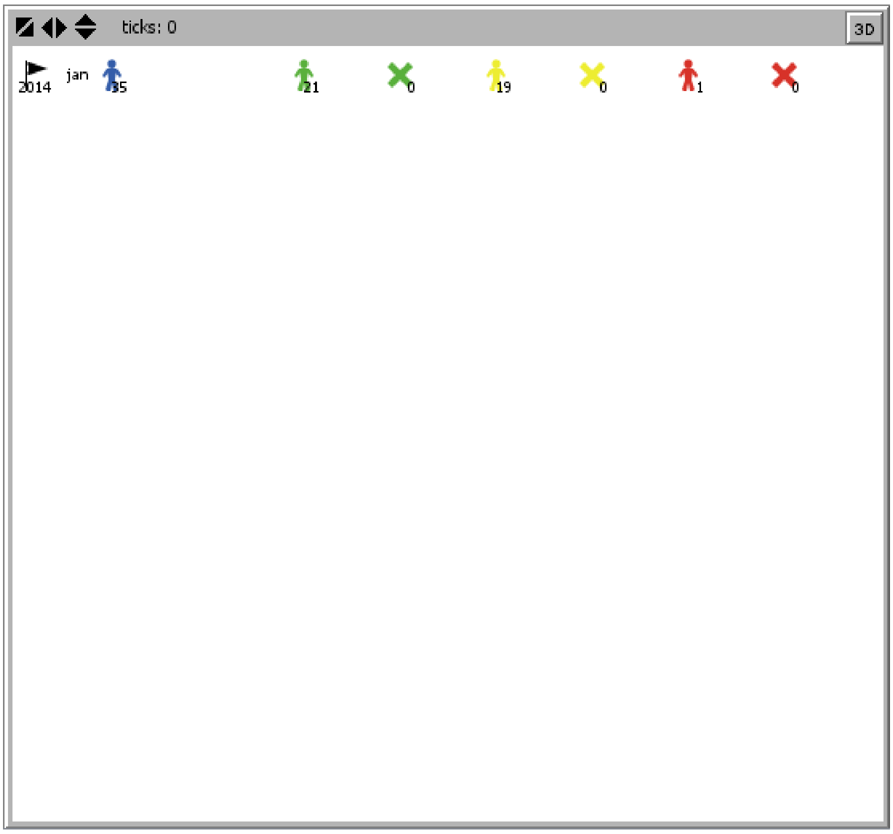

Figure 8.1: Simulation output: main window at ticks = 0.

resumed in the inception date and the numbers of adverse events (represented by a person) and claims (represented by a X) split by different colours depending on the severity level. The difference between *go* and *go forever* is that the first button only advances time of one tick, while the second has to be stopped because never ends. We left both the buttons to give the user the possibility of performing a step by step simulation or a faster one. Under the world window it is possible to find the premium and some statistics that helps the user to be informed about the distribution and exposure. On the right side there are two plots, on the top there is the graph of the total amount paid and the reserves at time t, while at the bottom you can see the cumulative distribution of incurred claims with inception equal or lower than the first year.

Remember that the premium has reached the stability after running 144 ticks, to give the possibility of prescription to all the adverse events generated in the simulation. In the following pages you can find two pictures of the interface as it appears before and after running.

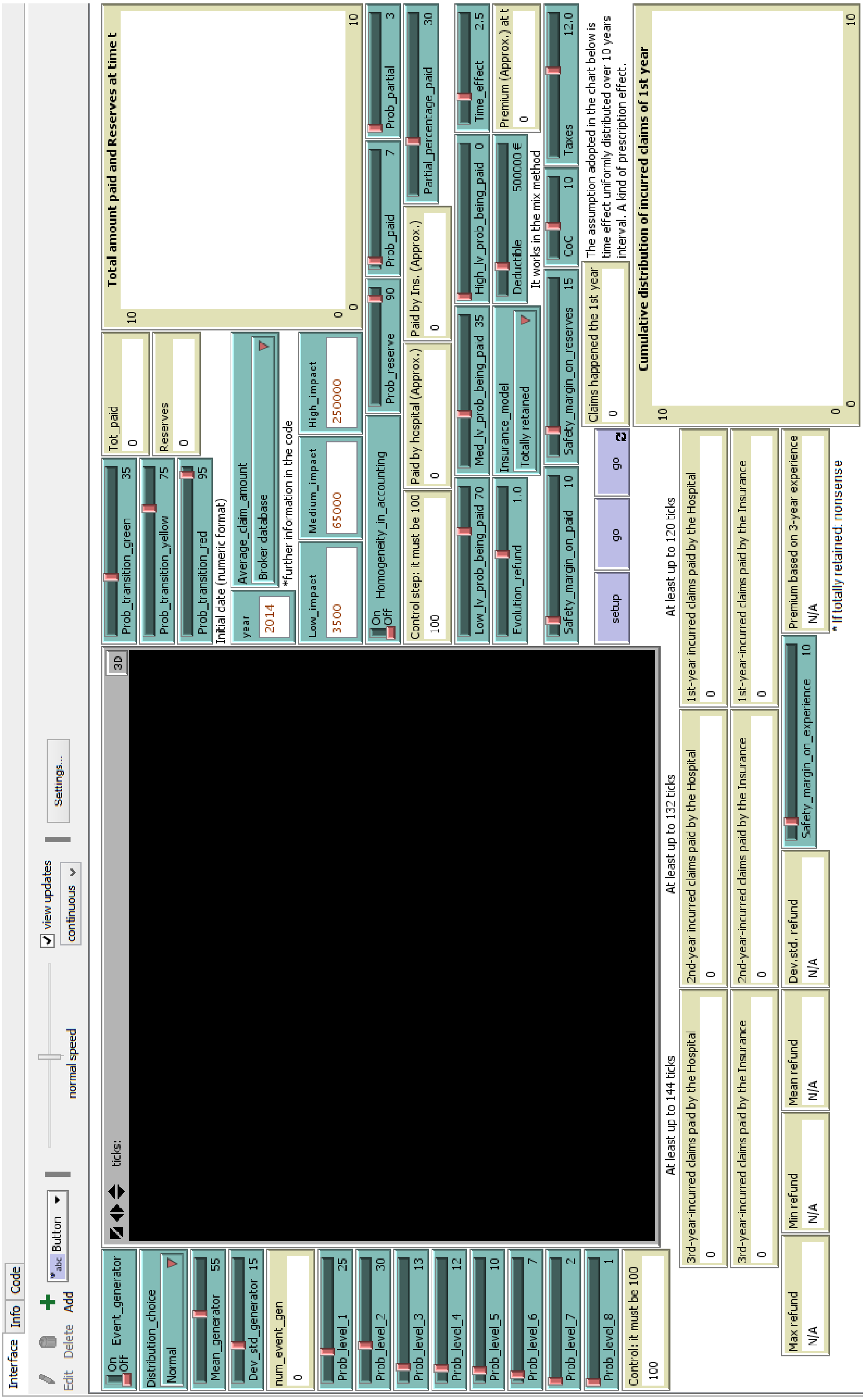

Figure 8.2: Simulation interface as it appears before running.

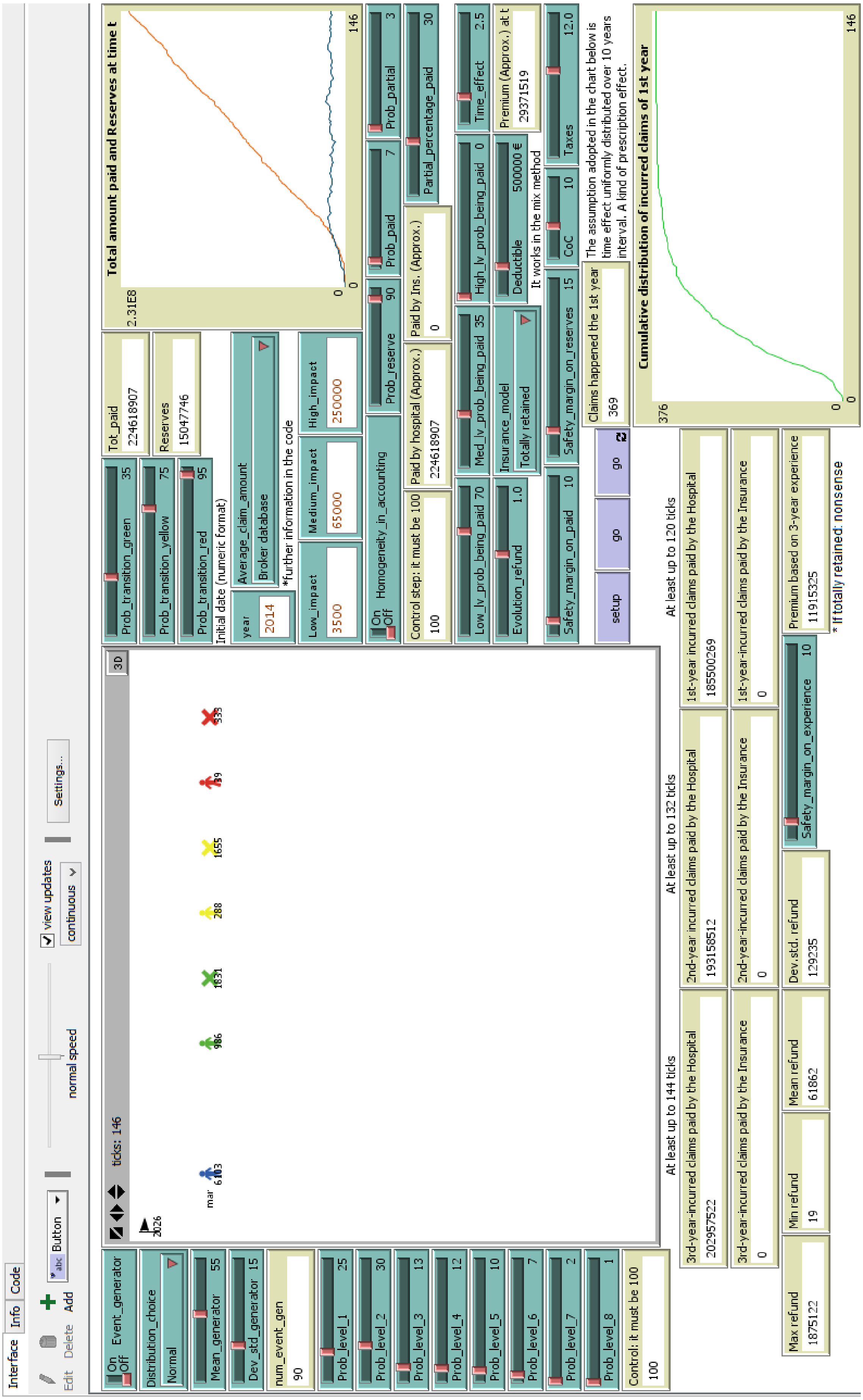

Figure 8.3: Simulation interface as it appears at the end of the simulation.

Let's see what kind of information it is possible to obtain from our outputs. This set of outputs shows the total amount paid either by the hospital or by the

At least up to 144 ticks	At least up to 132 ticks	At least up to 120 ticks
3rd-year-incurred claims paid by the Hospital 16731748	2nd-year incurred claims paid by the Hospital 24281102	1st-year incurred claims paid by the Hospital 24235948
3rd-year-incurred claims paid by the Insurance 4861902	2nd-year-incurred claims paid by the Insurance 4752289	1st-year-incurred claims paid by the Insurance 5595708

insurance with respect to that claims occurred in the initial three years. It is useful to measure the respective exposures to risks when deductible changes. From these

Max refund	Min refund	Mean refund	Dev.std. refund
1694329	1	56111	112422

outputs it is possible to read the maximum and minimum refunds generated by the simulation, in addition to the mean value and the standard deviation on the entire set of happening. It is also possible to compare the total number of claims occurred in a fixed year of the real life with the simulation. Finally, it is possible to

Claims happened the 1st year
392

read the estimated premium based on the assumptions stressed in the code, for the insurance policy having the parameters set at the beginning of the simulation.

Premium based on 3-year experience
8813694

Chapter 9

Results and final comments

The main purpose of the whole work is the creation of a simulation program by which assisting the hospitals and health facilities in their choice towards the best possible solution of an insurance policy of third party liability. Thanks to our program we have the possibility of reproducing different scenarios, based on the assumptions imposed by the code, but with a high degree of freedom due to the possibility of the user to modify the inputs. The first kind of investigation performed has been focused on the analysis of the premium variation with respect to different settings in the deductible amount, leaving all the other parameters unchanged. The environment in which the simulation takes place is characterized by the following parameters:

Parameters	
# of repetitions	150 for each deductible amount
Prob. levels	$25-30-13-12-10-7-2-1$
Distribution choice	Normal
Prob. transitions	$35-75-95$
Avg claim amount	Broker database

Table 9.1: Simulation's environment of the first experiment.

Data produced by the behaviour tool of NetLogo:

Deductible amount (x 1 000)							
€ 100	**€ 250**	**€ 500**	**€ 750**	**€ 1.000**	**€ 1.250**	**€ 1.500**	
19 322	14 728	10 965	9 720	9 032	9 140	8 973	Mean value
15 053	10 725	7 936	7 249	6 551	7 211	6 752	5th perc.
24 365	18 667	14 552	13 046	11 618	11 862	11 369	95th perc.
2 690	2 361	1 844	1 717	1 430	1 399	1 391	Std. Dev.

Table 9.2: Premium variation with respect to the deductible amount.

From the spreadsheet it is possible to observe how the insurance premium and the deductible amount go to opposite directions: the insurance premium decreases when the deductible amount increases. This is due to the lower exposure to risks that the insurer benefits by adopting a bigger deductible. For the initial deductible values we assist to a rapidly decreasing underwriting cost, then the function seems to be quite horizontal. This is due to the fact that the additional magnitude in terms of exposure to risks for the insurer is compensated to a smaller probability of such claims happening. The sensitivity of our program seems to be not sufficient to catch the differences in price for this levels of deductible. Probably with a bigger database it could be possible to calibrate better the interaction between parameters such that this linearity disappears.

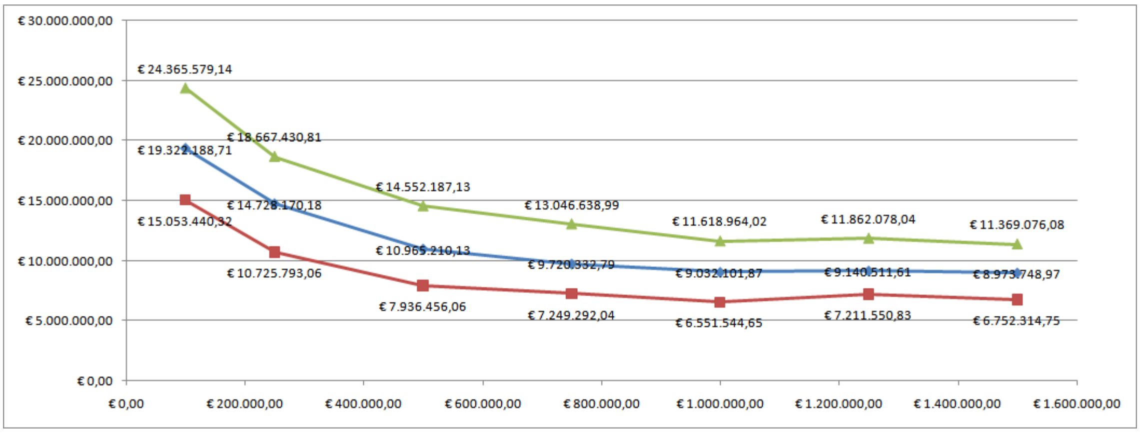

Figure 9.1: Mean price of an insurance policy with respect to the level of deductible. Lower and upper bounds represent the 5th and 95th percentile.

Thanks to our program it is also possible to analyse the impact of the probability distribution chose to model the adverse events on the premium. The environment in which this simulation has been performed is:

Parameters	
# of repetitions	200 for each deductible amount
Prob. levels	$25 - 30 - 13 - 12 - 10 - 7 - 2 - 1$
Distribution choice	Normal, Poisson and Exponential
Mean value	55
Standard deviation	15
Prob. transitions	$35 - 75 - 95$
Avg claim amount	Broker database

Table 9.3: Simulation's environment of the second experiment.

It is important to stress that the choice of the probability distribution modelling the adverse events is fundamental to get results in line with the reality. In our simulation the difference between the adoption of a normal distribution or a Poisson distribution has not a serious consequence on the premium, while the adoption of an exponential distribution reflects a generally higher probability of occurring claims with a serious economic impact because the 95th percentile is higher than both the previous distributions whatever is the deductible amount. This exposure to higher expenses is not reflected in the expected value, that follows the trends described by the normal and Poisson distributions.

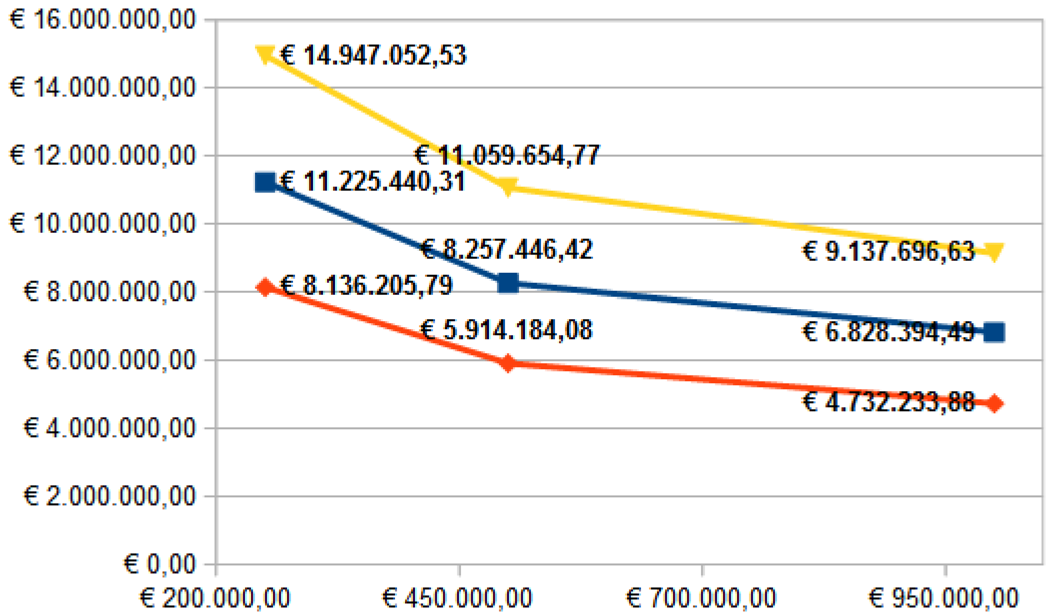

Figure 9.2: Mean price (blue) of an insurance policy with adverse events distributed according to a normal distribution. Lower (red) and upper (yellow) bounds represent the 5th and 95th percentile.

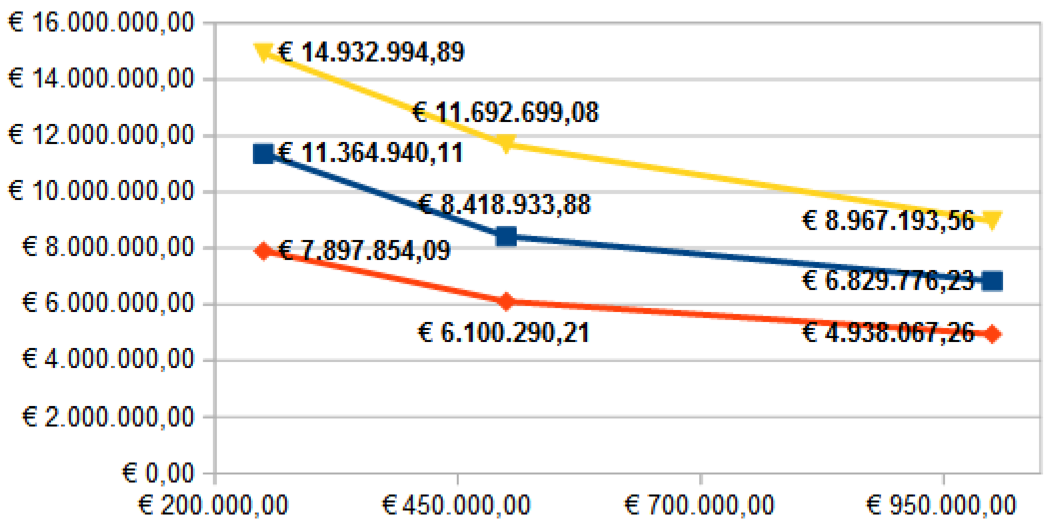

Figure 9.3: Mean price (blue) of an insurance policy with adverse events distributed according to a Poisson distribution. Lower (red) and upper (yellow) bounds represent the 5th and 95th percentile.

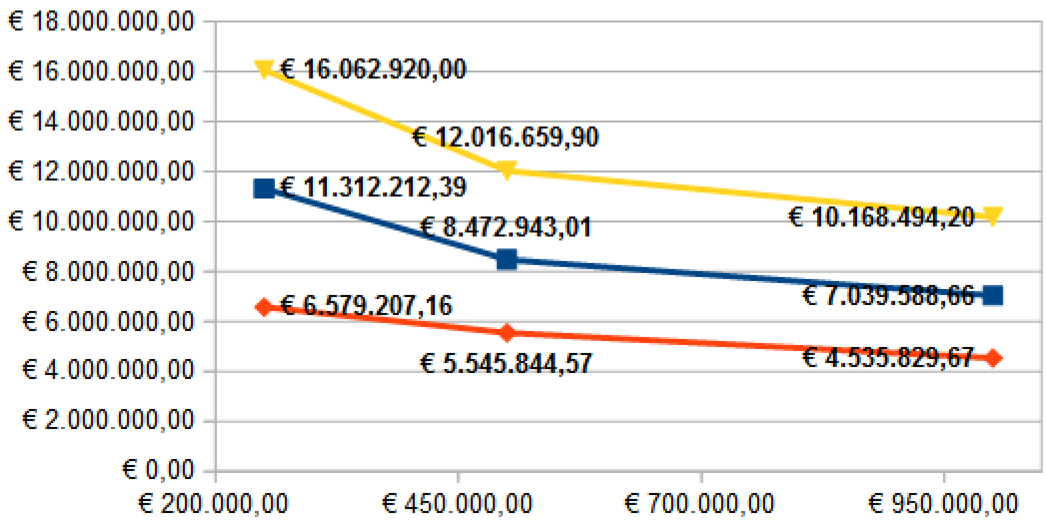

Figure 9.4: Mean price (blue) of an insurance policy with adverse events distributed according to an exponential distribution. Lower (red) and upper (yellow) bounds represent the 5th and 95th percentile.

Finally you can find the spreadsheet containing all the information just analysed that makes easier the comparison between the different distributions.

Deductible amount				
€ 250.000,00	€ 500.000,00	€ 1.000.000,00		
€ 11.225.440,31	€ 8.257.446,42	€ 6.828.394,49	Mean value	Normal distr.
€ 11.364.940,11	€ 8.418.933,88	€ 6.829.776,23		Poisson distr.
€ 11.312.212,39	€ 8.472.943,01	€ 7.039.588,66		Exponential distr.
€ 8.136.205,79	€ 5.914.184,08	€ 4.732.233,88	5^{th} percent.	Normal distr.
€ 7.897.854,09	€ 6.100.290,21	€ 4.938.067,26		Poisson distr.
€ 6.579.207,16	€ 5.545.844,57	€ 4.535.829,67		Exponential distr.
€ 14.947.052,53	€ 11.059.654,77	€ 9.137.696,63	95^{th} percent.	Normal distr.
€ 14.932.994,89	€ 11.692.699,08	€ 8.967.193,56		Poisson distr.
€ 16.062.920,00	€ 12.016.659,90	€ 10.168.494,20		Exponential distr.

Table 9.4: Analyses of the distribution's impact on the premium.

As we suggested during the description of the code, this program could be modify in order to consider much parameters, e.g. during the pricing phase of a third party liability of a public hospital the insurer needs to know the exact number of beds and the total amount of salary paid. Additional parameters concerning the structure in which the hospital is located are usually considered in the evaluation, this is due to the fact that the age of the building, number of elevators, number of floors, the presence of adequate fire protection and ventilation systems reduce the exposure to specific risks. The formula adopted in our estimation considers only three macro categories, the effectively cost of refunds and the reserves amount adjusted by coefficient whose value is based on the last premium paid, and taxes. With a bigger database it could be possible considering additional parameters and setting the coefficient on a larger basis.

9.1 Conclusions

The aim of this project has been an analysis of medical malpractice adopting as tool a software called NetLogo. Thanks to the capability of agent-based models in describing the behaviours of agents and their evolution, we could estimate the premium for a third party liability policy of public hospitals. In chapter 2 we focused on the importance of insurance, its evolution over time and the fundamental role played in the economy. A brief analysis on the problems of adverse selection and moral hazard is also performed and, as consequences, also the concept of deductible is reported. Chapter 3 faces the inversion of production cycle with the purpose of introducing the concepts of fair premium, net premium and commercial premium. The differences will be useful to understand the logic followed in the program created. Chapter 4 moves a step on towards the medical malpractice problem, here it is possible to find a first introduction to the concepts of adverse events and sentinel events. In addition the reader can perceive the magnitude of the problem thanks to the data presented. The analysis is based on the Italian situation and the American one, as comparison term. As the medical malpractice is strictly connected to the legislative background, in chapter 5 we decided to talk about the Italian legal system, in particular to the most important rules and amendments that affect the healthcare domain, from the origin up to the Balduzzi Decree. In chapter 6 we showed the possibility of adopting agent-based models as tool for describing social and economic phenomena. This is due to the fact that the laws underlying the relationship between the variables characterizing the study could be too difficult to be expressed by equation-based models. Chapter 7 is spent to explain the origin of the data we used for writing our code and a brief analysis of them is performed in order to extract some statistics useful for the program. In chapter 8 you can find the analysis and the assumptions of the program written and its code, then the explanation of the interface and all the possible parameters the user can interact with. Finally in chapter 9 there are the more relevant results obtained with the simulation.

- In our model the choice of the probability distribution adopted to model the adverse events over time does not affect in a relevant way the estimated premium. In particular there are no significant differences between normal, Poisson and exponential distributions in terms of mean value.

- Our program is not able to estimate the premium when the deductible amount is higher than 1 million due to the fact that the parameters, set as inputs, are based on a small database. Moreover, our starting point has been only one premium price on which we based the entire program, a the aim was to replicate the actual situation and acting on its characterizing parameters to observe and quantify the consequences.

Results could be better adopting a bigger database, having a larger set of historical premiums paid and having the possibility of introducing further parameters to our program. During the pricing phase, insurers often consider also parameters connected to the building and the structure in which the hospital is located, numbers of beds and the salary amount paid in the previous year. All these parameters have no effect on our estimation.

Appendix A

Protocol for monitoring sentinel events

The monitoring of sentinel events, already implemented in other countries, is an important public health action, representing an indispensable tool for the prevention of such occurrences and for the promotion of patient safety. For this reason the Department of Health has developed, with the technical support of the *Working Group evaluation of methodological approaches in terms of clinical risk*, this protocol for monitoring sentinel events, with the aim of providing to the regions and healthcare companies a unique methodology of surveillance and management of these events throughout the Country, to guarantee basic levels of care.

This protocol is an update to the month of July 2009. The previous version was revised and shared with the coordination of regions and autonomous provinces for patient safety.

Ministero del Lavoro, della Salute e delle Politiche sociali

DIPARTIMENTO DELLA QUALITÀ
DIREZIONE GENERALE DELLA PROGRAMMAZIONE SANITARIA,
DEI LIVELLI DI ASSISTENZA E DEI PRINCIPI ETICI DI SISTEMA
UFFICIO III

OSSERVATORIO NAZIONALE SUGLI EVENTI SENTINELLA

Segnalazione dell'evento sentinella

*Denominazione struttura sanitaria:

……………………………………………………………………………………………………

……………………………………………………………………………………………………

ASL /A.O. di appartenenza:

……………………………………………………………………………………………………

Regione: ……………………Provincia: ……………Comune: …………………………………..

Tipo struttura: ……………………………………………………………………………………..

*Referente per la compilazione:……………………………………………………………

Qualifica: ……………………………………………………………………………………

Tel: ……………………fax: ……………………e-mail: ……………………………………..

(Valorizzare almeno uno tra tel, fax e mail))

Data compilazione:……/……/……………………..

** dato obbligatorio*

*LISTA EVENTI SENTINELLA		
Indicare con il simbolo **[X]** *l'Evento Sentinella che è avvenuto:*		
1	**Procedura in paziente sbagliato**	
2	**Procedura chirurgica in parte del corpo sbagliata (lato, organo o parte)**	
3	**Errata procedura su paziente corretto**	
4	**Strumento o altro materiale lasciato all'interno del sito chirurgico che richiede un successivo intervento o ulteriori procedure**	
5	**Reazione trasfusionale conseguente ad incompatibilità AB0**	
6	**Morte, coma o grave danno derivati da errori in terapia farmacologica**	
7	**Morte materna o malattia grave correlata al travaglio e/o parto**	
8	**Morte o disabilità permanente in neonato sano di peso >2500 grammi non correlata a malattia congenita**	
9	**Morte o grave danno per caduta di paziente**	
10	**Suicidio o tentato suicidio di paziente in ospedale**	
11	**Violenza su paziente**	
12	**Atti di violenza a danno di operatore**	
13	**Morte o grave danno conseguente ad un malfunzionamento del sistema di trasporto (intraospedaliero, extraospedaliero)**	
14	**Morte o grave danno conseguente a non corretta attribuzione del codice triage nella Centrale operativa 118 e/o all'interno del Pronto Soccorso**	
15	**Morte o grave danno imprevisti conseguente ad intervento chirurgico**	
16	**Ogni altro evento avverso che causa morte o grave danno al paziente**	

**Barrare un solo evento per ogni segnalazione*

***Data dell'evento:** |__|__| |__|__| |__|__|__|__| ***Ora dell'evento**: |__|__| : |__|__|

Disciplina/Assistenza:

....

Luogo dove si è verificato l'evento:

Ambulanza |_|

Ambulatorio |_|

Bagni |_|

Corridoio |_|

Domicilio |_|

Reparto di degenza |_|

Sala operatoria |_|

Scale |_|

Terapia intensiva |_|

Altro |_| (Specificare, ad esempio Pronto Soccorso, Sala parto.....................................)

*Sesso: **M** |_| **F** |_|

***Anno di nascita:** |_|_|_|_|

Breve descrizione dell'evento: ....

....

....

***Esito dell'evento** (barrare solo una casella):

Morte |_|

Disabilità permanente |_|

Coma |_|

Stato di malattia che determina prolungamento della degenza o cronicizzazione |_|

Trauma maggiore conseguente a caduta di paziente |_|

Trasferimento ad una unità semintensiva o di terapia intensiva |_|

Reintervento chirurgico |_|

Rianimazione cardio respiratoria |_|

Richiesta di trattamenti psichiatrici e psicologici specifici in conseguenza di tentativi di suicidio o violenza subita nell'ambito della struttura |_|

Reazione trasfusionale conseguente ad incompatibilità AB0 |_|

Altro |_|

Se "Altro" Specificare (ad esempio Trattamenti terapeutici con ulteriori farmaci che non sarebbero stati altrimenti necessari, Richiesta di indagini diagnostiche di maggiore complessità, Traumi e fratture)

....

Cause e fattori che possono aver determinato l'evento o contribuito in qualche modo:

....

....

....

....

Tutte le informazioni fornite rimarranno confidenziali.

Invio scheda A

Il referente per la gestione del rischio clinico, ove presente, o un referente individuato dalla Direzione aziendale, provvede a compilare la scheda A, ad inviarla al Ministero, anche per il tramite della propria Regione di appartenenza, <u>al momento del verificarsi dell'evento o dell'avvenuta conoscenza dello stesso</u>.

Ministero del Lavoro, della Salute e delle Politiche sociali

DIPARTIMENTO DELLA QUALITÀ
DIREZIONE GENERALE DELLA PROGRAMMAZIONE SANITARIA, DEI LIVELLI DI ASSISTENZA E DEI PRINCIPI ETICI DI SISTEMA
UFFICIO III

OSSERVATORIO NAZIONALE SUGLI EVENTI SENTINELLA

Analisi delle cause e dei fattori contribuenti

1. EVENTO SENTINELLA

*Descrizione di ciò che è avvenuto, anche se possibile tramite un diagramma di flusso (allegare solo per invio cartaceo)

....

....

....

....

....

....

....

Indicare il metodo di analisi utilizzato per l'analisi delle cause e dei fattori che hanno contribuito al verificarsi dell'evento avverso:

Audit |__|
RCA |__|
Altro |__|

Se indicata la voce "Altro" Specificare...

2. CAUSE E FATTORI LEGATI ALLA COMUNICAZIONE

2.1. Sono emerse cause o fattori legati alla carenza/mancanza di informazione e comunicazione?

Sì |__| No |__| N.a. |__|

Se sì, Specificare ……………………………………………………………………………………

2.2. Sono emerse inadeguatezze nella documentazione analizzata ai fini del chiaro inquadramento del paziente, del piano di trattamento e della risposta del paziente al trattamento?

Sì |__| No |__| N.a. |__|

2.3. Sono emerse inadeguatezze nella comunicazione tra gli operatori sanitari nella gestione del processo assistenziale?

Sì |__| No |__| N.a. |__|

2.4. Sono emerse inadeguatezze nella comunicazione tra operatori sanitari e pazienti/familiari/accompagnatori, ovvero non sono stati coinvolti il paziente e/o i familiari/accompagnatori attivamente nel processo assistenziale?

Sì |__| No |__| N.a. |__|

3. CAUSE E FATTORI UMANI

3.1. Sono emerse cause o fattori correlabili alla carente formazione/addestramento degli operatori?

Sì |__| No |__| N.a. |__|

Se sì, Specificare ……………………………………………………………………………………

3.2. Sono emerse inadeguatezze nelle competenze/conoscenze degli operatori?

Sì |__| No |__| N.a. |__|

3.4. Sono emerse inadeguatezze legate alla organizzazione del lavoro (ad esempio organizzazione dei turni, fatica, stress)?

Sì |__| No |__| N.a. |__|

4. CAUSE E FATTORI AMBIENTALI

4.1. Sono emerse cause o fattori correlabili all'ambiente fisico ?

Sì |__| No |__| N.a. |__|

4.2. Se sì, Specificare:

Fattori strutturali (idoneità dei locali) |__|

Fattori legati alla logistica |__|

Fattori legati al microclima |__|

Altro |__| Specificare ....

5. CAUSE E FATTORI LEGATI ALLE TECNOLOGIE SANITARIE

A) Dispositivi medici e apparecchiature elettromedicali

5.1. Sono emersi cause o fattori correlabili all'uso di dispositivi medici ed apparecchiature elettromedicali

Sì |__| No |__| N.a. |__|

5.2. Se sì Specificare:

mancanza |__| malfunzionamento |__| uso non corretto |__|

5.3. Specificare a quale categoria appartiene il dispositivo secondo la classificazione Nazionale (D.M. 22/09/2005)

Codice Categoria |__| Codice CND |__|

Descrizione strumento

5.4. Esiste un piano di manutenzione preventiva per il dispositivo in oggetto?

Sì |__| No |__| N.a. |__|

5.5 E' stato rispettato il piano di manutenzione preventiva (inclusi eventuali aggiornamenti o patch software) per i il dispositivo in oggetto?

Sì |__| No |__| N.a. |__|

B) Farmaci

5.5. Sono emerse cause o fattori legati all'uso dei farmaci?

Sì |__| No |__| N.a. |__|

5.6. Se sì, Specificare:

mancanza |__| uso non corretto |__|

5.7. Se uso non corretto, Specificare:

Prescrizione |__| Conservazione |__|

Preparazione |__| Somministrazione |__|

C) Linee-guida, Raccomandazioni, protocolli assistenziali, procedure, barriere

5.8. Sono emerse cause o fattori legati a:

Linee-guida |__| Specificare:

Assenza |__| Inadeguatezza |__| Violazione |__|

Raccomandazioni per la sicurezza dei pazienti |__| Specificare:

Assenza |__| Inadeguatezza |__| Violazione |__|

Protocolli assistenziali |__| Specificare:

Assenza |__| Inadeguatezza |__| Violazione |__|

Procedure |__| Specificare:

Assenza |__| Inadeguatezza |__| Violazione |__|

Sono state individuate cause o fattori legati al venir meno di barriere/sistemi per la sicurezza o strumenti con funzione di protezione per il paziente, gli operatori nel contesto lavorativo-ambientale?

5.10. Sì |__| No |__| N.a. |__|

5.11. Se sì, Specificare ....

Piano d'azione

Specificare le azioni intraprese in seguito ai risultati emersi dall'indagine avviata dalla struttura ed in particolare all'analisi delle cause e dei fattori contribuenti e/o determinanti l'evento sentinella. Indicare anche quale figura professionale è stata individuata come responsabile del monitoraggio dell'azione (senza specificarne nome e cognome).

***Descrizione dell'azione n. 1:**

....

....

....

Responsabile dell'azione : ....

Indicatore di esito misurabile:

....

Giorno della misura |__|__| |__|__| |__|__|__|__|

Periodicità misura: ....*(Specificare se giornaliera, settimanale, mensile o altro)*

Coinvolgimento della Direzione aziendale Sì |__| No |__|

** dato obbligatorio*

Descrizione dell'azione n. 2:

....

....

....

Responsabile dell'azione : ....

Indicatore misurabile: ....

Giorno della misura |__|__| |__|__| |__|__|__|__|

Periodicità misura: ....*(Specificare se giornaliera, settimanale, mensile o altro)*

Coinvolgimento della Direzione aziendale Sì |__| No |__|

Descrizione dell'azione n. 3:
....

....

....

Responsabile dell'azione : ....

Indicatore misurabile: ....

Giorno della misura |__|__| |__|__| |__|__|__|__|

Periodicità misura: ....*(Specificare se giornaliera, settimanale, mensile o altro)*

Coinvolgimento della Direzione aziendale Sì |__| No |__|

Descrizione dell'azione n. …:
....

....

....

Responsabile dell'azione : ....

Indicatore misurabile: ....

Giorno della misura |__|__| |__|__| |__|__|__|__|

Periodicità misura: ....*(Specificare se giornaliera, settimanale, mensile o altro)*

Coinvolgimento della Direzione aziendale Sì |__| No |__|

Modalità di invio scheda B

Le strutture sanitarie inviano la scheda B del protocollo al Ministero, secondo le seguenti modalità: **il** referente per la gestione del rischio clinico, ove presente, o un referente individuato dalla Direzione aziendale, provvede a compilare la scheda B per l'analisi delle cause e dei fattori contribuenti e determinanti e ad inviarla al Ministero, anche per il tramite della propria Regione di appartenenza, entro 45 giorni solari dall'accaduto o dalla conoscenza dell'evento e dall'invio della scheda A.

Appendix B

Form for the voluntary reporting of adverse events

In the following pages it is possible to find the form for the voluntary reporting of alleged adverse events or eventi sentinella, created by *La città della Salute e della Scienza di Torino*. The objective is to give to the patients that suffered from unattended injuries, the possibility of informing the Risk Management unit in order to improve the health care service by putting into action an appropriate prevention protocol.

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La compilazione di questo modulo non esonera dalle segnalazioni obbligatorie o eseguite in ottemperanza a disposizioni aziendali (malfunzionamento dispositivi medici, pratiche infortunio, ecc.). Nel caso di presunto Evento Sentinella (vedi retro) contattare al più presto la SC Qualità, Risk Management e Accreditamento per i provvedimenti di competenza. Il modulo deve essere inviato alla S.C. Qualità Risk Management e Accreditamento.

Ospedale: ❑ Molinette/Presidi San Giovanni Battista ❑ CTO/Maria Adelaide ❑ Sant'Anna ❑ Regina Margherita

Tipologia evento

Evento evitato	❑ LIVELLO 1 situazione pericolosa/danno potenziale/evento non occorso	Evento avverso	❑ LIVELLO 3 nessun esito (evento accaduto, nessun danno)
			❑ LIVELLO 4 esito minore (osservazioni extra, nessun danno)
			❑ LIVELLO 5 esito moderato (osservazioni extra, lieve danno)
	❑ LIVELLO 2 situazione pericolosa/danno potenziale/evento occorso ma intercettato		❑ LIVELLO 6 esito tra moderato e significativo
			❑ LIVELLO 7 esito significativo (reintervento /prolungamento degenza)
			❑ LIVELLO 8 esito severo (disabilità permanente/decesso)

Qualifica di chi segnala l'evento:

Area : ❑ Medicina ❑ Chirurgia ❑ Area Emergenza/Intensiva ❑ Laboratorio ❑ Diagnostica per Immagini

❑ Altro ……………………………………………………………………………………

Data in cui si è verificato l'evento ____/____/_______ ora ___/___

Luogo in cui si è verificato l'evento (es. camera, bagno,sala medica, corridoio,ecc) :……………………………………………………………

Regime di erogazione: ❑ Ricovero Ordinario ❑ Ricovero DH/ DS ❑ Prestazione Ambulatoriale ❑ Altro ……………………

Descrizione dell'evento (che cosa è successo?)

………

………

………

Categoria evento

❑ Errore/Ritardo diagnosi	❑ Intervento chirurgico (es. lato/sede)	❑ Lesione dentaria
❑ Gestione del farmaco (*)	❑ Ritenzione corpi estranei	❑ Deficit tecnico - strutturale
❑ Gestione emocomponenenti (es. trasfusioni)	❑ Lesione da malposizionamento	❑ Deficit di vigilanza
❑ Esecuzione procedura	❑ Ustione intraoperatoria	❑ Organizzativo
❑ Aggressione utente/operatore	❑ Caduta	❑ Altro …………………………

(*) Nel caso di evento legato alla Gestione dei Farmaci compilare i campi successivi:

❑ Conservazione in reparto	❑ Preparazione	❑ Mancato monitoraggio
❑ Prescrizione	❑ Somministrazione	❑ Altro (es. anamnesi non completa, allergia non indicata)………………………………………

Fattori che possono aver contribuito all'evento (è possibile indicare più di una risposta)

FATTORI LEGATI AL PAZIENTE	❑ Condizioni generali precarie/ fragilità/ infermità ❑ Non cosciente/ scarsamente orientato ❑ Poca/ mancata autonomia ❑ Barriere linguistiche/culturali ❑ Mancata adesione al piano terapeutico/ assistenziale	FATTORI LEGATI AL SISTEMA	❑ Staff inadeguato/ insufficiente ❑ Insufficiente addestramento/ inserimento ❑ Protocollo/ procedura inesistente/ ambigua ❑ Difficoltà nel far rispettare protocolli/ procedure ❑ Mancata/ inadeguata comunicazione ❑ Mancanza/inadeguatezza attrezzature/materiale di consumo ❑ Mancata/inadeguata manutenzione attrezzature ❑ Problemi strutturali e/o ambientali
FATTORI LEGATI AL PERSONALE	❑ Difficoltà nel seguire istruzioni / procedure ❑ Fatica/ stress ❑ Presa scorciatoia/ regola non seguita ❑ Mancata/ inesatta lettura documentaz./ etichetta ❑ Mancata verifica preventiva apparecchiature		

Altri fattori (specificare):

A seguito dell'evento è stato necessario eseguire ulteriori indagini o prestazioni sanitarie? ❑ No ❑ Se Sì, quali? (specificare):……………………………………………………………………………………………

………

L'evento è documentato in cartella clinica? ❑No ❑ Sì | **Il paziente è stato informato dell'evento:** ❑ No ❑ Sì

Sono state o saranno intraprese azioni correttive/preventive a seguito dell'intervento? ❑ No ❑ Se Sì, quali? (specificare):……………………………………………………………………………………………

………

………

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LISTA DEGLI EVENTI SENTINELLA

1. Procedura in paziente sbagliato
2. Procedura chirurgica in parte del corpo sbagliata (lato, organo o parte)
3. Errata procedura su paziente corretto
4. Strumento o altro materiale lasciato all'interno del sito chirurgico che richiede un successivo intervento o ulteriori procedure
5. Reazione trasfusionale conseguente ad incompatibilità AB0
6. Morte, coma o grave danno derivati da errori in terapia farmacologica
7. Morte materna o malattia grave correlata al travaglio e/o parto
8. Morte o disabilità permanente in neonato sano di peso >2500 grammi non correlata a malattia congenita
9. Morte o grave danno per caduta di paziente
10. Suicidio o tentato suicidio di paziente in ospedale
11. Violenza su paziente
12. Atti di violenza a danno di operatore
13. Morte o grave danno conseguente ad un malfunzionamento del sistema di trasporto (intraospedaliero, extraospedaliero)
14. Morte o grave danno conseguente a non corretta attribuzione del codice triage nella Centrale operativa 118 e/o all'interno del Pronto Soccorso
15. Morte o grave danno imprevisti conseguente ad intervento chirurgico
16. Ogni altro evento avverso che causa morte o grave danno al paziente

Bibliography

Albolino, S., R. Tartaglia, T. Bellandi, A. M. V. Amicosante, E. Bianchini, and A. Biggeri

2010 "Patient safety and incident reporting: survey of Italian healthcare workers", *Quality and Safety in Health Care*, 19, Suppl 3, pp. i8-i12.

Anderson, P. W.

1972 "More is different", *Science*, 177, 4047, pp. 393-396.

Axelrod, R. and L. Tesfatsion

2006 "Appendix AA Guide for Newcomers to Agent-Based Modeling in the Social Sciences", *Handbook of computational economics*, 2, pp. 1647-1659.

Axtell, R. L. and J. M. Epstein

2006 "Coordination in Transient Social Networks: An Agent- based Computational Model of the Timing of Retirement", *Generative Social Science: Studies in Agent-based Computational Modeling*, p. 146.

Boero, R., M. Morini, M. Sonnessa, and P. Terna

2015 *Agent-based Models of the Economy: From theories to Applications*, Palgrave Macmillan, p. 232.

Cutler, D. M. and R. Zeckhauser

2004 "Extending the theory to meet the practice of insurance", *Brookings-Wharton Papers on Financial Services*, 2004, 1, pp. 1-53.

Danzon, P. M.

2000 "Liability for medical malpractice", *Handbook of health economics*, 1, pp. 1339-1404.

Eldabi, T.

2009 "Implementation issues of modeling healthcare problems: misconceptions and lessons", in *Winter Simulation Conference*, Winter Simulation Conference, pp. 1831-1839.

Fone, D., S. Hollinghurst, M. Temple, A. Round, N. Lester, A. Weightman, K. Roberts, E. Coyle, G. Bevan, and S. Palmer

2003 "Systematic review of the use and value of computer simulation modelling in population health and health care delivery", *Journal of Public Health*, 25, 4, pp. 325-335.

Gropello, G. and G. Gionta

2004 *Il manuale di riassicurazione.*

Heath, B., R. Hill, and F. Ciarallo

2009 "A survey of agent-based modeling practices (January 1998 to July 2008)", *Journal of Artificial Societies and Social Simulation*, 12, 4, p. 9.

Kirchhof, P. and N. Meseth

2012 "A survey on the use of simulation in German healthcare", in *Simulation Conference (WSC), Proceedings of the 2012 Winter*, IEEE, pp. 1-10.

Kohn, L. T., J. M. Corrigan, M. S. Donaldson, et al.

2000 *To err is human:: building a Safer Health System*, National Academies Press, vol. 6.

Morrisey, M. A., M. L. Kilgore, and L. J. Nelson

2008 "Medical Malpractice Reform and Employer-Sponsored Health Insurance Premiums", *Health services research*, 43, 6, pp. 2124-2142.

Posner, J. R.

1986 "Trends in medical malpractice insurance, 1970-1985", *Law & Contemp. Probs.*, 49, p. 37.