

Research Article

# Risk Profiling of Microbiological Hazards in Ready-To-Eat Foods in Niger

Roukaya Abdou Souley<sup>1,\*</sup>, Issoufou Amadou<sup>2</sup> , Halima Oumarou Diadie<sup>1</sup>, Abdourahmane Balla<sup>1</sup>

<sup>1</sup>Hygiene, Food and Nutritional Sciences Research Laboratory, Department of Crops Production, Faculty of Agronomy, Abdou Moumouni University of Niamey, Niamey, Niger

<sup>2</sup>Laboratory of Food Sciences and Technologies, Department of Crops Production, Faculty of Agronomy and Environmental Sciences, Dan Dicko Dankoulodo University of Maradi, Maradi, Niger

## Abstract

The risks posed by foodborne microbiological hazards are a concern for human health on a global scale. They are responsible for foodborne illnesses (FBI). The general objective of this study is to analyze the risks associated with microbiological hazards in ready-to-eat foods in Niger. A descriptive retrospective study was conducted in Niamey, Niger. Investigations were carried out at three (3) major hospitals in Niamey city (National Hospital of Niamey (HNN), General Reference Hospital, and the Amirou Boubacar Diallo National Hospital) to collect data on the FBI from 2019 to 2023. Then, a consumer survey was conducted for convenience among hundred (100) people who had been victims of the FBI to collect information on the causes, consequences, and economic impact of the FBI. The results showed that in total, eighty-nine (89) cases of FBI were recorded in the three hospitals during this period, including one (1) death. The National Hospital of Niamey has the largest cases (89.88%). However, the consumer survey noted that 72% of individuals suffering from FBI are over 15 years old. 31% are female and 69% are male. Also, 67% of FBI cases are caused by the consumption of food of animal origin. Medical treatment is the most widely used (56%) by the patients and the cost is considered low. This study can serve as a tool to help develop strategies for preventing health risks related to microbiological hazards in ready-to-eat foods in Niger.

## Keywords

Microbiological Risks, Food Poisoning, Incriminated Foods, Preventive Control System, Niamey (Niger)

## 1. Introduction

Food quality is defined according to its nutritional, organoleptic, health, and environmental characteristics. This quality can be affected by the presence or activity of microorganisms. Indeed, food products are mostly non-sterile and likely to be a growth medium for microorganisms [1]. Food and the water

used for their production, processing, and preparation are potential vectors of many microbiological and chemical hazards [2, 3]. Thus, the accidental ingestion of these microorganisms or products of their metabolism, often invisible to the naked eye, via food products can be the source of many dis-

\*Corresponding author: [abdousouley\\_roukaya@yahoo.fr](mailto:abdousouley_roukaya@yahoo.fr) (Roukaya Abdou Souley)

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eases, infections, and food poisoning [4, 5].

Foodborne illnesses are usually caused by bacteria, viruses, parasites, or chemical substances contaminating food. They are generally not lethal [6]. Also, the number of cases per outbreak is generally low, between 3 and 30 [7], but it can be much higher in certain circumstances. Foodborne diseases affect the health and well-being of the population and have repercussions on families, communities, businesses, and countries. They impose a heavy burden on the health system and significantly reduce the economic productivity of food throughout the chain in both developed and developing countries [8, 9]. Thus, serious and costly foodborne illnesses and outbreaks have occurred in developed countries and will continue to do so, despite food and agricultural systems being generally recognized as safe [7]. Non-compliance with international food standards, ineffective food regulatory control systems, and lack of access to safe drinking water are the main causes [10]. Foodborne illnesses represent a current public health issue, and as such, they are included among the notifiable diseases and require rigorous investigation to understand the disease better.

With an estimated 600 million cases of foodborne illness per year, according to the United Nations, unsafe food poses a threat to human health and economies and disproportionately affects vulnerable and marginalized people, including women, children, populations affected by conflict, and migrants. It is estimated that approximately 420,000 people worldwide die each year from ingesting contaminated food, and children under 5 years of age bear 40 percent of the foodborne illness burden, including 125,000 deaths per year [8]. The frequency of these foodborne illnesses is linked to street food, which consists mainly of ready-to-eat foods [5, 11]. However, it is necessary to carry out investigations to determine the risk linked to microbiological hazards in food. Hence, the present study was initiated and has the general objective of analyzing the risks linked to microbiological hazards in ready-to-eat foods in Niger, it is specifically about; determining the prevalence of diseases caused by the ingestion of food contaminated by microorganisms, determining the causes, consequences and economic impact of foodborne illnesses, and monitoring a microbiological risk control system linked to the consumption of food in Niger.

## 2. Materials and Methods

### 2.1. Study Zone

The study was carried out at the three (3) major hospitals of Niamey city, namely: The National Hospital of Niamey (NHN), Amirou Boubacar Diallo National Hospital in Niamey is affiliated with the Abdou Moumouni University of Niamey, and General Reference Hospital of Niamey (HGR), located at Latitude: N 13°30'47.20032'' Longitude: E 2°6'1.36764''; (Latitude: N 13°30'15.0462'' Longitude: E 2°4'53.75136'') and (Latitude: N 13°35'15.12708'', Longi-

tude: E 2°5'34.9746'') respectively.

### 2.2. Data Collection Tools

The study used documentation of the epidemiological services of the three (3) major hospitals in the city of Niamey. Indeed, data on the prevalence of FBI were collected in the epidemiological service of each of the three hospitals concerned by the study. All cases of FBI recorded over the last five (5) years were collected. KoboCollect was used to collect consumer survey data.

### 2.3. Target Population

To determine the prevalence of FBI, the target population was determined based on individuals who were registered in the database of the hospital's epidemiological services during the period 2019-2023.

For the consumer survey, this refers to any person who has been a victim of food poisoning at least once in their life.

### 2.4. Type of Sampling

An exhaustive analysis of the files of the various FBI cases recorded between 2019 and 2023 in the three hospitals concerned by the study was carried out. For the consumer survey, the sample size was determined exhaustively for convenience. Thus, a sample of one hundred (100) individuals who had all been affected at least once by FBI was taken into account for the consumer survey.

### 2.5. Inclusion Criteria

All existing data on FBI from 2019 to 2023. It should be noted that many FBI cases were not archived because the patient files were not properly completed and these diseases are not included in the list of diseases that must be reported. For the consumer survey, all people who had been a victim of the FBI at least once in their life were included in the study, regardless of their age, gender, social class, ethnicity, etc., and who had given their consent to participate in the study.

### 2.6. Data Collection Technique

Data on the prevalence of FBI were collected using the archives of the epidemiological services of the three main hospitals involved in the study. For the consumer survey, a face-to-face individual interview was conducted using the established survey form.

### 2.7. Data Analysis and Processing Techniques

The data collected on FBI cases recorded in the major hospitals of Niamey were entered and processed using Excel 2016 software. The percentages and frequencies were calculated.

For the consumer survey data, SPSS version 25 software was used for descriptive analyses. The khi2 statistical test at the 5% threshold was used to determine the link between certain variables.

### 3. Results and Discussion

#### 3.1. Results

The distribution of FBI cases over the last five (5) years

2019 to 2023 and per hospital in the three (3) major hospitals in Niamey city is shown in [Table 1](#), which shows that 38.20% of the recorded cases in the year 2019 is the highest number of FBI cases over the last five years. On the other hand, the year 2021 has the fewest recorded FBI cases (7.87%) of cases. It should also be noted that only one death was observed during this period in 2021 and this case was the one recorded in 2021 at the Amirou Boubacar National Hospital. In addition, [Table 1](#) shows that the HNN recorded the highest cases of FBI (89.88%) among the three hospitals in the city.

**Table 1.** Summary of FBI cases recorded by the hospital and per year in the three (3) major hospitals of Niamey city.

Hospitals Years	Niamey National Hospital		Amirou Boubacar National Hospital		General Reference Hospital		Total FBI	
2019	29	32.58%	3	3.38%	2	2.25%	34	38.20%
2020	23	25.84%	0	0	2	2.25%	25	28.09%
2021	6	6.75%	1	1.12%	0	0	7	7.85%
2022	10	11.23%	1	1.12%	0	0	11	12.16%
2023	12	13.48%	NA	NA	0	0	12	13.70%
Total	80	89.88%	5	5.61%	4	4.51%	89	100.00%

NA: Not available

The socio-demographic characteristics of respondents are shown in [Table 2](#) with 69% male and 31% female. Also, it is observed that 72% of the respondents are aged 15 years or more, 11% are aged 10-15 years and 17% are aged 5 to 9 years. The analysis of the level of education shows that 16% of the study population did not attend school and 2% attended Koranic school. Of the 82% of people who attended modern school, 26% have a higher level of education, 21% have a secondary level (6% high school and 15% middle school) and 35% have a primary level of education.

**Table 2.** Sociodemographic characteristics of respondents.

Variables	Categories	Amount	Frequencies (%)
Sex	Male	69	69
	Female	31	31
Age class	5-9 years	17	17
	10-15 years	11	11
Gender	≥15 years	72	72
	Married	38	38
	Divorce	1	1

Variables	Categories	Amount	Frequencies (%)
Ethnic (language)	Widow	4	4
	Single	57	57
	Hausa	73	73
	Zarma	26	26
	Songhai	1	1
	Tuareg	0	0
	Fulani	0	0
Education level	others	0	0
	Primary level	35	35
	Secondary level 1	15	15
	Secondary level 2	6	6
	Tertiary level	26	26
	Islamic studies	2	2
	analphabet	16	16

The characteristics of FBIs collected from consumers ([Ta-](#)

ble 3) showing 67% of respondents believe they were contaminated following the consumption of foods of animal origin and 33% believe that the disorders were caused by the consumption of foods of plant origin. In addition, 66% of consumers surveyed say that the incriminated foods were prepared at home and only 1% were bought at a restaurant. Furthermore, the failure to use adequate preservation techniques (49%) is one of the causes of the occurrence of these FBIs. Furthermore, 92% of consumer victims never had to consult a doctor when the disorders occurred and 47% say

they have been victims of these types of symptoms more than twice in their life. The analysis of the symptoms also shows that 94% refer to acute FBI and 6% present chronic FBI symptoms. For the management of these FBIs, 56% of respondents resorted to medical treatment (mostly by self-medication). 21% chose the traditional treatment option based on the use of local medicinal plants. Then, the cost of treatment is perceived as low by 57% of respondents. 29% used leaves decoctions freely for the cure.

**Table 3.** Presented FBIs characteristics among consumers.

Variables	Modalities	Frequencies (%)
Types of Foods Incriminated	Products of Plant Origin	33
	Products of Animal Origin	67
	Purchased on the road/street	33
Food Source Responsible for FBI	At the restaurant	1
	Homemade	66
	Refrigeration	27
Food preservation method used	Warm	24
	none	49
Medical follow-up when FBI occurs	Yes	8
	No	92
Hospitalization for FBI	Yes	1
	No	99
	Once	32
Frequency of occurrence Level of severity	Twice	21
	More than twice	47
	Severe	5
Typology of food poisoning	Moderate	81
	Simple	14
Type of FBI treatment	Acute	94
	Chronic	6
Cost of treatment medical follow-up when FBI occurs	Medical treatment (Medicines)	56
	Traditional treatment (Medicinal plant)	21
	No treatment	23
Hospitalization for FBI	High	5
	Medium	9
	Low	57
	Free	29

Distribution of information following the occurrence of FBI according to the food group consumed (Table 4). This shows that regardless of the number of times the individual surveyed suffered from FBI. The category of foods of animal

origin remains the most incriminated in the FBI. However, there is no significant relationship ( $P = 0.26$ ) between the occurrence of FBI and the type of food consumed.

**Table 4.** Occurrence of FBIs according to the food group consumed.

Number of times FBI	Types of food responsible for FBI		Total	P. value
	Products of animal origin	Products of plant origin		
On-time	18	14	32	0.26
Two times	16	5	21	
More than two times	33	14	47	
Total (%)	67	33	100	

Table 5 presents the gender frequency of the individuals surveyed according to the FBI treatment used; its results show that 56% of respondents use medical treatment to treat the FBI,

including 17% of women and 39% of men. The relationship between gender and the type of treatment used against the FBI is statistically significant ( $P = 0.019$ ).

**Table 5.** Distribution of respondents according to type of treatment.

Sex	Treatment used			Total (%)	P. value
	Others treatment	Treatment medical	Traditional treatment		
Female	3	17	11	31	0.019
Male	20	39	10	69	
Total (%)	23	56	21	100	

Table 6 presents the distribution of the FBI typology according to the food group responsible for the FBI. It shows that among the respondents, 94% suffered from acute FBI and animal food products origin seemed to be responsible for the onset of the disorders (64%). In addition, Table 6 shows that

59% of the cases of FBI are recorded in the three hospitals of moderate FBI and are caused by food products of animal origin. There was a significant correlation between the type of FBI and the type of food consumed ( $p = 0.02$ ).

**Table 6.** FBI typology and Severity according to the food group responsible for it.

Variables	Modality	Type of Food responsible for FBI		Total	P. value
		Products of animal origin	Products of plant origin		
Type of FBI	Acute	64%	30%	94%	0.36
	Chronic	3%	3%	6%	
Severity of FBI	Severe	3%	2%	5%	0.02
	Moderate	59%	22%	81%	

Variables	Modality	Type of Food responsible for FBI		Total	P. value
		Products of animal origin	Products of plant origin		
	Simple	5%	9%	14%	
	Total	67%	33%	100%	

Table 7 presents the severity of FBI, treatment type, and cost. It shows that 81% of these respondents had moderate FBI, and 56% used medical treatment to treat it. The rela-

tionship between the treatment and the FBI's severity is significant ( $P = 0.036$ ).

**Table 7.** Cost and type of treatment according to severity of FBI.

Variables	Modalities	Severity of FBI			Total (%)	P. value
		Grave	Moderate	Simple		
Treatment use	Other treatment	0	16	7	23	0.036
	Treatment medical	5	46	5	56	
	Traditional treatment	0	19	2	21	
	Total (%)	5	81	14	100	
Cost of treatment	High	5	0	0	5	0.000
	weak	0	50	7	57	
	free	0	22	7	29	
	Middle	0	9	0	9	

### 3.2. Discussion

The inventory of the prevalence of FBI in the three (3) major hospitals of Niamey city shows that among the three hospitals in which epidemiological data on FBI were recorded; the National Hospital of Niamey recorded the highest rate of FBI with 89.88% of cases followed by the Amirou Boubacar National Hospital and the General Reference Hospital with the rates of 5.6% and 4.5% of cases respectively. This could be explained by the fact that some cases of FBI received at the Amirou Boubacar Diallo National Hospital in Niamey during this period were transferred to the Niamey National Hospital for better management to avoid the spread of epidemics of these symptomatologic cases. It should also be noted that 2019 is the year that recorded the most cases of FBI among the five (5) years included in the study with 38.2% of cases. There were 28.08% of cases in 2020, 7.87% of cases in 2021, 12.36% of cases in 2022 and 13.49% of cases in 2023. In addition, it was revealed that the rate and cases of FBI have decreased over the years and this could be explained by the fact that the

population is increasingly interested in self-medication when the FBI occurs [12, 13]. For the consumer survey, it emerges from the analysis of the results on the socio-demographic characteristics that male respondents are the most affected by FBI with a rate of 69% of the study population. This can be explained by the fact that male individuals most often resort to eating outside the home during working hours, unlike female individuals [14, 15]. Indeed, the study has shown that male individuals aged 15 years old and above are those who have been most affected by the FBI.

In addition, foods of animal origin are the most incriminated in the occurrence of FBI (67%) than those of plant origin. These are mainly milk, meat, fish, and eggs. Also, these foods are most often displayed in public places without respecting hygiene standards for selling and storing these foodstuffs. Furthermore, it was also noted that respondents favor medical treatment over traditional treatment of FBI even though the majority of them do not go to the health center to treat FBI (92%). This situation could be explained by the availability of medications at outpatient pharmacy depots throughout the city of Niamey. Also, people rely on the pre-

scriptions of these street vendors without any fear of the underlying repercussions [16]. As for the cost of treatment, the results of the analysis of the survey data showed that the low-cost treatment is the most followed by the study population. This could be explained by the fact that the treatment is interrupted by the person concerned as soon as the symptoms of FBI disappear and the patient considers himself healed.

This study shows that the relationship between the severity of FBI and the type of food responsible for FBI is significant ( $P=0.02$ ), and 81% of the people surveyed suffered from moderate FBI with 59% of cases caused by products and foods of animal origin. This could be explained by the fact that products of animal origin are the most incriminated in the occurrence of FBI. These results are similar to those of Hachemi et al. [17] in a study in Blida Algeria which showed that the most frequently incriminated foods were foods of animal origin including eggs, meat, etc. There is a significant correlation ( $P=0.036$ ) between the respondents' treatment and the FBI's severity. Thus, it is noted that the more severe the FBI, the more people use medical treatment to treat themselves [9]. In addition, it was found that all individuals who suffered from severe FBI received high-cost treatment. On the other hand, those who suffered from moderate FBI received medium or low-cost treatment. It was noted that some of the respondents do not use any treatment and wait for the symptoms to dissipate. There is also a highly significant relationship between the severity and the cost of FBI treatment ( $P = 0.00$ ). This could be explained by the fact that the symptoms of severe FBI are more worrying and dangerous for people's health and that their treatment is much more expensive [3, 8].

## 4. Conclusion

Microbiological quality is one of the key parameters of food quality. Thus, it is vital to research, identify, and evaluate all the risks and dangers that microorganisms present in the food to ensure its hygienic quality and the consumer's health. The majority of the people surveyed in the three (3) major hospitals of Niamey city are male than female. It can be concluded that the distribution of FBI cases varies with decreasing numbers of FBI cases from 2019 to 2023. The consumer survey showed that the population of Niamey does not attach importance to visiting hospitals to treat food poisoning (1%). The most incriminated foods in the occurrence of these FBIs are foods of animal origin rather than foods of plant origin. More than the half of interviewers; widely, used medical treatment to manage the FBI. However, about one-quarter of the population does not treat the FBI rather than naturally get healed. Therefore, it is needed to extend this study on the established food enterprises in the area to quality control of their ready to eat foods in the chain of distribution.

## Abbreviations

FBI	Foodborne Illnesses
HNN	National Hospital of Niamey
HGR	General Reference Hospital of Niamey

## Author Contributions

**Roukaya Abdou Souley:** Conceptualization, Formal Analysis, Investigation, Methodology, Supervision, Writing – original draft

**Issoufou Amadou:** Formal Analysis, Resources, Software, Writing – review & editing

**Halima Oumarou Diadie:** Investigation, Supervision

**Abdourahmane Balla:** Conceptualization, Investigation, Methodology

## Conflicts of Interest

The authors declare no conflicts of interest.

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