

Full Length Research Paper

Risk factors associated with retail meat vendors in Lubumbashi, Democratic Republic of Congo

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Food safety risk factors associated with retail meat sales in Lubumbashi, Congo D.R., was assessed in 2013. The study involved 168 meat vendors. The methods used were an interview and direct observation. Females represented 55.9%, and males represented 44% of the study respondents. Their age ranged from 18 to 40 years (92.8%). Sixty percent had obtained a primary level of education, 38% a secondary level, and only 1.1% completed the university level of education. Sixty-nine percent had fixed activities, and 30.9% were mobiles. None had a training certificate in food safety or hygiene practices. Overall, the poor level of knowledge/attitude and practices was associated with low level of education and the age of the vendors (<40 years) ($p < 0.05$). Gender did not play a role ($p > 0.05$). Attitude, practices, and lack of food safety knowledge in meat handling, improper slaughtering processes, poor environmental and personal hygiene, inadequate storage of food and lack of potable water were identified as major risk factors which may contribute to various contamination of meat sold at retail outlets in Lubumbashi.

Key words: Retail meat vendors, attitudes, practices, knowledge, food safety, Lubumbashi, Congo D.R.

INTRODUCTION

Foodborne diseases are a significant cause of morbidity and mortality worldwide. The World Health Organization (WHO) estimated in 2010, 600 million foodborne illnesses and 420 million deaths worldwide; 91 million persons are affected in the developing world (WHO, 2015). In USA, the FoodNet identified 25.606 infections, 5.893 hospitalizations, and 120 deaths during 2018 (CDC,

2013). In developing countries, around 2.2 million of deaths are due to foodborne illnesses (Imathiu, 2017). There are up to 2.5 million deaths of children due to diarrheal disease, according to WHO (WHO, 2008). Besides, the foodborne diseases' prevalence could be much higher in developing world due to poor hygiene conditions, lack of running potable water, ignorance of

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basic food safety notions, improper handling of food and ignorance of storage processes of foodstuff (Stratev et al., 2017). Considering the regional difference, Africa shows the highest burden per population of foodborne diseases (Iwu et al., 2017). Mishandling of foodstuff may lead to spread of the initial contamination of raw food and cross-contamination of cooked food with pathogens such as bacteria and lead to foodborne diseases (Akabanda et al., 2017). Food handlers play a crucial role in ensuring food safety throughout the chain of production, processing, storage and preparation (Mathenge et al., 2017).

Many studies in developing countries have reported that food handlers were implicated as an important factor of foodborne outbreaks. They are usually uneducated, and they have shown poor knowledge of adequate hygienic practices during food preparation, processing and storage (Choudhury et al., 2011; Stratev et al., 2017; Alamo-Tonelado et al., 2018). Indeed, food handlers who had knowledge of good practices of safety while handling food could help to control foodborne illnesses as they are in direct contact with food especially cooked or ready to eat foods (Lee et al., 2017). Foodborne diseases associated with consumption of contaminated food with pathogens like *Campylobacter*, *Salmonella*, *Escherichia coli* O157:H7 and virus have been reported (Weam et al., 2016, Osimani et al., 2017; Shafini et al., 2017). Food products such as meats and meat products may harbour hazards like pathogens and their toxins or various contaminants or chemical residues; thus, they are considered as high-risk commodities (Haileselassie et al., 2013).

Consumption of meat and meat products sold at retail outlets has increased in the past years in Lubumbashi, DRC. Like in many developing countries, this phenomenon has economic implications. Since, this activity creates self-employment and provides meat/food at an affordable price to a large community of local population (Lamin-Boima, 2017; Ma et al., 2019). Around 2.9% (480,000 persons) of the population of Dhaka in Bangladesh depend on the income generated by street food vendors (Khairuzzamann et al., 2014). In Zambia, in 2003, street food sales employed around 16,000 people and had a turnover of 100 million US dollars (Imathiu, 2017). However, in most developing countries, street food vending activities are not under the regulation and protection of the government (Minh, 2017). In general, street food vendors operate in unsuitable hygienic conditions with lack of primary facilities. And there is evidence that street food may be exposed either to spoilage or pathogenic micro-organisms (Redzwan, 2016; Ekka, 2017).

Little is known about vendor's knowledge, attitudes, and practices in food safety of meat sold at retail outlets in the open market and along roadsides in Lubumbashi. The hygienic conditions in which meats are sold may lead

to a significant threat to public health. In open markets, in Lubumbashi meats are usually exposed at ambient temperature, on inappropriate structures, or directly on the floor. Also, there was a lack of potable water, storage facilities such as refrigeration, garbage disposal and primary facilities such as toilets. Shortage of data on the quality of retail meat sold in Lubumbashi and on meat handlers' behaviour as well as the risk factors related, has increased our concern.

The aim of this study was (i) to assess the food safety knowledge, attitudes and practices among retail meat vendors in Lubumbashi and; (ii) to report the risk factors in common places of meat distribution.

Information gathered in this study could be useful for the local government for evaluation of food safety policies to improve good hygiene practices in street food and meat handling in Lubumbashi.

MATERIALS AND METHODS

Data collection

Data were collected in 2013 from 6 municipalities of Lubumbashi city (Lubumbashi, Kenya, Kamalondo, Katuba, Kampemba and Rwashi). The main places of raw meat and ready-to-eat (RTE) meat selling sites were investigated. They were constituted of 12 open markets and 49 snack bars.

The study involved 168 meat vendors, of which 116 operated in open markets and 52 in snack bars. In markets, the first group of 104 respondents was vendors of fresh meat, among them 90 females and 14 males. The second group of 12 respondents was vendors of smoked game meat, among them 4 females and 8 males. However, all respondents in snack bars were males.

Methods

Two methods were used: Interview and direct observation. The interview was based on structured and straightforward questions translated from French into local languages (Swahili and Lingala) if needed. The expected answer to the questions was qualitative: YES or NO. Sometimes a classification was requested. The collected information included:

Socio-demographic characteristics such as gender, age, marital status, level of education and type of activity (whether the vendor had a mobile or a fixed activity).

Knowledge, attitudes and practices in meat/food handling were assessed by answering our questions. Each response was given a score "1" for a "YES" response or a score "0" for a "NO" response. The total of scores was counted and converted to a percentage based on the total number of characteristics. We assessed the level of knowledge/attitude or practices as poor for the rate < 50%; as fair, for between 50-69%; and as good for 70% and more.

In case of doubt, a classification from 1 to 5 was requested, and additional explanations from vendors were accepted. A "YES" response was considered for a ranking from 3 to 5 and given a score "1". For a ranking of 1 to 2 the response was regarded as "NO" and given a score "0".

The direct observation concerned the characteristics and hygiene of places where meat was sold, the behaviour of vendors, their personal hygiene, and their practices while handling meat or other

Table 1. Socio-demographics characteristics of meat vendors in Lubumbashi.

Characteristics	Frequencies (n = 168)	Percentages
Gender		
Female	94	56.0
Male	74	44.0
Age (years)		
18 - 40	156	92.9
> 40	12	7.1
Marital status		
Married	94	56.0
Single	74	44.0
Education		
Primary	102	60.7
Secondary	64	38.1
High level	2	1.2
Vending places		
Market	116	69.0
Snack bar	52	31.0

products.

Statistical analysis was carried out with SPSS 23, for multivariable regression analysis. Chi-square was used to assess the association between variables and the p-value was considered significant at the level of 0.05.

RESULTS

Socio-demographic profiles of meat vendors in Lubumbashi

The socio-demographic characteristics of meat vendors are recorded in Table 1. There was a difference in gender; women represented 55.9%, and men represented 44%. This difference was very significant in markets ($p=0.001$), where 81% of vendors were women, and only 18.9% were men. In some cases, women were accompanied by their babies or pre-school age children. In snack bars, 100% of vendors were male as the goat slaughter process, and cooking of RTE goat skewers are handled only by men.

The average age was of 18 to 40 years (92.9%). Most of the vendors were married (56%). Many vendors (60.7%) had obtained primary level of education, which was the lowest. Thirty-eight percent (38%) had completed secondary level of education, and only 1.1% had a university level of education.

Among all the vendors, 69% had a stationary activity,

while 30.9% of them were mobile. The mobility was concerning workers in snack bars, particularly because they were employed in many other snacks bars of the city.

None of the vendors in Lubumbashi was qualified to handle meat, and no one had a training certificate in food safety or hygiene practices.

Knowledge, attitude and practices of meat vendors

There was a poor knowledge, attitude and practices toward basic hygiene rules such as hand washing and body hygiene among meat vendors in Lubumbashi (Tables 2 and 3).

Only 32.7% of meat vendors washed their hands after using toilet facilities, 13.6% after the goat slaughter process and 0% after handling other products such as money and live animals. Only 39% of vendors used clean water to clean their vending sites and, 53.3% their utensils. Besides, 29.7 and 47% used wastewater to clean their vending places and utensils, respectively. Some vendors (19.6%) performed a dry cleaning of their vending places with brush; others (26.1%) used cloth to wipe their utensils at the end of daily activities.

Concerning personal hygiene, 61.3% of vendors were aware of taking a shower before they leave home to go for their activities, and 88.7% wore clean clothes. Thirty-

Table 2. Hygiene practice on sell places.

Parameter	Frequencies of answer (%)				
	Markets (n=116)		Snack bars (n=52)		Total (n=168)
	Yes	No	Yes	No	Total of yes
Cleaning the place of work					
Mandatory day once a week (in markets)	116 (100)	0	-	-	116 (69.0)
Everyday (Snack bars)	-	-	52 (100)	-	52 (30.9)
Personal initiative (Markets and snack bars)	65 (56.0)	51 (43.9)	-	-	65 (38.6)
I pay someone to do it for me*	43 (37.0)	73 (62.9)	17 (32.6)	35 (67.3)	60 (35.7)
Before starting activities	116 (100)	0	52 (100)	0	168 (100)
After the activities	0	116 (100)	0	52 (100)	0 (0)
Cleaning was achieved					
With clean water	46 (39.6)	70 (60.3)	21 (40.3)	31 (59.6)	67 (39.8)
With waste water	27 (23.2)	87 (76.7)	23 (44.2)	29 (55.7)	50 (29.7)
Dry clean with a brush	28 (24.1)	88 (75.8)	5 (9.6)	47 (90.3)	33 (19.6)
Cleaning utensils					
After each usage	29 (17.2)	87 (75.0)	0	0	29 (17.2)
At the end of the day	76 (65.5)	40 (34.4)	45 (86.5)	7 (13.4)	121 (72.0)
When handling different products	21 (42.5)	95 (81.3)	0	52 (100)	21 (12.5)
Cleaning utensils with					
Clean water	70 (60.3)	46 (39.6)	23 (44.2)	29 (55.7)	93 (55.3)
Waste water	44 (37.9)	72 (62.0)	35 (44.3)	17 (32.6)	79 (47.0)
With a dry cloth	38 (32.7)	78 (67.2)	6 (11.5)	46 (88.4)	44 (26.1)

Those who delegate the cleaning process don't know how it was carried out. -, Not applicable.

Table 3. Knowledge of personal hygiene among meat vendors in Lubumbashi.

Parameter	Frequency of answers « yes » (%) All meat vendors (n=168)
Body hygiene before work	103 (61.3)
Wearing clean clothes for work	149 (88.6)
Wearing hair protection and gloves while selling	0
Wearing jewels and watch	67 (39.8)
Carrying a mobile phone	125 (74.4)
Washing hand (Without soap)	
After tip to toilet ^a	55 (32.7)
After touching money and other products than meat	0
After changing baby nappy	0
After contact with live animals	0
After the slaughter process	23 (13.6)
After cleaning stand and cooking stall	13 (7.7)
Temporary cessation of activities	
In the case of diarrhoea	41 (24.4)
In the case of Typhoid fever ^b	51 (30.3)
Other diseases	20 (11.9)
Voluntary detection of infections ^c	26 (15.4)

^aIf water is available. ^bAccording to the vendor's perception. ^cExceeded by the multiple requests for voluntary screening for infections.

Table 4. Global scores of knowledge and attitude among meat vendors.

Variable	Frequencies (n = 168)	Percentages (%)
Body hygiene	103	61.3
Wearing Clean clothes	149	88.7
Wearing Hair and hand protection	0	0.0
Wearing Jewels and Watch	67	39.9
Carrying a Mobile phone	125	74.4
Stop the activity in case of diarrhoea	42	25.0
Stop the activity in case of typhoid fever	41	24.4
Stop the activity in case of other diseases	16	9.5
Voluntary detection of diseases	19	11.3
Level of knowledge		
< 50% (Poor)	141	83.9
50 - 69% (Fair)	22	13.1
70%+ (Good)	5	3.0

Table 5. Global scores of hygiene practices among vendors

Variable	Frequencies (n = 168)	Percentages (%)
Hand washing after toilet	55	32.7
Hand washing after slaughter	23	13.7
Hand washing after the cleaning process	13	7.7
Cleaning vending places 1 mandatory day	116	69.0
Cleaning every day	52	31.0
personal initiative	65	38.7
With clean water	67	39.9
With wastewater	51	30.4
Dry cleaning	33	19.6
Cleaning utensils with clean water	93	55.4
Cleaning utensils with wastewater	78	46.4
Cleaning with a cloth	44	26.2
Level of practice		
< 50% (Poor)	139	82.7
50 - 69% (Fair)	29	17.3
70%+ (Good)	0	0.0

nine per cent (39.9%) were wearing hand jewels and watch, and 74.4% were carrying their mobile phones.

In the case of diseases, 24.4 and 30.4% were willing to stop their activities if they suffer respectively from diarrhoea or typhoid fever. None had a health certificate, and only 15.4% were interested in a voluntary screening of diseases.

Regarding the global score, only 3% of vendors had a good level of knowledge/attitude toward food hygiene practices. Thirty per cent (13.1%) had a fair level, and 83.9% had a poor level (Table 4). The poor level was

significantly associated with the age of vendors (18-40 years) ($p=0.004$), the primary level of education ($p=0.013$), and their mobile activity ($p=0.046$). The gender did not play a role ($p=0.585$) (Table 6).

None of the vendors had obtained a score of good practices toward food hygiene safety. However, 17.3% had a fair level of practices, and 82.7% had a poor level (Table 5). In this case, also, the poor level was associated with the age of vendors (18-40 years) ($p=0.000$). But vendors who had obtained a secondary level of education showed the poorest level of practices

Table 6. Association of vendors' characteristics with the level of knowledge of food hygiene practices.

Characteristics	Level of knowledge			Total (%)	Test* and p-value
	< 50% (Poor)	50 - 69% (Fair)	70%+ (Good)		
Gender					
Female	78(83)	14(14.9)	2(2.1)	94(100)	$\chi^2 = 1.07$; df = 2; p = 0.585
Male	63(85.1)	8(10.8)	3(4.1)	74(100)	
Age					
18 - 42 years	135(86.5)	16(10.3)	5(3.2)	156(100)	$\chi^2 = 11.05$; df = 2; p = 0.004
> 42 years	6(50)	6(50)	0(0)	12(100)	
Education					
Primary	91(89.2)	8(7.8)	3(2.9)	102(100)	$\chi^2 = 12.62$; df = 4; p = 0.013
Secondary	50(78.1)	12(18.8)	2(3.1)	64(100)	
High level	0(0)	2(100)	0(0)	2(100)	
Type of activity					
Fixe	93(80.2)	18(15.5)	5(4.3)	116(100)	$\chi^2 = 6.18$; df = 2; p = 0.046
Mobile	48(92.3)	4(7.7)	0(0)	52(100)	

Table 7. Association of vendors' characteristics with the level of food hygiene practices.

Characteristics	Level of practice		Total (%)	Test and p-value
	< 50% (Poor)	50 - 69% (Fair)		
Gender				
Female	78(83)	16(17)	94(100)	$\chi^2_{(a)} = 0.01$; df = 1; p = 0.926
Male	61(82.4)	13(17.6)	74(100)	
Age				
18 - 40 years	132(84.6)	24(15.4)	156(100)	$\chi^2_{(b)}$; p = 0.000
> 40 years	7(58.3)	5(41.7)	12(100)	
Education				
Primary	80(78.4)	22(21.6)	102(100)	$\chi^2_{(c)} = 13.11$; df = 2; p = 0.001
Secondary	59(92.2)	5(7.8)	64(100)	
High level	0(0)	2(100)	2(100)	
Type of activity				
Fixe	96(82.8)	20(17.2)	116(100)	$\chi^2_{(c)} = 0$; df = 1; p = 0.992
Mobile	43(82.7)	9(17.3)	52(100)	

(a) Chi-Square of Pearson Test; (b) Fisher's exact Test ; (c) Likelihood ratio.

(p=0.001) than their colleagues less educated. Gender and type of activity did not reveal any difference in practices (p=0.926 and p=0.992, respectively) (Table 7).

Risk factors associated with retail meats vendors

In this study, we identified many risk factors associated

with the environment where the meat was sold and with the vendors' practices during their activities. Among them are as follows:

The conditions of meat vending

In the market, meats were directly displayed on concrete

stalls or wooden table, or directly on the floor. Plastic, cardboard, old newspaper or other materials were used as a tablecloth. There were no scopes to avoid insect or dust during the display.

The meat processing and handling

Vendors used knives, metal saw, axe and machete to cut the meat into small pieces weighing 50 to 120 g. All the handling processes were achieved with bare hands. Sometimes, meats of different species, fish and vegetables were sold by a single vendor without a proper separation.

The absence of a refrigeration system, improper storage process and packaging

There was no refrigeration system during vending activities. Vendors kept unsold meat in deep freezer of market's warehouse. Thus, the meat was frequently frozen and unfrozen. In snack bar also, raw meat and cooked skewers were kept at ambient temperature.

In the market, clean and unused polythene bags were used for packaging. However, in snack bars, RTE goat skewers were served on plastic or metallic plates to consumers who eat in the snack bar. For those who took away their dishes, old papers or newspapers, as well as reusable polythene bags, were used for packaging.

The slaughtering processes

There is no formal abattoir in Lubumbashi dedicated to goat slaughter. In general, goats were slaughtered in a backyard, in the market or along roadsides. The slaughter process was carried out with the bare hands. Those who achieved this process did not wear aprons, hair protection or rubber boots. Most of them wore regularly dirty clothes as work clothes to do their duties.

The use of ingredients

Fresh onions, white vinegar, salt, cooking oil and in some cases nitrites salts were used for seasoning of skewers. Besides, meat handlers used secret seasoning, which was reported to be the key to success and made the vendors famous in this field.

The access to water and absence of waste management system

Vendors had no permanent access to clean and potable water. Most of the time, water was purchased, in

polythene bags, from street vendors of water. However, in the rainy season, vendors use rainwater. In all cases, water was stored in a single bucket and used for washing hands, stands and utensils.

Both in market and snack bars, there was no defined waste management system. The waste was disposed on the floor at the vending site, and often in an illegal unloads around the market. Moreover, after goat slaughter, usually the gastro-intestinal contents, wastewater, and all the garbage were disposed of in the public sewers.

DISCUSSION

This study was conducted to assess the knowledge, attitude, and practices among meats vendors in Lubumbashi, and to identify risk factors associated with retail meat vendors in Lubumbashi.

Socio-demographic characteristics

Most of the vendors were women. The difference in gender was significant in the market where 81% were women ($p=0.001$), and 18.9% were men. Similar results were reported in many other studies, where women were also much involved in food street vending activities compared to men (Martins, 2006; Lee et al., 2017). However, in snack bars in Lubumbashi, all the vendors were men as the slaughter of goat is carried out only by men. A similar finding was reported in Nairobi. Indeed, the survey was conducted in establishments dealing with animal products such as butcheries where most of the workers were males (Mathenge et al., 2017). In countries such as Pakistan, Malaysia and Taiwan, men were also the most representatives (Zeeshan et al., 2017).

The average age of the respondent to our survey was 18 to 40 years (92.9%). The same range of age of street food vendors and food handlers was reported in other studies (Meleko et al., 2015, Afolaranmi et al., 2015). In Lubumbashi, most of the vendors were married (56%). Like finding in Nairobi in Kenya, where 55.7% of street vendors were also married.

The majority (60.7%) of meat vendors in our survey had obtained a primary level of education, which was the lowest. Thirty-eight (38%) had achieved a secondary level of education, and only 1.1% had a university level of education. In Haiti, 22.5% of street vendors were illiterate; 45% had a primary level of education, 26.2% a High school level and 6.3% a university level (Sapamundo et al., 2015).

Most of the vendors in Lubumbashi had a stationary activity (69%), while 30.9% of them were mobile. Similar results were reported in Sudan, where 64 % of the vendors had fixed activities (Abdalla et al., 2009). Contrary to our study, in Benin, 76.7% of the street food vendors surveyed were mobile (Ohin et al., 2018).

FAO and WHO recommend that food vendors must hold a basic training in food safety and hygiene practices by relevant authorities before they are licensed for the activity. Still, in Lubumbashi, none of the vendors was qualified for handling meat, and no one had a training certificate in food safety or hygiene practices. Studies suggested that vendors trained in food safety hygiene had a good level of knowledge and practices of hygiene when handling food (Rahman et al., 2012; Adane et al., 2018). Despite this, in China, there was no significant difference in food safety knowledge among vendors who had received training in food safety and those who did not train (Ma et al., 2019).

Knowledge, attitude and practices

In our study, only 3% of meats vendors had a good level of knowledge/attitude toward food hygiene practices while the majority had a poor score (81.9%), and 13.1% had a fair score. Regarding their practices in hygiene and food handling, none of the vendors had a good score. The majority had a poor score (82.7%), and the others had a fair score (17.3%). In Owerri Town in Nigeria also, vendors who had a poor level of knowledge in food hygiene showed poor hygienic practices (Iwu et al., 2017). Similar findings were reported in developing countries like Soudan and Western Africa, among others (Barro et al., 2007; Abdalla et al., 2008).

Age and gender have been discussed in the knowledge, attitude and practice of hygiene in the handling of meat and food products. In our study, vendors aged under 40 years and less educated, appeared to be associated with a poor level of knowledge/attitude ($p=0.004$). Besides, the same group of vendors (< 40 years) showed a poor level of food hygiene practices ($p=0.000$), although they had obtained a secondary level of education. But in both cases, there was no difference between genders. In a study conducted in Ghana, there was no association between the vendors' ages with the knowledge and practice of food hygiene (Dun-Dery and Addo, 2016). But another study in the same country showed that the group of vendors aged from 36-45 years has a high awareness of food hygiene (Dajaan et al., 2018). Like in our study, in Uganda also, the low level of education of vendors was associated with poor knowledge of hygiene practices during food handling and preparation (Muyanja et al., 2011). In Nepal, for instance, food sold by illiterate vendors showed a higher incidence of bacterial contamination (Khadka et al., 2018). In USA, there was an association between gender, age and level of education. Indeed, women appeared to provide the best hygienic quality of food compared to men. However, these women were at least 40 years old and had an instruction-level of secondary school (Omemu and Aderoju, 2008).

Although hands are recognized to be a significant vehicle of biological hazards; in this study, only 32.7% of meat vendors washed their hands after using toilet facilities. This percentage was of 13.6% after the goat slaughter process. But all vendors never wash their hands after handling other products such as money and live animals. In India, most of the vendors did not wash their hands, and they handled money with bare hands while serving food (Reddi et al., 2015). In Brazil, 67% of street food vendors were reported to wash their hands at least 4 times a day while working. Besides, 33% of them did not wash at all their hands, and others used only water without detergent (Cortese et al., 2016). For hand washing to be considered as effective, it must be carried out with a detergent such as soap and hands must be well rinsed and wiped preferably with disposable papers (Bloomfield and Scott, 1997; CDC, 2013, Galgamuwa et al., 2016).

Concerning body hygiene, 61.3% of meat vendors in Lubumbashi were aware of taking a shower before and after the day of work. Most of the respondents (88.6%), of which the majority were women, considered it useful to wear clean clothes for work, but there was no association between gender and the level of knowledge/attitude and practices in food safety and hygiene practices ($p>0.05$). This corroborated with the findings of Malavi et al. (2017).

In our study, none of the vendors was wearing hair protection or gloves. But, most of them wore hands jewels and watches (39.8%), and 74.4% were frequently using their mobile phones. Vendors in India did not wear hair protection, and 28% were scratching their scalp while preparing food. In addition, 60% had long fingers nails, and 64% wore jewelry (Reddi et al., 2015). Only 20.8% of vendors covered their hair in Ethiopia (Amare et al., 2019). Although in Nigeria, vendors were aware of keeping their bodies and clothes clean, they did not consider as necessities to wear hair protection, to remove hand and arm jewelry and to keep nails short (Omemu and Adejoru, 2008). The poor personal hygiene was pointed out in contamination of street food. Indeed, lack of body hygiene and wearing hand jewelry or other accessories were established as a high-risk factor of cross-contamination between food and food handler's hands, cuts or sores, mouth, skin, and hair (Campos et al., 2009; Rane, 2011). Thus, good personal hygiene must be considered for meat handlers to avoid cross-contamination from them to the meat during handling, vending or storage processes.

In Lubumbashi, meat vendors had not a health certificate which allows them to practice activity in direct contact with fresh or cooked meat. Besides, only 15.4% were interested in screening for infection voluntarily. Though, medical examination of food handler is essential for the control of transmissible diseases from food handlers to the food they are manipulating. Similar results

were reported in Dhaka in Bangladesh, where most of the vendors had not a health certificate or a license to operate in their business (Khairuzzamann et al., 2014). Regulatory authorities in Ghana recommend that foods vendors must be screened for transmissible diseases at least every six months. However, during an investigation, 71% of vendors surveyed were tested, and 64% of them had the screening more than six months ago (Apanga et al., 2014).

In our survey, vendors were aware of foodborne diseases such as cholera and typhoid fever. But they did not apply basics hygiene rules like washing hands with clean water when handling food. In most developing countries, street food vendors were not completely ignorant of food safety practices, but they could not practice them (Baluka et al., 2015; Galgamuwa et al., 2016; Ohin et al., 2018). Nevertheless, 24.4 and 30.4% of meat vendors in Lubumbashi were willing to stop handling meat if they suffer from diseases such as diarrhoea and typhoid fever respectively. In Nigeria, also, in the case of diarrhoea, 24% of street food vendors were reported willing to stop their activities (Omemu and Aderoju, 2008). During our study, some of the meat vendors reported that they suffered, at least once, of diarrhoea or typhoid fever in the last 3 months before our survey. However, none had to stop his activity because they could use auto medication or use traditional remedies to get rid of the disease. In Bloemfontein, South Africa, street food vendors prepared food for public consumption while sick, and they could not stop their activity because their living depends on the daily return of the trade (Alami, 2016). In Ethiopia, food handler has been reported to suffer from diseases like diarrhoea, cholera, typhoid fever (Tsfaye, 2018). Studies showed that pathogens were frequently isolated in contaminated street food (Shaltot et al., 2015; Amare et al., 2019). Thus, foods handlers may lead to cross-contamination of food with bacteria when they suffer from specific diseases.

In Lubumbashi, 39% of meat vendors claimed to use clean water to clean their stands and 55.3% their utensils. Otherwise, 29.7% of respondents used wastewater to clean their stands and 47% to clean their tools. Similar results were reported in Jigjiga in Ethiopia, where 39.4% of vendors washed their utensils with dirty water which was used several times (Bereda et al., 2016). In this study, dry cleaning was performed by 19.6 % of respondents using a brush for cleaning their stands, and 26.1% used a cloth to wipe their utensils at the end of daily activities. These practices were reported before among street food vendors in many studies (Barro et al., 2007; Ologhobo et al., 2010). Utensils were frequently reported to be the vehicle of cross-contamination of street vended foods. The contamination of the raw products and recontamination of RTE products result in most cases from the use of

utensils that were not thoroughly cleaned; or when good hygiene practices were not applied by food handlers (Taulo et al., 2008; Carrasco et al., 2012). Furthermore, using a cloth to wipe dirty utensils can be considered as a risk factor of contamination of food and other surfaces. Gorman et al. (2002) found dishcloths to be contaminated with pathogens following chicken preparation in a domestic kitchen in Ireland. Thus, these pathogens may be transferred onto many other surfaces and food during the handling process.

Risk factors

During our survey, we identified many risk factors which may contribute to food contamination. Regarding vending sites, in Lubumbashi, meats were vended in poor sanitary conditions. It was directly displayed on concrete stalls, wooden tables, plastic or other materials. The meat was exposed to insect and dust. In Jigjiga also, vending places were in the wooden stall, canopies and polythene containers (Bereda et al., 2016). Wooden stalls and other surfaces may act as risk factors since they were associated with contamination of meat. Indeed, microorganism's niches and environmental pollution were found on those types of surfaces. For instance, bacteria were recovered from a wide range of food contact surfaces, including stainless steel, rubber, wood, polystyrene and glass material (Mafu et al., 2011; Patrignani et al., 2016).

Poor vending conditions were also reported in many studies. Indeed, vendors handled foods in unsanitary conditions at ground level and had their food exposed to flies, rats and cockroaches (Ehiri et al., 2001; Alamo-Tonelado et al., 2018). The presence of dust and flies are risk factors as they may harbour pathogens and lead to contamination of food. Indeed, flies and the environmental conditions such as water, dust, rains, winds, and urbanization were identified as vectors of zoonoses and contamination of street vended food (Adeyemo et al., 2009).

Concerning meat processing and handling in Lubumbashi, the meat was cut into small pieces to be sold at affordable prices. Still, all the handling processes were achieved with bare hands. Moreover, there was no proper separation between meats of different species, fish and vegetables. Food of animal origins such as meat and fish and their products are considered as high-risk commodities regarding pathogens, natural toxins and other contaminants they may harbour (Novoslavskij et al., 2016; Boukili et al., 2019).

Furthermore, meat processing was identified as a significant risk of meat contamination. Indeed, cutting, mincing, handling or packaging process may lead to cross-contamination between material or allow bacteria presents on the surface to spread and distribute homogeneously in the meat (Abongo'o and Momba, 2009;

Shilenge et al., 2016; Shafini et al., 2017). In Nairobi, sausages had the highest count of coliform due to post handling process, which involved the cutting of the sausage (Kariuki et al., 2017). Moreover, mixing different type of food may originate in the cross-contamination of safe products (Cadirci et al., 2010).

In our survey, there was no refrigeration system both in snacks bars and markets. Besides, we noticed inadequate storage processes and packaging. Unsold cooked skewers were kept at ambient temperature and reheat to be sold the following day. The unsold meat was held in a deep freezer in the market's warehouses and unfroze the next morning. Keeping the perishable food such as meat in an inadequate range of temperature or refreezing a completely thawed food is considered as risk factors since these processes may accelerate the growth of contaminating bacteria (Akabanda et al., 2017; Mercier et al., 2017). Like in Lubumbashi, studies reported that vendors kept food at ambient temperature during vending activities (Cortese et al., 2016; Tesfaye, 2018). Vendors who kept leftovers food more than 2 days provided food of poor microbiological quality (Derbew et al., 2013). The storage of the food at an inadequate temperature can act as an incubator media for pathogens, whether the food is raw or cooked. Food which was held at an ambient temperature between 15-45°C for more than 4 h presented a significantly higher risk for public health (Tafesse et al., 2014).

In Lubumbashi's markets, vendors used clean and unused polythene bags for packaging. However, in snack bars, old papers, newspapers, cardboard and other inappropriate material were used for skewers packaging. These practices increase the risk of cross-contamination of food with various contaminants such as pathogens or chemicals. In Pakistan also, vendors served food in paper bags plain or with newsprint. These bags were made using glue which was not recommended by any food control authority (Ahmed et al., 2017). Packaging may be contaminated with spoilage or pathogenic microorganisms (Patrignani et al., 2016). Indeed, bacteria and fungi were isolated from paper-based packaging made with recyclable material (Hladíková et al., 2015). Thus, attention should be paid to the material used for packaging since it may act as a source of contamination of food.

In Lubumbashi, goat 'slaughtering processes took place in the market, in the backyards and along roadsides with the bare hands, without formal equipment. There was no formal abattoir for goats. Unlike in Ghana, there were formal slaughterhouses. However, some vendors did not use them because of the distance from the chop bar to the abattoir and the exorbitant fees charged for ante-mortem inspection of livestock (King et al., 2000).

Absence of formal abattoir and improper slaughtering processes constitute risk factors of meat contamination

through the production chain. Further cross-contamination of meat may result in abattoir environment or following contact with meat handlers, and thus increasing the risk of food contamination (Rouger et al., 2017).

In our survey, vendors used fresh onions, white vinegar, salt, cooking oil and nitrites salts for the seasoning of the skewers. However, some of the ingredients were kept secret because they were the key to success, according to vendors. Spices used in food preparation may act as a vehicle for biological or chemical hazard through food products. Spices such as black pepper, paprika and others may be contaminated by biological hazards when not handled properly (Carrasco et al., 2012). Like in our study, in South Africa, 56% of mobile vendors used unlabeled and unpacked spices, and 37 % purchased them from the traditional daily or weekly markets and prepared them themselves at home. And yet, studies have demonstrated that homemade condiments were contaminated with *Bacillus cereus* (Alami, 2016). In Nigeria, to increase the palatability of foods, vendors used spices such as crayfish and soybean. Unfortunately, these ingredients were subject to frequent contamination from vendors' unwashed hands and material used for packaging such as leaves, old newspapers and reusable polythene bags (Ehiri et al., 2001).

Vendors had no permanent access to clean and potable water in this study. They purchased water in polythene bags sold by street vendors of water; or used rainwater and stored it in a single bucket to be used for washing hands, stands and utensils. The same practices were reported in Ghana (Dajaan et al., 2018). Many studies have suggested that the lack of clean water was enhancing the possibility of cross-contamination between hands, work surfaces, utensils, and foods (Vollaard et al., 2004; Khadka et al., 2018). Pathogens present in water may contaminate surfaces, utensils and further, foodstuff. Thus, the lack of potable water may act as a potential risk factor for food poisoning.

In this study, we noticed the lack of a waste management system which contributed to environmental pollution. Indeed, vendors threw their garbage on their vending places, or illegally around the market, along roadsides or in public sewers. In Gauteng, South Africa, also, 56% of vendors poured wastewater into the storm water drainage system (Martins, 2006). Similarly, in Pakistan, 80% of street food vendors threw their wastewater along roadsides. Others threw their leftover foods in their vending vicinity and contributed to creating an unsanitary environment (Ahmed et al., 2017).

Conclusion

It was found from this study that meat was vended in

poor sanitary conditions in Lubumbashi. The lack of knowledge, attitude and practice of hygiene in meat handling by retail meat vendors appears to be a real threat to public health. Meat vendors must be regarded as a critical control point in the chain of distribution of meat of good hygienic quality. Furthermore, we identified that poor environmental conditions at the vending site, the lack of personal hygiene, the improper handling and storage processes as well as the lack of potable water and the waste disposal are important risk factors which may lead to various contamination of meat sold at a retail outlet in Lubumbashi.

Recommendations

These data may be used as a basis for evaluation of the food safety policies which would be set up, in joint effort with the public health authority, to improve Good Hygiene Practices in street food and meat handling in Lubumbashi. However, street food vending activities will not be prohibited as long as it contributes to the informal economy in the city. Local government, as well as regulatory authorities, may support these activities by recognizing them as a part of the economy. However, they should provide regulation and control to ensure food safety of meat vended at a retail outlet, and thus reduce the risk toward public health.

We highly recommend that the local administration provides primary facilities such as adequate vending places where minimal services are provided like potable water, energy, tile-flooring outlets, coated walls and waste management. Each point of meat sale should be equipped with a basic hygiene appliance containing a refrigerator if possible, with transparent displays to facilitate the customer's choice. Storage warehouses in the market must be equipped with refrigerators or freezers to ensure better storage of meats.

We also recommend that the local authorities provide conventional goat's slaughterhouses and request minimal training in goat slaughtering for those who are involved in this practice.

Furthermore, the local government should raise awareness of the threat of improper practices in meat/food handling and set up control measures to oversee meat vending activities in markets and streets. For instance, vendors must be licensed before they practice their business; and they should undergo medical screening for transmissible diseases. Meat vendors should be aware of the role they play in the transmission of foodborne illnesses.

Finally, an educational program and food safety training should be considered for persons dealing with meat and street food. This program requires a substantial investment. But the cost/benefit of the educational program in good hygiene practice during

meat/food handling is more economical than dealing with consequences of foodborne diseases due to lack of knowledge in food handling.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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