Chemical terrorism: risk modeling proposal for attacks involving ricin in mass gatherings in Brazil

Terrorismo químico: proposta de modelagem de risco envolvendo ricina em eventos de grande visibilidade no Brasil

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ABSTRACT Mass gatherings are at the center of terrorist strategies and are being repeated more frequently at international level. During the last years, Brazil has been the stage of mass gatherings, and it is supposed to host the Fifa Sub-17 World Cup this year. It is assumed that large exposure in these contexts increases vulnerability to threats, therefore it is necessary that safety planning be supported in risk management studies. It is considered that a greater knowledge of the topic is the first step towards an efficient defense system. This study aims to evaluate the probability of a ricin terrorist attack on a mathematical model. Existing literature shows reports of episodes of use of ricin as a chemical weapon. The choice of ricin is justified because it's a relatively easy biotoxin extraction from castor bean, which is an endemic plant in the Brazilian territory. For such study, we used game theory and the Major probability equation for terrorism risk analysis. The parameters analyzed were the resources of attack, defense, and value of the target. The probability equation has been optimized for defense.

KEYWORDS Chemical terrorism. Ricin. Probability. Computer simulation. Risk management.

RESUMO *Grandes eventos estão no centro de estratégias terroristas e vem-se repetindo com frequência no âmbito internacional. Durante os últimos anos, o Brasil é palco de megaeventos esportivos; e este ano sediará a Copa do Mundo Fifa Sub-17. Assume-se que a maior exposição, nesses contextos, aumenta a vulnerabilidade ante as ameaças não convencionais, assim, é necessário que o planejamento da segurança brasileira seja apoiado em estudos sobre gestão de risco. Considera-se que um maior conhecimento sobre o tema é o primeiro passo para um sistema de defesa eficiente. A literatura apresenta relatos de episódios de emprego da ricina como arma química. Assim, este estudo objetivou avaliar a probabilidade de risco de um ataque terrorista com ricina, em um modelo matemático. Para isso, foi utilizada a teoria dos jogos e a equação de probabilidade de Major para análise de risco de terrorismo. A escolha da ricina justifica-se pelo fato de se tratar de uma biotoxina de extração relativamente simples, proveniente da mamona, que é uma planta endêmica no território brasileiro. Os parâmetros analisados foram os recursos de ataque, defesa e valor do alvo. A equação de probabilidade foi otimizada para defesa.*

PALAVRAS-CHAVE *Terrorismo químico. Ricina. Probabilidade. Simulação por computador. Gestão de riscos.*

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Introduction

Although the phenomenon of terrorism is not a novelty of the 21st century, after the attacks of September 11, 2001, an international effort to prevent and combat this threat can be noted. Previously confined to mainly domestic political struggles, contemporary terrorism is characterized by its transnationalization, randomness of targets and absence of a clear objective to be negotiated, suggesting that, nowadays, it has moved on from being a means to become an end in itself. In addition, and of particular importance, it is the hybrid character of these organizations that are disguised as religious ideals to legitimize 'holy wars' between good and evil[1].

Apart from this general characterization, there is no consensus in the literature as to what terrorism and / or a terrorist group might be, making it difficult to combat or prevent it[2]. Prabha[3] notes the volatility of the conceptual definition broadly susceptible to the context. Thus, in realities in which conflicts of a socioeconomic nature stand out, terrorism is defined in the clash between possessors and dispossessed, while, in realities in which the weight of social confrontations of a political nature assume greater relevance, it is defined as a tactic for increase the bargaining power of one of the actors in conflict[3].

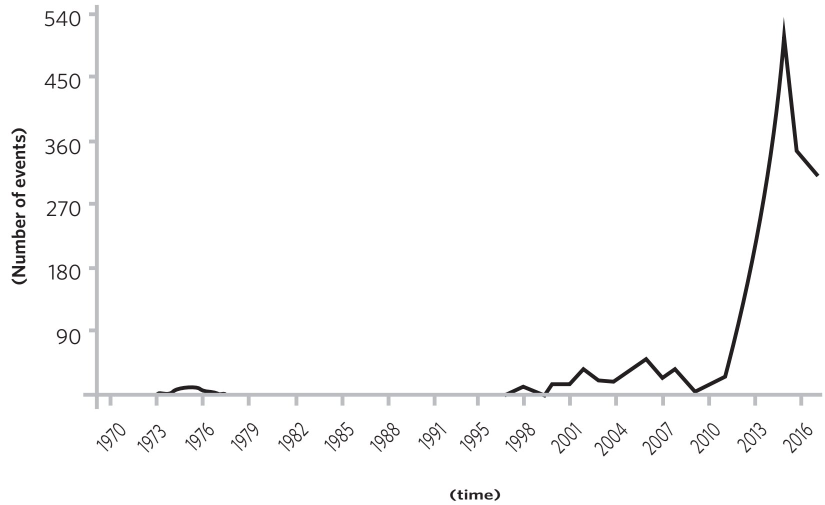
Despite the implication that conceptual inaccuracy brings to the formulation of policies to prevent and combat terrorism, one common aspect to the literature and international reports on the subject is the impact that the attack on the Twin Towers in 2001 had on the way the world began to organize around the issue. It can be said that this event led to a paradigmatic break not only in the literature on the subject, but also in the *modus operandi* of international politics.

Immediately after the attacks, the United Nations adopted Resolution nº 1.373[4] condemning terrorism and seeking to improve international cooperation against this type of threat. In 2002, the Organization of American States (OAS) adopted the Inter-American Convention against Terrorism, with a view to strengthening hemispheric cooperation to prevent, combat and eliminate terrorism. Finally, the most emblematic of the international documents against terrorism, Resolution nº 1.540, of the United Nations[5], dealing, for the first time, with associated terrorism and Weapons of Mass Destruction (WMD). This document emphasizes the danger of the acquisition of WMD by non-state groups (terrorism), addressing threats not covered by existing non-proliferation mechanisms, especially those dealing with control in biological, chemical and nuclear areas. This emphasis on the dangers of the association between terrorism and WMD is a reaction not only to the events of September 11, but to those that preceded and succeeded this episode.

As previously stated, since the attacks of September 11, 2001, terrorism has acquired new features, becoming transnational and making use of social networks for the cooptation of new members – most of the time, young people who have no identity with the cause propagated by these organizations. These aspects contributed to the randomness of the attacks carried out since then, making it difficult to anticipate the preparation of the security forces.

Graph 1 shows the terrorist events over the past two decades.

Graph 1. Terrorist events over time



Source: Global Terrorism Database[6].

An increase in the number of events since 1998 can be observed, when Al-Qaeda attacked United States embassies in Nairobi, Kenya, and Dar es Salaam, Tanzania. The increase presented between the years 2013 and 2016 can be explained by the large number of successive events, such as the attack on the Boston marathon, the letters containing ricin addressed to politicians in the United States, in 2013, and the attack on the headquarters of the newspaper 'Charlie Hebdo', France, in 2015. The high number of events, after 2013, is also due to the various attacks using chemical weapons in the war in Syria during that period.

Conceptually, chemical weapons can be defined as a chemical used to cause intentional death or damage by their toxic properties. Ammunition, devices and other equipment specifically designed to neutralize toxic chemicals also fit the definition of chemical weapons. These weapons cause a much higher number of casualties than conventional ones and with less material used. The low cost and the relative ease of its production and management made possible the diffusion of its employment by terrorist groups.

As seen before, the international reaction took the form of resolutions calling on States to cooperate with efforts to prevent and combat terrorism, which, in practice, can only be done when such measures are converted into national legislation on the subject, enabling the creation of national emergency and risk management plans[7]. Brazil has presented, in the early years of the 21st century, a significant increase in its inclusion in the international scene; and, as a consequence, it is most requested to host events of great proportions. Although it has a peaceful tradition, this projection requires efforts around defense and security-related topics[8].

Leaders from public and private spheres began to look for risk analysis to assess the risks that each potential target has and guide decisions related to the protection measures to be adopted. According to Parnell[9], the President of the United States has asked the Department of Homeland Security to conduct a bioterrorism risk assessment in order to guide the prioritization of research investments, planning and preparation related to biosafety.

Since 2007, when it hosted the Pan-American Games, the first in a series of major international events, there has been a growing concern that Brazil could be the scene of a terrorist attack. Even if such consideration seems uncertain in view of the non-conflictive position of the Country in international politics, the increased circulation of foreign delegations, as well as the flow of tourists and the very profile of high visibility of the events, increases the Brazilian vulnerability in the face of unconventional threats.

In June/July 2019, Brazil hosted the 46th edition of the America's Cup; and in October, will host the Fifa Under-17 World Cup, events of great international visibility. Thus, given the context, the availability of the raw material, the low cost, and the relative simplicity in the production of ricin, it is defended the relevance of studies, that can help in the preparation of the teams of first response, as firefighters, civil defense and police forces; furthermore, stimulate reflections on the subject.

Thus, this study aims to analyze the likelihood of risk of a terrorist attack in Brazil with ricin, highlighting the importance of expanding knowledge as a first step towards an efficient defense system; since the identification of the agent is crucial not only for the containment of the spread and the control of the contamination, with the correct provision of assistance to victims, but also for the correct choice of individual responder protection equipment. Unlike a terrorist attack using conventional weapons, in an attack of chemical origin, there is an aggravation arising from the initial ignorance of the substance employed, which delays, when it does not compromise, the work of the first responders[10]. In this way, the mathematical equations of the probabilistic risk approach can help in estimating the consequences of a chemical attack, being able to contribute to support the allocation of resources for the facing/mitigation of risks in anti-terrorism studies.

Ricin: the castor bean toxin

The choice for ricin was not a random one. This toxin presents great potential to be used as a chemical weapon, since it is produced from the seed of the castor bean (*Ricinuscommunis L.*). It is estimated that each seed can contain approximately 1% to 5% of the molecule[11,12].

The world's largest producer of castor bean is India, followed by China and Brasil[13]. The extraction of one ton of oil generates around 1.2 tons of residues, called castor bean pie. The ricin is concentrated in the pie. Both pie and peel can be used as organic fertilizer and as alternative feed for ruminants animals[14]. However, there are cases of poisoning in animals by ingestion of the pie, and chemical or thermal treatment is necessary.

Ricin is a water-soluble toxin and very potent for men, animals and insects. It is considered to be a high-risk chemical for living beings under the Organization for the Prohibition of Chemical Weapons (OPCW), and is also classified as a Category B biological agent by the Centers for Disease Control and Prevention[15]. The substances of this class present moderate ease of dissemination, intoxication results in moderate morbidity and low mortality and requires surveillance and improvement of diagnosis.

Clinical and pathophysiological effects of ricin poisoning will depend on dose/concentration, time and route of exposure. The main routes of exposure are ingestion, inhalation and contact with the eyes, but can also be injected. In case of contact with the skin, if it is intact, there will not likely be intoxication or absorption, due to the fact that the ricin is a toxin of a protein nature of high molecular weight[16] *(chart 1)*.

Chart 1. Exposure routes, lethal dose of 50% of the population and symptoms associated with ricin exposure

Exposure Route	LD50	Symptoms
Ingestion	25-100 mg/kg	It starts in about 4 hours or 6 hours, but can have a latency period of up to 10 hours. Abdominal pain, vomiting with or without blood, diarrhea with or without blood, heartburn, dysphagia. May cause severe inflammation of the bowel and stomach, disorientation, drowsiness, weakness, seizure and excessive thirst. There is electrolyte imbalance, dehydration, hypotension and circulatory collapse. May have blood in the urine. It can lead to death.
Injection	5-15μg/kg	May have latency from 10 hours to 12 hours. Fever, headache, dizziness, nausea, anorexia, hypotension, abdominal pain and may present wound in the local of the injection.
Dermatological/ Ophthalmic	-	Contact with skin may cause pain, irritation and possible allergy. Contact with eyes may cause conjunctivitis, lacrimation, swelling, redness, tissue destruction, retinal hemorrhage, impaired vision and blindness. Contact with eyes may cause body poisoning and may lead to death.

Source: Audi et al., 2005[11]; Musshoff and Madea, 2009[12]; CDC, 2011[16]; Fonseca and Blanco, 2014[17].

Of all exposure routes, the aerial dissemination of ricin has the greatest potential as a threat to urban populations. However, aerosol dissemination can also be used for water and food contamination[15].

The mode of action of ricin in the body is the agglutination of red cells, followed by intense hemolysis. The main symptoms of poisoning are: respiratory paralysis and vasomotor system, abdominal cramps, diarrhea, loss of appetite, increased heart rhythm, lack of motor coordination, fever and haemorrhage[17].

Ricinine, an alkaloid found in the castor bean leaf, can be used as a biomarker, and according to some studies, it can be found in the urine of the person exposed after contamination[11,17,18]. In case of exposure, the treatment is symptomatic and supportive, since there are no antidotes available for ricinine[11,12,19].

Because it is a white powder, it can be visually confused with several other products, making it difficult to identify quickly. Rapid detection and identification of the substances present in a sample is crucial for the management of a suspected case of ricin attack. There are detectors of this toxin based on RTQ-PCR and Elisa, however they can offer false-positive results in the presence of other substances, being necessary taking samples as well as sending them to the reference laboratory for agent confirmation[20-22].

If ricin has been used as an aerosol, consideration should be given to possible re-aerosolization, resulting in new cases of airway exposure poisoning. This is an essential concept for the decontamination of people and materials in the affected area. Decontamination of people exposed to ricin consists only of removing clothing, followed by washing the skin with running water. 0.5% sodium hypochlorite solutions have been shown to be effective in decontamination of materials[23,24].

Game theory and adverse risk assessment

Among the chemicals related in the Organization for the Prohibition of Chemical Weapons (OPCW), ricin poses a high risk, as stated above, due to its high toxicity, high availability and ease of extraction.

Risk assessment has helped first response teams to evaluate, communicate and manage the risk posed by chemical agents used in terrorist attacks. In the Adverse Risk Assessment (ARA) or probabilistic risk analysis, uncertain risks were modeled using probability distributions for threats, vulnerabilities, and consequences. It is a technique that has been employed over time to evaluate the probabilities and consequences of system failures. It is also used to guide decisions related to corporate and government risk management.

The study on the risk of terrorism resembles the study of complex engineering systems as well as natural disasters. However, it presents human intent, in contrast to complex engineering systems, and is generated by human intelligence[25]. For these particularities, this article proposes the combination of game theory, to the extent that it is used for modeling phenomena, when there are two or more actors (players), that is, two or more decision makers[26]. Game theory is a mathematical theory, created to model actions, studying decision making among actors when there is interdependence of results, that is, when they interact with each other making choices. It is a form of analysis of strategic decisions in which players act taking into account the reaction of their opponents or the consequence of their actions to themselves[27]. Since ARA is a probability-based assessment, and game theory, a system that studies strategies, it is understood that combining these two tools will produce a model for analyzing possible scenarios involving terrorism.

In the application of this model, an equation is used that calculates probability in a consistent way, based on the possible strategies of actions of each player. Thus, the profile is created with all possible situations, since each player will have individual preferences for each situation in the game[27].

According to Fricker[28], there are three types of game theory that are applicable to terrorism analysis: the classic games, in which the actors, the strategies and actions are completely specified – in this type of game the balances between attackers and defense are studied; repetitive games, that occur over time and have attacker and defense interacting repeatedly – are used to study strategies that may result in unfavorable outcomes; and board games, which consist of opposing simulation with two or more real players using a set of rules, data and procedures that describe a conflict. The latter type is used for risk analysis.

From this perspective, the Major[25] equation will be used. The probability of success of a terrorist attack can be calculated by this equation, which is based on the model proposed by Woo[29], set out below:

$$\log\{P(U[C,T])\} = a - b_1C - b_2T$$

In which:

P(U[C,T]) is the probability of attack success;

a is a given factor;

b_1 and b_2 are parameters estimated by experts from empirical data;

C is the target location;

T is the classification of the target as for the type.

This model describes the probability depending on where the event may occur. The data is obtained from statistical analysis of past events, tests, models, simulations and expert evaluations of the subject. However, in terrorist events, this probability does not fully apply, since there is no pattern of attack based on past events, because motivations change over time. The model proposed by Major[25] shows to be more efficient than that of Woo[29], since it considers, in addition to the target, two other factors: attack resources and defense resources. These factors are relevant in this work because, for the study, financial capital and the number of individuals will be considered. Major's model:

$$p(V_i, A_i, D_i) = \exp\left(\frac{-A_i D_i}{\sqrt{V_i}}\right)$$

In which:

A_i is the attack feature;

D_i is the defense feature;

V_i is the target value.

Major[25] also considers the loss, or expected loss, by proposing an equation for its calculation. Loss analysis is important, because, for the construction of the risk assessment, the best defense strategy will always be the one that combines the highest probability of success of the attack with the least expected loss. In other words, the best defense strategy will always be the one that minimizes the expected loss of targets.

The equation for calculating the expected loss of Major[25] is:

$$PE = \sum_i V_i * p(V_i, A_i, D_i)$$

In which:

$p(V_i, A_i, D_i)$ is the probability of attack success;

A_i is the attack feature;

D_i is the defense feature;

V_i is the target value.

Methodology

In order to achieve the objective of analyzing the risk probability of a terrorist attack with ricin in Brazil, it was sought to define a scenario, more significant and closer to reality, for the attack with the biotoxin. The mathematical software Octave was used, version 4.2.1, for the analysis of the equations, applying the game theory as a basis of strategy of the players, attackers and defenders.

The scenario and the weighting of variables

It is difficult to estimate values for damage resulting from chemical attacks. Similarly, it is complex to define numbers for each variable, as it cannot be said how much a terrorist attack costs for an extremist group. In this way, the attack value in this work was estimated from the forms of dispersion that the ricin can have. The more difficult the route to obtain and manufacture the chemical weapon, the greater the associated attack capability.

It is known that, at the end of the normal route of extraction of the ricin, a powder is obtained. This can be dispersed in three ways: dispersion in a water tank, dispersion through aerosols and dispersion of the powder in air ducts.

The dispersion of this powder into a water tank is the form of attack that involves the least expense and risk to the attacker. In addition, the ingestion of water-soluble powder is the lowest form of health impact, requiring a large amount for the damage to be considerable.

As specific targets were not studied in the present study, the target values were assigned numbers of 0.05 (lowest impact target) up to 1.00 (highest impact target)as shown in *chart 2*. These values were assigned so that the resources associated with each variable were in the same order of magnitude.

Chart 2. Values assumed for the defense and target resource, according to the order of magnitude of the attack resource

Defense and Target Valu	
0.05	0.55
0.08	0.60
0.10	0.65
0.15	0.70
0.20	0.75
0.25	0.80
0.30	0.85
0.35	0.90
0.40	0.95
0.45	1.00
0.50	-

Source: Own elaboration, 2018.

Therefore, for the purpose of calculating the risk analysis, the value 0.10 was given to the form of dispersion of ricin in a water tank. This same powder, if dispersed in ventilation ducts of a building, generates a greater risk for the attacker, increasing its exposure. The dispersion of this aerosol-shaped material means that the attacker must treat the toxic substance after extraction, transforming it into a colloid.

It is necessary that the attacker has chemical concepts to carry out this transformation, which makes this route of exposure with greater allocation of resources. Inhalation of this material is extremely severe; and with low amounts, it can lead to death. Thus, it is the form that poses the greatest risk to the exposed population. This latter scenario was chosen to be worked on in this article; and this strategy of attack was given the value 1.00.

If a terrorist attack were to happen today in Brazil, the first team to arrive would be the police, because of the ease of access and proximity to the population. From that, the defense was considered, taking the agent into consideration. It is also known that the cost of a chemical weapon is, in general, much lower than that of a police officer for the State, whose salary today is about R$ 3.500,00 in the state of Rio de Janeiro. It was then defined that it is worth 0.5 of the dispersion pathway value, that is, being the exposure value 0.10, the value of only one police officer is 0.05.

Probability of successful attack

The probability related to each defense value and predefined target was calculated, maintaining the constant attack, so that the influence of the defense and target values on the probability of success of attack could be observed, taking into account a route of exposure.

Expected loss

The expected loss is the effective loss that the target can have according to the attack. It can be calculated according to the expected loss equation.

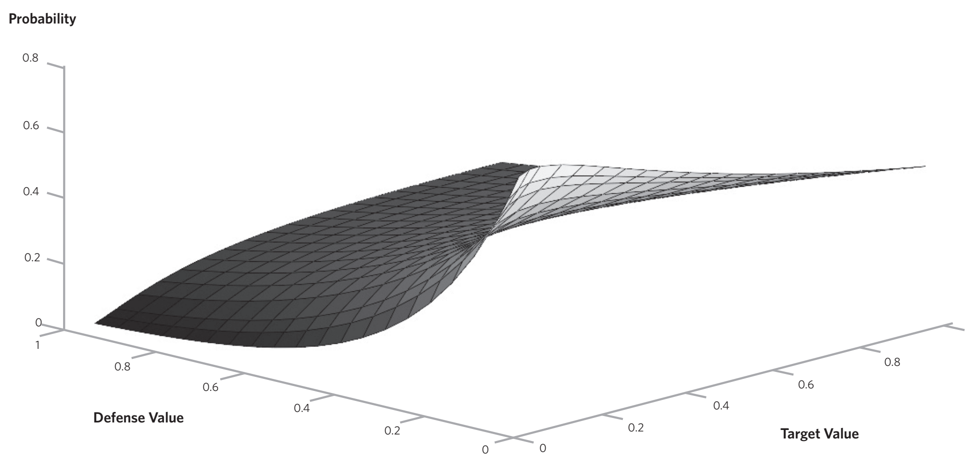
Results and discussion

The results were obtained based on the equations and postulates of the article 'Advanced Techniques for Modeling Terrorism Risk', by John A. Major[25], Senior Vice President Guy Carpenter & Company, Inc.

Probability of successful attack

The results of the Major[25] equation for calculating the probability of success of the aerosol dispersion attack containing ricin as a chemical weapon agent are shown in *graph 2*.

Graph 2. 3D graph for probability in cases of ricin attack via aerosol



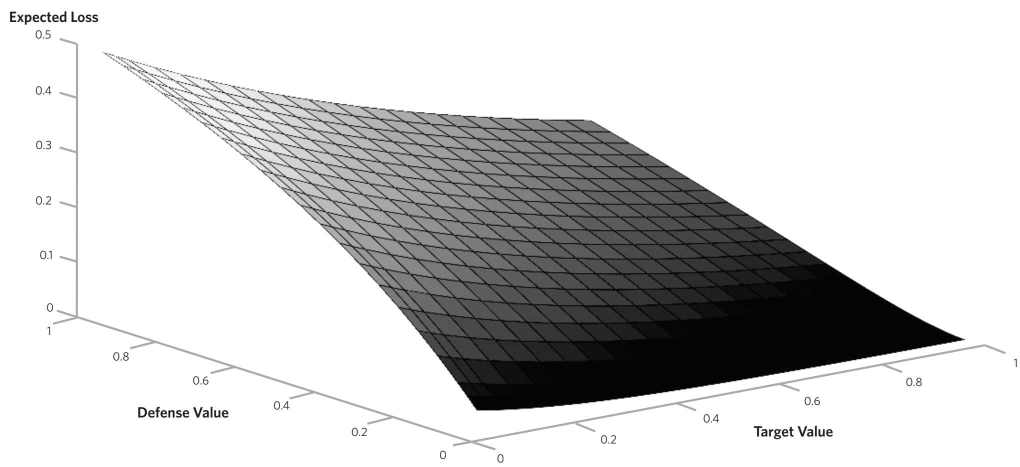
Source: Own elaboration, 2018.

It is observed, based on the graphic behavior, that the highest probability of success is associated with values of lower defense value and lower target value. That is, the greatest chance of successful attack occurs when the value of the target is low, and the defense, too. From the theory of games, this behavior can be associated to the fact that defense is greater in the most valuable targets, leaving the least valuable unprotected. On the other hand, if the attacker knows that the defender is allocating his resources optimally, then there is no way to determine the likelihood of attack success, so he would have no way of knowing the best target to attack. However, as is postulated in game theory, the attacker does not know which defense strategy and vice versa, so the probability analysis is critical to the attack. Therefore, it is necessary that there is a cautious choice of strategy on the part of the defense, in order to seek greater loss for the attacker. This balance is called the expected loss balance. Thus, in addition to analyzing the probabilities of attack, one should also analyze the expected loss, which is the amount of damage that will be suffered by the target in the event of an attack with the predefined conditions. The attacker must choose the target so that the expected loss exceeds the expected loss balance.

Expected loss

Through the expected loss equation, the loss associated with each predefined target and defense value was calculated in an attack with dispersion of aerosols containing ricin (*graph 3*).

Graph 3. 3D graph for expected loss in cases of ricin attack via aerosol



Source: Own elaboration, 2018.

For the construction of this mesh, an attack resource value equal to 1 was considered. It is observed that the expected loss is greater when one has a greater defense feature, and is smaller when the defense feature is low. It can also be seen that the expected loss is higher in smaller target values, even if this effect is not so considerable.

It makes sense that the expected loss is greater in the lower value target and with the highest defense. The targets that aggregate low values are, in general, those that present the greatest fragility and low security systems. When high defense resources are allocated at this location, it will naturally be the point at which it will have the greatest loss, as the defense will suffer the most damage. In addition, attacks are known to be most likely to succeed on the cheapest targets, so these are most likely to be attacked. That's why they add the largest expected loss.

The expected loss variation is called by Major[25] of expected loss balance. That balance shows that, if the attack feature is low, then the target better be low-value too, as the expected losses associated with the highest values targets are smaller than the expected losses associated with the highest values targets, thus increasing the damage.

According to game theory, the attacker's strategy options are the choice of targets and the allocation of attack resources to them, up to N targets; that is, the attacker defines his targets and sets his attack mode and those are his moves. On the other hand, the defense strategy is to choose, simultaneously, the allocation of resources for the N targets. This way, the choice of the expected loss that causes the least damage can be made, in the cases exposed in this work, analyzing the results.

The counterterrorist team should be prepared and invest resources based on the highest expected loss achieved. Not knowing how the attacker will choose the targets, the defender chooses the strategy that results in the worst expected loss, regardless of the attacker's choice of target. The simulation must be done by assuming the attack resource value, so that the defense resource allocation is effective in decreasing the expected loss.

Sometimes, it is more advantageous to leave fewer valuable targets defenseless and invest in defending the most valuable targets, because the expected loss of a less valuable target, even if the probability of attack success is 100%, will be less than the expected loss of the defense resources on the valuable targets. Thus, when choosing the strategy used by the defense, one should try to equalize the expected losses on all targets, minimizing the effects of an attack.

Final considerations

This article demonstrates the need for the development of studies of this nature, considering its relevance not only as a subject for academic reflection, but also with overflowing to the daily training and preparation of the Security Forces.

The model proposed by Major takes into account three variables, which makes it a good simulation. However, the author himself says that this model takes into account the prediction of human behavior, which in reality is difficult to pinpoint. When considering an exercise in which one of the actors is a terrorist cell, the level of unpredictability, as we have seen, increases exponentially. However, as this paper shows, it possible to well portray the concepts of game theory with rationality over terrorist acts through artificial intelligence. For the application of this system, values were assigned to the attacking, defensive and targeting resources empirically, through weightings. The greatest difficulty remained in defining the values for the targets, which calls for the accomplishment of more improved studies necessary to improve the weighting of values.

This work draws attention to the theme of terrorism, which is extremely important for a country on the eve of hosting another highly visible international event. Furthermore, it was considered that, despite the non-conflicting profile of Brazil in the international scenario, the context of a large event, associated with the relative simplicity of ricin extraction and its abundance in Brazil, calls for an analysis of the risk of a successful terrorist attack using there for risk probability calculation. While recognizing the limitations of every methodological choice, the task is to raise the relevant debate not only for the academic exercise, but mainly for the preparation of the Health and Safety Forces in Brazil.

Given the complexity of the subject and the limitations, this study does not exhaust the issue or present closed models, but, yet, offers possible analytical ways and that invite further researches for its refinement. It is, therefore, about contributing to a debate under construction.

Collaborators

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References

1. Ganor B. Global Alert: The Rationality of Modern Islamist Terrorism and the Challenge to the Liberal Democratic World. New York: Columbia University Press; 2019.

2. Schmid A. Terrorism: The Definitional Problem. J Internat Law. 2004; 36(2):375-419.

3. Prabha K. Defining terrorism. Strategic Analysis. 2000; 24(1):125-35.

4. Estados Unidos da América. Resolução nº 1.378. S/RES/1373 [internet]. Washington, DC: Security Council; 28 Set 2001. [acesso em 2018 dez 2]. Disponível em: https://documents-dds-ny.un.org/doc/UNDOC/GEN/N01/557/43/PDF/N0155743.pdf.

5. Estados Unidos da América. Resolução nº 1.540. S/RES/1540.Washington, DC. Security Council. 28 Abr 2004. [acesso em 2018 dez 2]. Disponível em: https://www.un.org/ga/search/view_doc.asp?symbol=S/RES/1540%20(2004).

6. Global Terrorism Database [internet]. Baltimore: University of Maryland; 2001 [acesso em 2018 nov 30]. Disponível em: https://www.start.umd.edu/gtd/search/.

7. Cardoso TAO, Vieira DN. Bacillus anthracis como ameaça terrorista. Saúde debate. 2015; 40(107):1138-48.

8. Brasil. Decreto Legislativo nº 373, de 25 de setembro de 2013. Aprova a Política Nacional de Defesa. Diário Oficial da União. 26 Set 2013.

9. Parnell GS, Burk RC, Merrick JRW. Intelligent Adversary Modeling of Homeland Security Networks. In: 63º Annual Conference and Expo of the Institute of Industrial Engineers; 2013 May18-22; San Juan, Puerto Rico. New York: Curran Associates; 2013. p. 2038-47.

10. Pita R, Ishimatsu S, Robles R. Actuación sanitaria en atentados terroristas con agentes químicos de guerra: más de diez años después de los atentados con sarín en Japón (1a parte). Emergencias 2007; 19:323-36.

11. Audi J, Belson M, Patel M, et al. Ricin poisoning: a comprehensive review. Journal Am. Medical Assoc. 2005; 294(18):2342-51.

12. Musshoff F, Madea B. Ricin poisoning and forensic toxicology. Drug Test Anal. 2009; 1(4):184-91.

13. Scientific Opinion of the Panel on Contaminants in the Food Chain on a request from the European Commission on ricin (from Ricinus communis) as undesirable substances in animal feed. The EFSA Journal. 2008; 726(1):1-38.

14. Severino LS. O que sabemos sobre a torta de mamona. Campina Grande: Embrapa; 2005.

15. Centers for Disease Control And Prevention. Emergency Preparedness and Response. Bioterrorism Agents/Diseases; 2018. Atlanta: CDC; 2018. [acesso em 2018 ago 10]. Disponível em: https://emergency.cdc.gov/agent/agentlist-category.asp.

16. Centers for Disease Control And Prevention. The National Institute for Occupational Safety and Health. Emergency Response Safety and Health Database. RICIN: Biotoxin; 2011. Atlanta: CDC; 2011. [acesso em 2018 ago 10]. Disponível em: https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750002.html

17. Fonseca NBS, Blanco BS. Toxicidade da ricina presente nas sementes de mamona. Semina: Ciênc. Agrárias 2014; 35(3):1415-24.

18. Sousa RB, Oliveira SEM, Santos MC, et al. Ricina e a Convenção para Proibição de Armas Químicas no Brasil. Virtual Quím. 2014; 6(3):744-60.

19. Garland T, Bailey EM. Toxins of concern to animals and people. Rev Sci Tech 2006; 25(1):341-51.

20. Sturm MB, Schramm VL. Detecting ricin: sensitive

luminescent assay for ricin Achain ribosome depurination kinetics. Anal Chem 2009; 81(8):2847-53.

21. Sehgal P, Khan M, Kumar O, et al. Purification, characterization and toxicity profile of ricin isoforms from castor beans. Food Chem Toxicol 2010; 48(11): 3171-6.

22. Godoy MG, Fernandes KV, Gutarra MLE, et al. Use of VERO cell line to verify the biodetoxification efficiency of castor bean waste. Process Biochemistry 2012; 47(4):578-84.

23. Spivak L, Hendrickson RG. Ricin. Critical Care Clinics. 2005; 21(4):815-24.

24. Mackinnon PJ, Alderton MR. An investigation of the degradation of the plant toxin, ricin, by sodium hypochlorite. Toxicon 2000; 38(2):287-91.

25. Major JA. Advanced Techniques for Modeling Terrorism Risk. J Risk Finance 2002; 4(1):15-24.

26. Sartini BA, Garbugio G, Bortolossi HJ, et al. Uma Introdução a Teoria dos Jogos. In: Anais da II Bienal da Sociedade Brasileira de Matemática; 2004 Out 25-29; Salvador. Salvador: UFBa; 2004. p. 18-36.

27. Silva KC, Inácio TVP, Blum GG. Teoria dos Jogos: uma análise da aliança Isis-Boko Haram. Geograp. Opportuno Temp. 2017; 3(1):116-23.

28. Fricker RDJ. Game Theory in an Age of Terrorism: How Can Statisticians Contribute? In: Wilson AG, Wilson GD, Olwell DH, editors. Statistical Methods in Counterterrorism. Game theory, modeling, syndromic surveillance and biometric authentication. New York: Springer; 2018. p. 3-7.

29. Woo G. Insuring Against Al-Qaeda. In: Insurance Project Workshop; 2003. Cambridge: National Bureau of Economic Research; 2003. Massachusetts. 2003. p. 1-14. [acesso em 2018 ago 10]. Disponível em: http://www.nber.org/~confer/2003/insurance03/woo.pdf.

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