An Emergency Management Plan to Face a Foodborne Criminal Attack

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Context

- In the framework of **the project PrHoDom** (Protection of Home Health Care Structures) we are working with the 3rd biggest HHC in France, which is the hospital center "Soins et Santé", in order to develop **decision making tools to support the different phases of its crisis management plans**.

- In this paper we focus on **the response to a biological risk**. Food poisoning transmitted to man is frequent in our societies whatever the continent could be. They can be of **accidental or malicious origin**.

- **Food defense** is focused on **protecting the physical food supply chain**. It differs from other food safety studies where the food contamination is unintentional.

- In our case the **food contamination is** targeted, i.e. **criminal**. Such criminal attacks can take place in farms, food processing plants, distribution chains, retail stores or restaurants.

Outline

- Food Poisoning Outbreaks,
- The Investigated Scenario,
- The Collaborative Response to the Outbreak ,
- An Extension of the SIR Model,
- The Linear Programming Model,
- Experiments.

Food poisoning outbreaks

Agent	Cause	Consequences	Incubation	Lethality	Treatment
Botulinum A	Bacteria	Nerve impairment	1-3 days	5%-25%	Antitoxin
Escherichia Coli	Bacteria	Kidneys impairment	3-8 days	3%-5%	Rehydration
Hepatitis A	Virus	Liver impairment	14-28 days	0.6%	Analgesics, antipyretics
Listeria	Bacteria	Sepsis, brain infection	10-28 days	17%	Antibiotics
Salmonella	Bacteria	Gastroenteritis, dehydration	1-2 days	1%	Antibiotic therapy for elderly
Shigella Dysenteriae	Bacteria	Dysentery, acute intestinal inflammation	1-7 days	20%	Antibiotics
Staphylococcus Aureus	Bacteria	Vomiting, Dysentery	1-8 hours	0.02%	Antibiotic therapy

Food poisoning outbreaks

- A foodborne illness outbreak with “Botulism A” toxin took place in Peoria (Illinois) in 1983. 28 persons were hospitalized, and **20 patients were treated with Botulinum antitoxin**.
- A Shigella Dysenteriae occurred among the staff of a Texas hospital laboratory on October 1996 . This outbreak was most likely due to a **criminal contamination of food with a hospital stock culture**, due to the revenge of an employee. 12 people were contaminated and 4 were hospitalized.
- An outbreak of Hepatitis A took place in Monaca (Pennsylvania) on November 2003. Approximately **555 persons with hepatitis A** have been identified and **3 persons have died**.
- An outbreak of Listeria took place in Colorado on October 2011 and infected 147 people. **Contaminated cantaloupes resulted in 33 deaths**.
- In April 2013, a food poisoning caused by Staphylococcus Aureus in ice cream occurred in Freiburg (Germany). 13 people were contaminated and 7 were hospitalized. None of the personnel of the hotel presented some symptoms of illness.

Police carry out more raids in Cologne, Germany, after biological weapon arrest

- Homeland Security News Wire.
- Published 15 June 2018.
- Police in the German city of Cologne on Friday searched several empty apartments in a high-rise, following the Tuesday discovery of the highly toxic substance ricin in one of the apartments. On Thursday, police charged a 29-year-old man with producing a biological weapon and for “preparing a serious act of violence against the state.”

The investigated scenario

- Food and water contaminations define a easy way for criminals to realize a biological attack. **Botulinum toxin is one of the most poisonous substances known**. Botulinum bacteria are easy to be found in nature; they can grow with few equipment and they can be introduced without difficulty in foods.
- **A caterer prepares and carries meals for a group of inhabitants** of the metropolis of Lyon. **A significant portion of its customers** is made up of **patients of a Home Health Care Structure** (25%). Meals are delivered to patients once or several times a week.
- A newly hired **employee is spreading Botulinum toxin in milk desserts**. Botulinum toxin is colorless, odorless and tasteless. Lots of customers are contaminated, who may belong to the home health care structure.
- **An antitoxin exists**, **it must be administered** as soon as the symptoms appear and that is to say **between 12h and 72h after ingestion**. **Beyond that** period, the infected **person must be cared in an intensive care unit** without delay to substitute the respiratory and digestive dysfunctions. In the absence of medical care, the case fatality rate can reach 78%.

The collaborative response to the outbreak

- The medical response to the biological attack is the **emergency management plan sharing HHC places and conventional hospital beds**. **ICU beds** are the required resource **for the acute phase** of botulism and **home health care** can support breathing and nutrition assistance **for the recovery phase** of botulism.

- **Collaboration** efficiency between conventional hospitals and Home Health Care has been noted **for** several pathologies such as **congestive heart failure, chronic respiratory failure, multiple sclerosis,** etc.

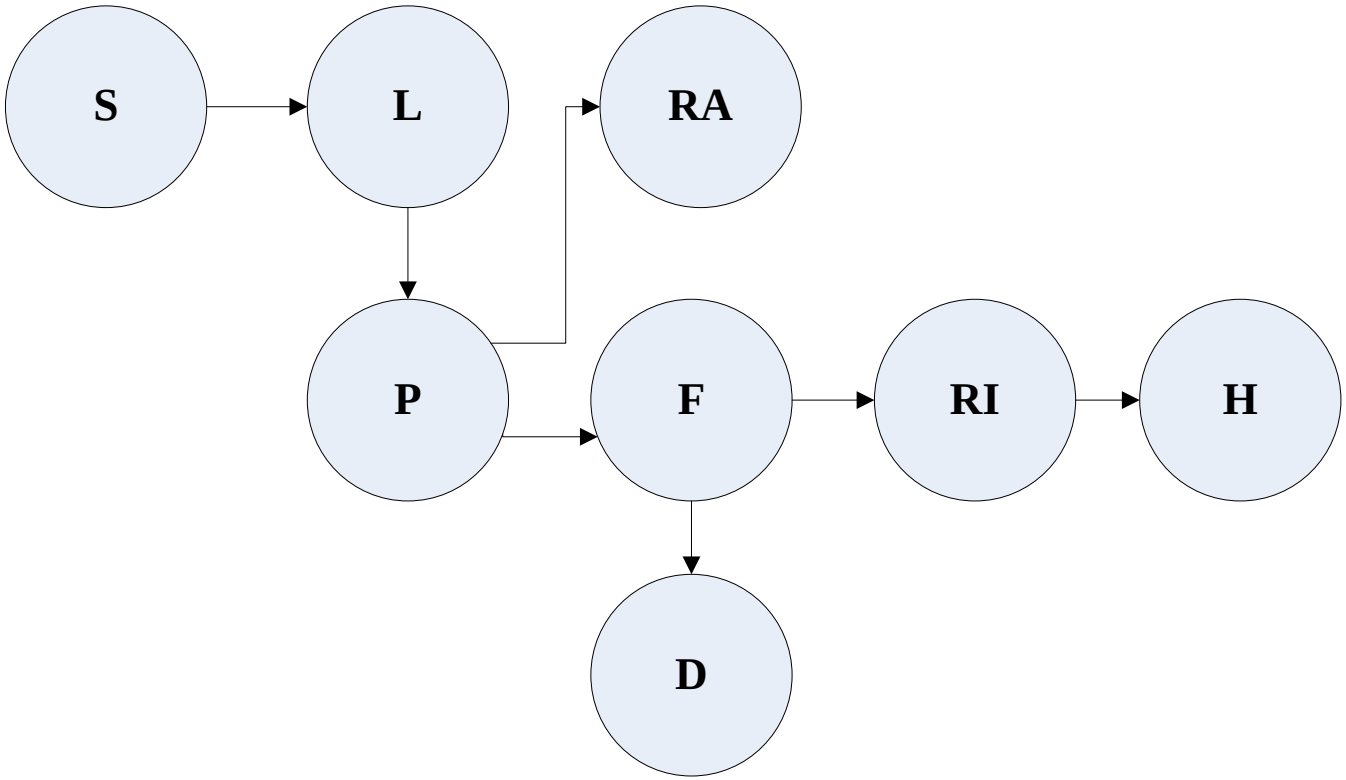
- **First-line treatment**: an **antitoxin administration** which requires a 7 days hospitalization which can be done **in HHC**. Its cost is equal to 2 500 Euros and 300 Euros * 7, i.e. **4 600 Euros**.

- **Second-line treatment**: A patient admission during **two weeks in ICU** followed by **two weeks in HHC**. Its cost is equal to 2300 € *14 and 300 € * 14, i.e. **36 400 €**. The equivalent full stay in hospital costs 2300 € *14 and 1000 € * 14, i.e. 46 200 € if the hospital has enough resources i.e. nurses and beds.

An extension of the SIR model

- S for susceptible, i.e. a customer who can eat the infected food,
- L for latent, i.e. a customer who has eaten the infected food,
- P for prodomal (with symptoms), i.e. an infected customer who develops symptoms (dysphagia, dysarthria, arm or leg weakness, double vision, fatigue, etc.) within a range of several hours to several days,
- RA a recovered patient thanks to antitoxin, i.e. a prodomal customer treated with Botulinum antitoxin as soon as symptoms appear,
- F for fulminant, i.e. an infected patient with acute respiratory distress which has been hospitalized in an emergency department and who waits for an intensive care bed thanks to mechanical ventilation ; non recovered prodomal customer turns into fulminant patient if untreated with antitoxin,
- RI and H a recovered patient thanks to ICU cares, i.e. a fulminant patient who has found an ICU bed and next a HHC support,
- D for dead, i.e. a fulminant patient who has not found an ICU bed; generally delayed patients waiting for ICU cares died with a rate of 36% due to respiratory infections.

An extension of the SIR model



The linear programming model

Our objective function minimizes :

- The **antitoxin cost and hospitalization cost** for medication in a home health care structure for 7 days, respectively 2 500 Euros and 300 Euros * 7, i.e. **4 600 Euros**,

- The cost of **patient admission** during two weeks **in ICU** followed by two weeks **in home health care** for breathing assistance, respectively 2 300 Euros *14 and 300 Euros * 14, i.e. **36 400 Euros**,

- The **human life cost**, i.e. the legal indemnity in France for a 65 old victim, i.e. **300 000 Euros**.

The linear programming model

Our constraints enable that :

- Customers can be infected from the first period to the period where the attack is detected and located.
- All customers eating food are infected and become latent.
- The next days, only a part of customers develops symptoms (immunogenicity). Antitoxins are administrated as soon as symptoms appear, without waiting medical test confirmation, in a HHC structure.
- The number of antitoxin doses is limited and shared by hospitals. They are dispensed only to prodomal customers who become patients.
- Without antitoxin medication, patients wait in ED for hospitalization in ICU, part of them are admitted and part of them begin to died,
- Next to ICU admissions, patients are admitted to Home Health Care.
- The numbers of ICU beds and HHC places are limited but they are used only for a defined length of stay.
- Non-treated patients died.

Experiment

- French strategic stockpiles of Botulinum antitoxin is around 50 doses. However, the **available doses will range from 50 to 100**, per hospital. We hypothesize that the antitoxin doses are immediately available.
- There are around 200 ICU beds in the Metropolis of Lyon located in 5 different places. Knowing that ICU beds are required for surgery and for medical pathologies, we suppose that from 1/4 to 3/4 of the beds can be freed by hospitals to receive infected patients. The number of available **ICU beds ranges from 50 to 150**.
- On day 4, enough victims who ate the foods of the caterer are suspected to have botulism. Consequently **the caterer is aware of the attack at the earliest at the end of period 4** and stops its activity.
- Accidental poisoning has not been retained because it would have led first to a discovery of the incident earlier and second to a shorter outbreak duration thanks to a single source of contamination instead of several criminal sources of contamination. **The worst case scenario is studied**.

Experiment

Number of doses for Home Health Care Hospital	Number of doses for the Conventional Hospital	Number of ICU beds	Number of deaths	Medical cost	Number of ICU stays for HHC patients	Number of ICU stays for CH patients
50	50	50	189	59 027	0	50
50	50	75	164	52 450	0	75
50	50	100	139	45 873	0	100
50	50	125	114	39 298	0	125
50	50	150	89	32 728	20	130
50	100	50	139	44 283	0	50
50	100	75	114	37 708	0	75
50	100	100	89	31 138	0	100
50	100	125	64	24 568	0	125
50	100	150	39	17 999	24	126
100	100	50	89	29 548	0	50
100	100	75	64	22 978	0	75
100	100	100	39	16 409	0	100
100	100	125	15	9 851	11	114
100	100	150	0	6 006	15	125

Conclusion

- This work studied the impact of a foodborne attack with Botulinum toxin i.e. one of the most poisonous substance.
- An optimization tool based on a linear programming model is proposed, in order to calculate the human and economic consequences of the attack in terms of the number of deaths and the cost of the medical response.
- It enables us to assess the medical responses based on hospital and HHC collaboration, to size the human and material resources, to anticipate the victim admission in ICU and HHC.
- The number of deaths can reach two hundred victims and the hospitalization cost is of several millions of Euros. To face such crisis, collaboration between Conventional Hospitals and Home Health Care structures is a good response.
- The emergency management plan is currently negotiated.

Discussion

Thanks for your attention