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Knowledge, Attitudes, and Practices of Red Meat Handlers in Moroccan Slaughterhouses

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ABSTRACT

Meat handlers are vectors of pathogens in slaughterhouses and can play a major role in the microbiological contamination of meat. The level of knowledge of meat handlers in slaughterhouses is a critical factor in food safety. Good hygienic practices in the slaughterhouse are required to reduce the risk of microbiological contamination while handling meat. This study evaluated workers' knowledge, attitudes, and practices in four municipal slaughterhouses in Morocco. A total of 267 employees were evaluated using a structured survey. The results showed that workers had acceptable knowledge and practices, and their attitudes were very satisfactory, averaging 52.87%, 50.9%, and 63.07%, respectively. A positive correlation between the workers' level of knowledge and education was found in all studied slaughterhouses. Similarly, the results indicated a positive correlation between knowledge and attitudes at Meknes and Kenitra slaughterhouses. The impact of the studied sociodemographic characteristics may vary from one slaughterhouse to another. In conclusion, the study suggested that although the knowledge, attitudes, and level of practice of food handlers were very satisfactory, some aspects related to the control of the health status of the handlers and personal protective equipment had to be underlined. Ongoing food safety training should become mandatory to enhance food safety in the slaughterhouses of study locations.

Keywords: Attitudes, Food Safety, Hygienic practices, Knowledge, Slaughterhouse

INTRODUCTION

The increasing number of epidemic outbreaks of food poisoning and food crisis worldwide forces authorities to apply the best hygiene and quality practices (Baş et al., 2006). According to the world health Organization, Global estimates on foodborne diseases indicate the annual infection of more than 600 million people by consuming contaminated food with bacteria, viruses, or parasites, and 420000 deaths (WHO, 2017). Poor hygiene and sanitation conditions in meat processing establishments, such as slaughterhouses, contribute significantly to the high incidence of community-acquired foodborne diseases, which are frequent and sometimes severe (Egan et al., 2007; Lues and Van Tonder, 2007; WHO, 2006).

In Morocco, more than 90% of collective food poisoning is due to bacteria, of which meat products constitute 11% (Belomaria et al., 2007). In 2016, the Moroccan Poison Control Center (CAPM) recorded 2723 cases of food poisoning, 53% of which were cases of collective food poisoning (Ghailani et al., 2020). Butchers working in slaughterhouses are the main vectors for meat contamination (Todd et al., 2010; Jianu and Chiș, 2012; Matchawe et al., 2019). Investigations into foodborne disease outbreaks have shown that poor personal hygiene plays a major role in the passive transmission of pathogens, such as Noroviruses, *Salmonella* species, *Staphylococcus aureus*, and *Shigella* species. These pathogens are often present in handlers' wounds, mouth, skin, and hair. Furthermore, the unwashed hands of workers can also transmit pathogens, particularly fecal pathogens (Sharif et al., 2013; Lambrechts et al., 2014).

Morocco has 180 municipal slaughterhouses, 3 approved private slaughterhouses, and 223 (out of 702) uncontrolled rural slaughterhouses (Annual report of the court of auditors of Morocco, 2018). Most of these slaughterhouses do not fulfill the hygienic requirements recommended by the National Office for Sanitary Safety of Food Products (ONSSA), such as a lack of hygiene training for working staff (Annual report of the court of auditors of Morocco, 2018). A knowledge, attitude, and practice (KAP) survey is a structured, standardized questionnaire used for a particular population to collect information about what is known, believed, and done on a specific topic (WHO, 2008). This type of investigation serves as an educational diagnosis of populations (Salih et al., 2019). Surveys on KAP have become a widely used means of research worldwide for public health studies to propose reflections on the training of food handlers, given their responsibility for food safety and consumer health (Ahmed et al., 2020). Several studies have been conducted to evaluate these processes in food safety in international slaughterhouses (Annor and Baiden, 2011; Abdul-Mutalib et al., 2012; Soares et al., 2012).

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The current study is a complement to previous research published by the Laboratory of Microbiology and Molecular Biology, Mohammed V University, Rabat, Morocco, providing information on the level of knowledge, attitudes, and practices of workers, as well as on the microbiological situation of the slaughter areas of the municipal slaughterhouses of Marrakech city located in southern Morocco (Bahir et al., 2022). This study aimed to assess the knowledge, attitudes, and practices of food handlers in four Moroccan municipal slaughterhouses in Rabat, Salé, Kenitra, and Meknes, situated in Morocco.

MATERIALS AND METHODS

Ethical approval

All the information in this study was based on the recommendations of the Faculty of Sciences, Mohammed V University, Rabat, Morocco. Authorizations were requested from the administration of each slaughterhouse, which granted permission to carry out the surveys. The manipulators involved in the current study were reported anonymously.

Study area

Present work concerned four municipal slaughterhouses located in the northwest of Morocco (Rabat, Sale, Kenitra, and Meknes). In Morocco, the sanitary inspection of municipal slaughterhouses is carried out by the veterinarians of ONSSA, while the administrative management is under the supervision of the Ministry of Interior. The choice of the studied slaughterhouses was based on the accessibility to their geolocation. The authorization of the responsible authorities was obtained for the realization of this survey. For this purpose, the interviewed participants included 267 randomly selected male employees working in cattle or sheep slaughterhouses, cutting rooms, or the carcass transportation sector. The number of interviewed participants in each slaughterhouse varied depending on the size of the abattoirs and their willingness to participate in the surveys. Meat handlers were voluntarily and randomly selected. A structured questionnaire with different sections was administered to all participants. The questions were explained and read aloud to the participants, who were given sufficient time to answer each question. No one was forced to participate in the survey.

Survey

The survey was conducted between January and April 2021. Based on previous research, a structured four-part study was developed to assess the sociodemographic characteristics, knowledge, attitudes, and slaughter practices of food handlers (Angelillo et al., 2001). Information on the sociodemographic characteristics of the handlers was mainly related to their work area in the slaughterhouse, age, level of education, work experience, training in meat hygiene, and health status. The information on workers' knowledge of food safety included 10 questions related to microbiological risks of carcass contamination, the importance of refrigeration and personal hygiene, and risks related to foodborne illness, to which participants were given the option of answering "Agree" or "Disagree". Following the same, respondents' attitudes toward food safety were also assessed by 10 questions addressing their personal hygiene and the cleaning of surfaces used during the slaughter process, as well as the standard cleaning of the used equipment. The participants could be scored 0-10 for the knowledge and attitude sections. The obtained results have been converted to 100%. Scores between 40% and 70% were considered acceptable, while scores more than 70% were considered excellent. The slaughter practices section included 18 questions on topics related to hygiene and the wearing of personal protective equipment during work. Participants were asked to answer "yes" or "no". A score was assigned to each correct answer and converted to a percentage. An average was calculated for each section to get a global idea of the handlers' knowledge, attitudes, and practices.

Statistical analysis

The statistical analysis was performed using version 2021 of XLSTAT Life Sciences, UK. The relationship between the sociodemographic profile of the carcass handlers and their KAP levels was determined using the chi-squared test. Differences in the mean of participants within each group studied were analyzed using a one-way ANOVA integrated post hoc test to show that particular differences between pairs of means are significant. Statistical significance for all tests was set at $p \leq 0.05$ using Ducan Test.

RESULTS

Sociodemographic characteristics of respondents

Tables 1 to 4 summarize the results concerning sociodemographic characteristics. Information on the sociodemographic characteristics of the carcass handlers included their work area in the slaughterhouse, age, education level, work experience, and hygiene training. The findings indicated that 56% (n = 45), 65% (n = 26), and 66% (n = 56) of participants were practicing cattle slaughter in Rabat, Salé, and Meknes, respectively. However, almost all

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respondents (93.55%, n = 58) were sheep slaughters in Kenitra. A minority in Rabat worked in trip cleaning (6.25%) or transporting the carcasses (17.25%) to cold storage (Table 1).

The majority of handlers aged between 18 and 40 years, according to their recruitment, physical strength, and performance during the different slaughter operations. A few workers were under 18 years of age in Rabat (4%) and Kenitra (4.84%, Table 2). College and primary levels of education were 26.25% and 38.5% in Rabat, 60% and 20% in Sale, 30.59% and 32.94% in Meknes, and 35.48% and 27.42% in Kenitra, respectively (Table 3). The majority of handlers had good professional experience and worked for more than 20 years, compromising 41.25% in Rabat, 50% in Sale, 31.76% in Meknes, and 47.77% in Kenitra slaughterhouse (Table 4).

Table 1. Distribution of the work section of handlers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Working area	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Sheep	20 (16)	30 (12)	22.35 (19)	93.54 (58)	105
Cattle	56.5(45)	65 (26)	65.88 (56)	3.23 (2)	129
Cleaning Tripe	6.25 (5)	5 (2)	2.35 (2)	3.23 (2)	11
Transport of carcasses	17.5 (14)	0 (0)	9.42 (8)	0 (0)	22
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

N: Number of workers

Table 2. Age distribution of handlers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Age categories	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total
< 18 YO	5 (4)	0 (0)	0 (0)	4.84 (3)	7
18 -30 YO	28.75 (23)	25 (10)	25.88 (22)	25.81 (16)	71
31-40 YO	23.75 (19)	30 (12)	37.65 (32)	19.35 (12)	75
41-60 YO	22.50% (18)	35 (14)	23.53 (20)	37.10 (23)	75
> 60 YO	20 (16)	10 (4)	12.94 (11)	12.90 (8)	39
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

YO: Years old, n: Number of workers

Table 3. Distribution of handler's education level in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Education level	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Informal	13.75 (11)	20 (8)	17.65 (15)	17.74 (11)	45
Primary	38.75 (31)	20 (8)	32.94 (28)	27.42 (17)	84
College	26.25 (21)	60 (24)	30.59 (26)	35.49 (22)	93
High school	16.25 (13)	0 (0)	12.94 (11)	17.74 (11)	35
Academic	5 (4)	0 (0)	5.88 (5)	1.61 (1)	10
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

Informal: Manipulators who never had any basic education, n: Number of workers

Table 4. Distribution of work period of handlers in the municipal slaughterhouses of Rabat, Salé, Meknes and Kenitra in Morocco

Working period	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
0-4 years	8.75 (7)	0 (0)	11.77 (10)	14.52 (9)	26
5-10 years	17.50 (14)	20 (8)	21.18 (18)	11.29 (7)	47
11-15 years	10 (8)	15 (6)	12.94 (11)	11,29 (7)	32
15-20 years	22.5 (18)	15 (6)	22.35 (19)	16,13 (10)	53
>20 years	41.25 (33)	50 (20)	31.76 (27)	46.77 (29)	109
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

n: Number of workers

Handler training in meat hygiene and handling

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In the four slaughterhouses, the majority of workers had no training in hygiene and meat handling. Only a minority of workers received this type of training, including 12.5% in Rabat, 20% in Sale and 7.06% in Meknes, and 0% in Kenitra (Table 5). With regard to the number of training sessions, the majority were rarely trained (1 to 4 times per year). Thus, of the 10 workers who received training, 70% (n = 7) rarely received training when offered by private companies in the Rabat slaughterhouse, and 30% (n = 3) received training 1 to 4 times per year. In Salé slaughterhouse, workers (n = 8) rarely received training. For Meknes, only 5% (n = 4) of the workers had training once a year 2.5% (n = 2) barely received any hygiene training (Table 6). On the other hand, 100% (n = 24) of the workers in all slaughterhouses who received training considered training as effective (Table 7), and intended to conduct such training in the near future (Table 8).

Table 5. Distribution of handlers training in hygiene and handling meat in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Hygiene-training	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Yes	12.50 (10)	20 (8)	7.06 (6)	0 (0)	24
No	87.50 (70)	80 (32)	92.94 (79)	100 (62)	243
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

n: Number of workers

Table 6. Variation of training courses taken by workers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Number of hygiene-training	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
One per month	0 (0)	0 (0)	0 (0)	0 (0)	0
4 per year	20 (2)	0 (0)	0 (0)	0 (0)	2
1 per year	10 (1)	0 (0)	66.66 (4)	0 (0)	5
Rarely	70 (7)	100 (8)	33.34 (2)	0 (0)	17
Total	100 (10)	100 (8)	100 (6)	0 (0)	24

n: Number of workers

Table 7. Appreciation of the quality of hygiene training received by workers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Quality of hygiene-training	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Effective	100 (10)	100 (8)	100 (6)	0 (0)	24
Not effective	0 (0)	0 (0)	0 (0)	0 (0)	0
Total	100 (10)	100 (8)	100(6)	0 (0)	24

n: Number of workers

Table 8. Worker's appreciation of the willingness to follow hygiene training in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Willingness to follow hygiene-training	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Yes	82.50 (66)	75 (30)	94.12 (80)	85.48 (53)	229
No	17.50 (14)	25 (10)	5.88 (5)	14.52 (9)	38
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

n: Number of workers

The medical situation of the workers

The majority of handlers did not have a health certificate. According to the current regulation in Morocco, there should be medical files for all meat handlers, and the files must be updated annually. These files must be made available to the veterinary inspector. This document indicates the medical aptitude to perform slaughter activities. However, it has been observed that staff are rarely provided with medical certificates, which are not updated in Rabat, Sale, Meknes, and Kenitra at rates of 93.75% (n = 75), 82.5% (n = 33), 78.82% (n = 67), and 88.71% (n = 55), respectively (Table 9). On the other hand, 41.18% of the workers had a medical check-up before being hired in the slaughterhouse of Meknes (Table 10), and a very small number of workers did this operation before in Rabat, Sale, and in Kenitra slaughterhouses. Only 20% of the workers in the Kenitra slaughterhouse continued these check-ups (Table 11). The interval of the sanitary control of workers varied from one slaughterhouse to another. In Rabat, the majority of workers (41.25%, n =

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33) checked their health status every 3 months, and 20% (n = 10) and 17.5% (n = 14) of them reported having consulted a doctor between 6 months to a year, respectively. In Meknes and Kenitra, the majority of handlers declared having checked their health status between 6 months and a year. In the Salé slaughterhouse, 50% (n = 20) of the workers never checked their health status (Table 13). Except for the Kenitra slaughterhouse, many workers never consulted a doctor in their life, 21.25% (n = 17), 25% (n = 10), and 16.47% (n = 14) of workers in Rabat, Salé, and Mèknes, respectively (Table 13).

Table 9. Possession of medical certificates by workers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Possession of a medical certificate	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Yes	6.25 (5)	17.5 (7)	21.18 (18)	11.29 (7)	37
No	93.75 (75)	82.50 (33)	78.82 (67)	88.71 (55)	230
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

n: Number of workers

Table 10. Administrative requirement of a pre-employment medical check-up for workers at the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Pre-employment medical check-Up	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Yes	17.5 (14)	15 (6)	41.18 (35)	24.19 (15)	70
No	82.5 (66)	85 (34)	58.82 (50)	75.81 (47)	197
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

n: Number of workers

Table 11. Continuity of medical checks in the slaughterhouse by workers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Respondents who followed medical checks in the slaughterhouse	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Yes	0 (0)	0 (0)	0 (0)	20 (3)	3
No	100 (14)	100 (6)	100 (35)	80 (12)	67
Total	100 (14)	100 (6)	100 (35)	100 (15)	70

n: Number of workers

Table 12. Last health check carried out by workers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

The last health check carried out	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
1 month	17.5 (14)	2.5 (1)	10.59 (9)	4.84 (3)	27
3 months	8.75 (7)	2.5 (1)	11.76 (10)	27.42 (17)	35
6 months	13.75 (11)	15 (6)	20 (17)	11.29 (7)	41
12 months	12.5 (10)	17.5 (7)	16.47 (14)	12.9 (8)	39
>12 months	26.25 (21)	37.5 (15)	24.71 (21)	43.55 (27)	84
Never	21.25 (17)	25 (10)	16.47 (14)	0(0)	41
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

n: Number of workers

Table 13. Health check interval by workers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Health Check Interval	Rabat percentage (n)	Sale percentage (n)	Meknes percentage (n)	Kenitra percentage (n)	Total (n)
Every 3 months	41.25 (33)	0 (0)	17.65 (15)	11.29 (7)	55
Every 6 months	17.5 (14)	2.5 (1)	21.18 (18)	17.74 (11)	44
Every 12 months	20 (16)	10(4)	27.05 (23)	24.19 (15)	58
If necessary	15 (12)	37.5(15)	23.53 (20)	46.77 (29)	76
Never checked before	6.25 (5)	50 (20)	10.59 (9)	0 (0)	34
Total	100 (80)	100 (40)	100 (85)	100 (62)	267

n: Number of workers

Handlers' hygiene knowledge

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Generally, a good knowledge of hygiene was approached by half of the workers (54.16%, 55.8%, 48.7%, and 52.9% in the slaughterhouses of Rabat, Sale, Meknes, and Kenitra, respectively). Most workers were aware of the microbiological risks, the importance of good hygiene practices in the workplace, and the impact of shelf life on meat contamination. In the Kenitra slaughterhouse, only 37% (n = 23) of the workers knew that unhygienic handling could be a source of meat contamination. In the slaughterhouses of Rabat and Kenitra, 59% (n = 47) and 55% (n = 34) of workers knew that refrigeration delays contamination, respectively, while this was not the case for workers in Salé (25%) and the slaughterhouse in Meknes (18.18%). In the Rabat and Meknes slaughterhouses, 51.3% (n = 41) and 56.5% (n = 48) of the workers were aware that microbial contamination of meat could cause serious illnesses leading to hospitalization and sometimes death, respectively. The level of knowledge of handlers about the risk of microbial contamination by a person suffering from diarrhea was generally very low at 46% (n = 37), 32.5% (n = 13), 35.3% (n = 30), and 44% (n = 27), in Rabat, Sale, Meknes, and Kenitra, respectively (Table 14).

Table 14. Hygiene knowledge of handlers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Percentage of correct answers (n) / The statements	Rabat (n = 80)	Sale (n = 40)	Meknes (n = 85)	Kenitra (n = 62)
Can meat spoilage be caused by microorganisms?	69 (55)	75 (30)	61.18 (52)	71 (44)
Is the contamination of meat very risky due to the shelf life?	75 (60)	85 (34)	68.2 (58)	55 (34)
Could unsanitary practices be a source of carcass contamination?	68 (54)	65 (26)	70.6 (60)	37 (23)
Can contamination be caused by direct contact between bare hands and animals or materials?	70 (56)	70 (28)	68.2 (58)	65 (40)
Does the chilling of meat at temperatures below 20°C contribute to delaying microbial deterioration?	59 (47)	25 (10)	18.18 (15)	55 (34)
Can microbial contamination cause serious illness leading to hospitalization and sometimes death?	51.3 (41)	47.5 (19)	56.5 (48)	35 (22)
Can healthy carriers carry microbes?	31.3 (25)	75 (30)	63.5 (54)	68 (42)
Can a handler with diarrhoeal syndromes be a source of risk?	46 (37)	32.5 (13)	35.3 (30)	44 (27)
Can water be a source of microbial contamination?	38 (30)	48 (19)	23.5 (20)	55 (34)
Can water from hoses used for cleaning be a source of contamination of carcasses?	34 (27)	35 (14)	21.18 (18)	44 (27)
Average knowledge estimate*	67%	55.8%	58.3%	52.9%

*Average knowledge estimate: Represents the average value of obtained data percentage for each bellow investigated response**,** n: Number of workers

Table 15. Attitudes of handlers towards hygiene and meat handling in the municipal slaughterhouses of Rabat, Salé, Meknes and Kenitra in Morocco

Percentage of correct answers (n) / The statements	Rabat (n = 80)	Sale (n = 40)	Meknes (n = 85)	Kenitra (n = 62)
Hand washing after the toilet with a disinfectant is mandatory	77.5 (62)	80 (32)	79 (67)	80.64 (50)
The handler must check his state of health	87.5 (70)	50 (20)	89 (76)	53.22 (33)
Handling meat with lesions on the hand is a risk of contamination	20 (16)	10 (4)	26 (22)	11.29 (7)
The state of health must be checked before employment	82.5 (66)	15 (6)	59 (50)	24.19 (15)
Training is very interesting for me	82.5 (66)	75 (30)	94 (80)	85.48 (53)
Disinfecting abattoir premises is a way to avoid contamination	87.5 (70)	85 (34)	76 (65)	96.77 (60)
The wearing of protective equipment (Apron) is necessary	11.25 (9)	32.5 (13)	52 (44)	53.22 (33)
Cleaning the slaughter area before slaughter operations	87.5 (70)	85 (34)	76 (65)	96.77 (60)
Cleaning of equipment before slaughter is desirable	71.25 (57)	50 (20)	79 (67)	80.64 (50)
The deposit of organ meats on the ground is prohibited	62.5 (50)	67.5 (27)	55 (47)	32.25 (20)
Average attitudes estimate*	67%	55%	58.3%	61.44%

*Average attitude estimate: represents the average value of obtained data percentage for each bellow investigated response**,** n: Number of workers

Hygiene attitudes

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Generally, the various handler statements regarding attitudes, hygiene, and meat handling were satisfactory. The mean values of correct answers were significantly positive in each slaughterhouse at 67.3% in Rabat, 55.1% in Salé, 68.5% in Meknes, and 61.44% in Kenitra. The majority of handlers in Rabat slaughterhouse (82.5%) agreed with the obligation of continuous monitoring using medical tests before hiring. On the other hand, handlers at Salé (85%) and Kenitra slaughterhouse (75.81%) considered it unnecessary. The majority of workers agreed with the continuous monitoring of medical tests. Attitudes in relation to hand washing and the importance of disinfecting premises were very satisfactory. The attitudes of the majority of workers concerning wearing personal protective equipment were weak. In Rabat and Salé, 88.75% (n = 71) and 67.5% (n = 27) of slaughterers considered using an apron during slaughtering operations as unnecessary, respectively. In the same direction, 80% (n = 64), 90% (n = 40), 74.11% (n = 22), and 88.71% of the handlers in Rabat, Salé, Meknes, and Kenitra slaughterhouses considered the handling of carcasses with lesions on the hands did not constitute a risk of contamination, respectively. In the Salé slaughterhouse, 67.74% (n = 20) of handlers considered that the deposit of meats on the floor did not contain any risk of contamination (Table 15).

Hygiene practices

Regarding slaughter practices of handlers, the average of correct responses obtained was between 47.9% and 54.12%. Most handlers reported that they washed their hands before the slaughter. Their responses were at the rates of 77.5% (n = 62) in Rabat, 80% (n = 32) in Salé, 78.8% (n = 67) in Meknes, and 100% (n = 62) in Kenitra, but they did not generally use a disinfectant except for one employee in Kenitra. Similarly, most handlers washed their hands after using the toilet but did not use sanitizer. In the 4 slaughterhouses, the majority of workers declared that they handled carcasses with lesions on their hands at response rates of 80% (n = 64) in Rabat, 90% (n = 36) in Salé, 74.1% (n = 63) in Meknes and 88.7% (n = 55) in Kenitra. More than half of the handlers in Rabat and Meknes slaughterhouses announced that they handled carcasses with diarrheal syndrome (57.5% and 56.5%). On the other hand, the majority of workers declared this fact in Salé and Kenitra, 85% (n = 34) and 61.3% (n = 38), respectively. As for the cleanliness of the handlers, the majority cut their nails and used boots, but most of them did not use gloves and aprons during slaughter operations. The majority of the handlers in Salé slaughterhouse (75%) announced that meat did not affect the working environment, unlike in Rabat, Meknes, and Kenitra slaughterhouses, 62.5% (n = 50), 89.4% (n = 76) and 69.4% (n = 43), respectively. Most slaughterers followed good practices to clean the slaughter area and equipment before and after the slaughter process (Table 16).

Table 16. Food handlers' practices toward food hygiene and sanitation in the municipal slaughterhouses of Rabat, Salé, Meknes and Kenitra in Morocco

Percentages of answers (n) / Slaughterhouse's station	Rabat percentage (n=80)		Sale percentage (n=40)		Meknes percentage (n=85)		Kenitra percentage (n=62)	
Questions	**Correct**	**Wrong**	**Correct**	**Wrong**	**Correct**	**Wrong**	**Correct**	**Wrong**
Hand washing before handling	77.5 (62)	22.5 (18)	80 (32)	20 (8)	78.8 (67)	21,2(18)	100 (62)	0 (0)
If so, do you wash them with one of the disinfectants?	37.10 (23)	62.90 (39)	25 (8)	75(24)	24.7 (21)	54.11 (46)	0 (0)	100 (100)
Do you wash your hands every time you use the restroom?	83.75 (67)	16.25 (13)	85 (34)	15 (6)	81.2 (69)	18.8 (16)	100 (62)	0
With or without soap?	28.36 (19)	60 (48)	30 (12)	70 (28)	16.5 (14)	83.5 (71)	3.22 (2)	96.8 (60)
Do you handle carcasses when you have injuries on your hands?	20 (16)	80 (64)	10 (4)	90 (36)	25.9 (22)	74.1 (63)	11.29 (7)	88.7 (55)
Do you handle carcasses when you are sick or suffering from diarrhoeal syndromes?	42.5 (34)	57.5 (46)	15 (6)	85 (34)	43.5 (37)	56.5(48)	38.7 (24)	61.3 (38)
Do you keep your fingernails long?	81.25 (65)	18.75 (15)	85 (34)	15 (6)	42.4 (36)	57.6 (49)	87.1 (54)	12.9 (8)
Do you wear gloves during slaughter?	8.75 (7)	91.25 (73)	5 (2)	95 (38)	17.6 (15)	82.4 (70)	0 (0)	62 (100)
During slaughter, is there any contact with the skin, walls, floor, or equipment?	37.5 (30)	62.5 (50)	75 (30)	25 (10)	10.6 (9)	89.4 (76)	30.6 (19)	69.4 (43)
Do you use an apron during the process?	15 (12)	85 (68)	10 (4)	90 (36)	20 (17)	80 (68)	13 (21)	49 (79)
Do you use boots during slaughter?	85 (68)	15 (12)	100 (40)	0 (0)	94.1 (80)	5.9 (5)	74.2 (46)	25.8 (16)
Do you place the cutters and winches on the floor?	60 (48)	40 (32)	30 (12)	70 (28)	22.4 (19)	77.6 (66)	50 (31)	50 (31)
Are carcasses and offal placed in direct contact with floors, walls, or other equipment during hide removal and transport operations?	62.5 (50)	37.5 (30)	67.5 (27)	32.5 (13)	55.3 (47)	44.7 (38)	32.3 (20)	67.7 (42)
Do you clean slaughter equipment daily?	26.25 (21)	62.5 (50)	55 (22)	45 (18)	18.8 (16)	81.2 (69)	0 (0)	100 (62)
Cleaning of the area before	87.5 (70)	12.5 (10)	85 (34)	15 (6)	76.5 (65)	24.7% (21)	96.8 (60)	3.2 (2)
The cleaning of the area after	88.75 (71)	11.25 (9)	72.5 (29)	27.5 (11)	96.5 (82)	3.5 (3)	96.8 (60)	3.2 (2)
Cleaning the front knives	71.25 (57)	28.75 (23)	50 (20)	50 (20)	78.8 (67)	22.2 (19)	80.6 (50)	19.4 (12)
Cleaning the knives after	61.25 (49)	38.75 (31)	50 (20)	50 (20)	51.8 (44)	48.2 (41)	62 (100)	0(0)
Average practices estimate*	54.12%	45.25%	51.7%	47.5%	47.9%	51.1%	51.3%	48.7%

*Average practices estimate: represents the average value of obtained data percentage for each bellow investigated response**,** n: Number of workers

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Correlation between the level of knowledge and sociodemographic factors of handlers in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Rabat slaughterhouse

The obtained results in Rabat slaughterhouse showed a positive correlation between the handlers' level of knowledge and their education level (X^2=3.09, $p > 0.05$), as well as with the training handlers (X^2=1.87). No correlation was reported between the age and professional experience of the handlers (Table 17).

Sale slaughterhouse

A significant correlation was observed between the level of knowledge and the level of education ($X^2 = 1.61$). The other statistical indices show no correlation with the level of knowledge (Table 18).

Meknes slaughterhouse

In Meknes slaughterhouse, there was a highly significant correlation between the handlers' level of knowledge and their level of education (X^2=11.85; $p < 0.01$; Odds ratio =8.21). A positive correlation was also observed between their knowledge level and professional experience (X^2=1.67; Odds ration=3.74). The other statistical indices almost show no correlation between age, slaughter area, training, and level of hygiene knowledge (Table 19).

Kenitra slaughterhouse

The statistical indices obtained in Kenitra slaughterhouse showed a positive relationship between the knowledge of the handlers and their slaughter area, and their level of education with X^2=1.4 and X^2=1.07, respectively. No other statistical indices were significant (Table 20).

Table 17. Relationship between the level of knowledge of the handlers and their sociodemographic characteristics in Rabat slaughterhouse achieved on January 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	34	30	64	0.05	0.82	0.94	0.88	0.43-0.59
	Cleaning Trips + Transport of carcasses	9	7	16					
Age	Young people (18 – 40)	28	18	46	0.12	0.73	0.94	0.85	0.42-0.58
	Age 40 - 60	22	12	34					
Level of education	Low: Informal or primary	28	10	38	3.09	0.08	1.35	2.31	0.42-0.57
	High: middle school, high school, or university	23	19	42					
Work experience	Low period (0-4 years)	6	2	8	0.16	0.69	1.10	1.41	0.40-0.55
	High period (4-more than 4 years)	49	23	72					
Training	Yes	5	5	10	1.87	0.17	0.70	0.40	0.40-0.55
	No	50	20	70					

CI: Confidence interval

Table 18. Relationship between the level of knowledge of the manipulators and their sociodemographic characteristics in Sale slaughterhouse achieved on January 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	30	8	38	0.53	0.47	0.79	0.00	0.33-0.52
	Cleaning Trips + Transport of carcasses	2	0	2					
Age	Young people (18 – 40)	16	6	22	0.13	0.71	0.94	0.76	0.36-0.56
	Age 40 - 60	14	4	18					
Level of education	Low: Informal or primary	13	3	16	1.61	0.20	1.30	2.60	0.38-0.60
	High: middle school, high school, or university	15	9	24					
Work experience	Low period (0-4 years)	0	0	0	-	-	-	-	0.32-0.49
	High period (4-more than 4 years)	33	7	40					
Training	Yes	13	3	16	0.56	0.46	1.15	1.78	0.36 -0.56
	No	17	7	24					

CI: Confidence interval

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Table 19. Relationship between the level of knowledge of handlers and their sociodemographic characteristics in Meknes slaughterhouse achieved on March 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	56	19	75	0.96	0.33	1.24	1.96	0.39-0.53
	Cleaning Trips + Transport of carcasses	6	4	10					
Age	Young people (18 – 40)	43	11	54	0.01	0.91	0.99	0.94	0.35-0.47
	Age 40 - 60	25	6	31					
Level of education	Low: Informal or primary	40	3	43	11.85	0.01	1.50	8.21	0.36-0.49
	High: middle school, high school, or university	26	16	42					
Work experience	Low period (0-4 years)	9	1	10	1.67	0.20	1.27	3.74	0.39-0.53
	High period (4-more than 4 years)	53	22	75					
Training	Yes	4	2	6	0.19	0.67	0.89	0.68	0.38-0.52
	No	59	20	79					

CI: Confidence interval

Table 20. Relationship between the level of knowledge of the handlers and their sociodemographic characteristics in the municipal slaughterhouse of Kenitra achieved on March 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	35	25	60	1.40	0.24	0,58	0.00	0.42-0.60
	Cleaning Trips + Transport of carcasses	2	0	2					
Age	Young people (18 – 40)	20	11	31	0.30	0.59	0.91	0.74	0.40-0.57
	Age 40 - 60	22	9	31					
Level of education	Low: Informal or primary	19	9	28	1.07	0.30	0.85	0.55	0.37-0.54
	High: middle school, high school, or university	27	7	34					
Work experience	Low period (0-4 years)	7	2	9	0.81	0.37	1.25	2.12	0.41-0.59
	High period (4-more than 4 years)	33	20	53					
Training	Yes	0	0	0	-	-	-	-	0.42-0.60
	No	36	26	62					

CI: Confidence interval

Correlation between respondents' attitude level, knowledge, and sociodemographic characteristics in the municipal slaughterhouses of Rabat, Salé, Meknes, and Kenitra in Morocco

Rabat slaughterhouse

The relationship between attitude level and sociodemographic characteristics in Rabat slaughterhouse showed a strong significant correlation ($X^2 = 5.96$; $p < 0.05$) between slaughter area and attitude level. An excellent attitude is related to the cattle slaughter zone. The odds ratio presented a value of 0.25, indicating a negative attitude effect for the cleaning trips and transporting carcasses. The chi-square, prevalence, and odds-ratio indices indicated no relationship between age and attitude level. There was also a significant correlation between education and attitude level (low education is related to an excellent attitude). This can be explained by the correlation between attitude level and work experience (Odds ratio = 4.20, $p > 0,05$, Table 21).

Sale slaughterhouse

In Sale slaughterhouse, the results showed a correlation between age and attitude level (the youngest manipulators had a positive attitude, compared to the oldest manipulators) with $X^2 = 3.30$. There was no correlation between knowledge and attitude level ($X^2 = 0$, $p > 0.05$).

Meknes slaughterhouse

There was a correlation between knowledge and attitude in Meknes with $X^2 = 2.63$. The statistical indices showed almost no correlation between age and attitude level (Table 23).

Kenitra slaughterhouse

In Kenitra slaughterhouse, knowledge correlated with attitude ($X^2= 3.21$). The statistical indices indicated almost no correlation between attitude level and the other variables (Table 24).

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Correlation between hygiene and meat handling practices and sociodemographic characteristics of handlers in Rabat, Sale, Meknes, and Kenitra slaughterhouses

Rabat slaughterhouse

The results regarding the correlation between sociodemographic factors and slaughter practices showed a highly significant correlation between practice level and slaughter area (X^2 =11.55; p < 0,05). Prevalence and Odds-ratio confirmed this correlation, showing a negative effect between the level of practices and the washing of the entrails and the transport area with 0.16 and 0.31, respectively. The results also revealed a positive correlation between the level of practice and the education level of handlers (X^2 = 3.17). Unacceptable slaughter practices were associated with low education levels (Table 25).

Sale slaughterhouse

The results in the Sale slaughterhouse showed a positive correlation between slaughter practices and handlers' level of education (X^2 = 1.78, prevalence = 0.55, and Odds-Ratio = 0.39). The results of the slaughter area, age, and work experience showed no significant relationship between these factors and the level of handlers' practices.

Meknes slaughterhouse

In the slaughterhouse of Meknes, the results indicated that an acceptable level of slaughter practices was related to a young age range of handlers with an X^2=2.37. The other statistical indices showed almost no significant relationship between slaughter practices and other sociodemographic factors.

Kenitra slaughterhouse

In the slaughterhouse of Kenitra, the obtained results showed almost no positive correlation between slaughter practices and sociodemographic factors.

Table 21. Relationship between the level of attitude of the manipulators, their sociodemographic characteristics, and their level of knowledge in Rabat slaughterhouse achieved on January 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	35	25	60	5.96	0.01	0.48	0.25	0.42-0.57
	Cleaning Trips + Transport of carcasses	2	0	2					
Age	Young people (18 – 40)	20	11	31	0.001	0.97	0.99	0.98	0.38-0.52
	Age 40 - 60	22	9	31					
Level of education	Low: Informal or primary	19	9	28	3.86	0.05	0.55	0.39	0.42-0.58
	High: middle school, high school, or university	27	7	34					
Work experience	Low period (0-4 years)	7	2	9	3.53	0.06	3.00	4.20	0.31-0.43
	High period (4-more than 4 years)	33	20	53					
Training	Yes	0	0	0	1.13	0.29	1.52	2.04	0.42-0.57
	No	36	26	62					
Knowledge	Acceptable	10	20	30	0.49	0.48	1.28	1.42	0.39-0.54
	Excellent	13	37	50					

CI: Confidence interval

Tableau 22. The relationship between the level of attitude of the manipulators, their sociodemographic characteristics, and their level of knowledge in Sale slaughterhouses achieved on January 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	15	23	38	1.26	0.26	-	-	0.40-0.63
	Cleaning Trips + Transport of carcasses	0	2	2					
Age	Young people (18 – 40)	6	16	22	3.30	0.07	0.49	0.30	0.41-0.64
	Age 40 - 60	10	8	18					
Level of education	Low: Informal or primary	6	10	16	0.07	0.79	0.90	0.84	0.41-0.64
	High: middle school, high school, or university	10	14	24					
Work experience	Low period (0-4 years)	0	0	0	-	-	-	-	0.41-0.65
	High period (4-more than 4 years)	18	22	40					
Training	Yes	8	8	16	1.11	0.29	0.75	0.50	0.41-0.64
	No	16	8	24					
Knowledge	Acceptable	8	8	16	0.00	1.00	1.00	1.00	0.41-0.65
	Excellent	12	12	24					

CI: Confidence interval

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Table 23. Relationship between the level of attitude of the manipulators, their sociodemographic characteristics, and their level of knowledge in Meknes slaughterhouse achieved on March 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	34	41	75	0.84	0.36	1.51	1.93	0.43-0.59
	Cleaning Trips + Transport of carcasses	3	7	10					
Age	Young people (18 – 40)	22	32	54	0.23	0.63	1.15	1.25	0.43-0.58
	Age 40 - 60	11	20	31					
Level of education	Low: Informal or primary	16	27	43	0.94	0.33	0.78	0.65	0.43-0.59
	High: middle school, high school, or university	20	22	42					
Work experience	Low period (0-4 years)	7	3	10	2.15	0.14	1.54	2.81	0.44-0.59
	High period (4-more than 4 years)	34	41	75					
Training	Yes	3	3	6	0.11	0.74	1.16	1.32	0.43-0.59
	No	34	45	79					
Knowledge	Acceptable	10	25	35	2.63	0.10	0.62	0.47	0.43-0.58
	Excellent	23	27	50					

CI: Confidence interval

Table 24. Relationship between the level of attitude of the handlers, their sociodemographic characteristics, and their level of knowledge in Kenitra slaughterhouse achevied on March 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	22	38	60	0.15	0.70	0.73	0.58	0.41-0.59
	Cleaning Trips + Transport of carcasses	1	1	2					
Age	Young people (18 – 40)	15	16	31	1.06	0.30	1.36	1.70	0.42-0.60
	Age 40 - 60	11	20	31					
Level of education	Low: Informal or primary	13	15	28	0.17	0.68	1.13	1.24	0.42-0.61
	High: middle school, high school, or university	14	20	34					
Work experience	Low period (0-4 years)	5	4	9	0.24	0.62	0.87	0.70	0.41-0.59
	High period (4-more than 4 years)	34	19	53					
Training	Yes	0	0	0	-	-	-	-	0.41-0.59
	No	22	40	62					
Knowledge	Acceptable	10	21	31	3.21	0.07	0.59	0.39	0.42-0.61
	Excellent	17	14	31					

CI: Confidence interval

Table 25. Relationship between the level of hygiene practices of handlers and their sociodemographic characteristics in Rabat slaughterhouse achieved on January 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	11	50	61	11.55	0.01	0.31	0.16	0.39-0.53
	Cleaning Trips + Transport of carcasses	11	8	19					
Age	Young people (18-40)	12	34	46	1.34	0.25	0.68	0.57	0.40-0.55
	Age 40-60	13	21	34					
Level of education	Low: Informal or primary	14	24	38	3.17	0.07	1.93	2.48	0.39-0.53
	High: middle school, high school, or university	8	34	42					
Work experience	Low period (0-4 years)	1	6	7	0.67	0.41	0.50	0.41	0.39-0.53
	High period (4-more than 4 years)	21	52	73					

CI: Confidence interval

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Table 26. Relationship between the level of hygienic practices of handlers and their sociodemographic characteristics in Sale slaughterhouse achevied on January in Morcco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	14	24	38	0.14	0.71	0.74	0.58	0.40-0.63
	Cleaning Trips + Transport of carcasses	1	1	2					
Age	Young people (18 – 40)	8	14	22	0.03	0.87	0.94	0.90	0.40-0.63
	Age 40 - 60	7	11	18					
Level of education	Low: Informal or primary	4	12	16	1.78	0.18	0.55	0.39	0.40-0.63
	High: middle school, high school, or university	11	13	24					
Work experience	Low period (0-4 years)	0	0	0	-	-	-	-	0.40-0.63
	High period (4-more than 4 years)	15	25	40					

CI: Confidence interval

Table 27. Relationship between the level of hygiene practices of handlers and their sociodemographic characteristics in Meknes slaughterhouse achieved on March 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	39	36	75	0.23	0.63	0.87	0.72	0.44-0.59
	Cleaning Trips + Transport of carcasses	6	4	10					
Age	Young people (18-40)	32	22	54	2.37	0.12	1.41	2.01	0.44-0.59
	Age 40-60	13	18	31					
Level of education	Low: Informal or primary	24	19	43	0.29	0.59	1.12	1.26	0.44-0.59
	High: middle school, high school, or university	21	21	42					
Work experience	Low period (0-4 years)	4	6	10	0.76	0.38	0.73	0.55	0.44-0.59
	High period (4-more than 4 years)	41	34	75					

CI: Confidence interval

Table 28. Relationship between the level of hygiene practices of handlers and sociodemographic characteristics in Kenitra slaughterhouse achieved on March 2021 in Morocco

Variables		Level of knowledge		No.	X^2	P-value	Prevalence Ratio	Odds Ratio	CI
		Acceptable	Excellent						
Slaughter area	Cattle + Sheep	16	44	60	0.53	0.47	0.53	0.36	0.38-0.55
	Cleaning Trips + Transport of carcasses	1	1	2					
Age	Young people (18 – 40)	11	20	31	1.25	0.26	1.57	1.89	0.39-0.56
	Age 40 - 60	7	24	31					
Level of education	Low: Informal or primary	9	19	28	0.54	0.46	0.78	0.68	0.41-0.59
	High: middle school, high school, or university	20	33	53					
Work experience	Low period (0-4 years)	2	7	9	0.81	0.37	0.59	0.47	0.41-0.59
	High period (4-more than 4 years)	41	34	75					

CI: Confidence interval

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DISCUSSION

This study provided valuable information on the knowledge, attitudes, and practices of handlers regarding hygiene and meat handling in four municipal slaughterhouses in Morocco. The information collected on workers' knowledge of food safety highlighted the microbiological risks of contamination of carcasses, the importance of refrigeration and personal hygiene, and the risks related to foodborne diseases. Regarding handler attitudes, the study identified the handler's personal hygiene, cleaning of surfaces used during the slaughter process, and standard cleaning of equipment used. Considering slaughter practices, topics related to hygiene and wearing personal protective equipment during work should be focused. Several studies have reported that handlers working in meat processing factory directly impact foodborne disease outbreaks (Howes et al., 1996; Clayton et al., 2002). The results of this study showed adequate knowledge and practices, while attitudes were very satisfactory. In the four slaughterhouses, almost all respondents were aware of the microbiological contamination of carcasses and the risks associated with consuming contaminated meat. At the same time, they were not aware of the modes of disease transmission as most of them believed that working with diarrhoeal syndrome or using water from cleaning pipes during slaughter did not have any contamination risk. This is in agreement with the study by Matchawe et al. (2019), who reported that 43.1% of respondents in the slaughterhouse of Yaoundé, Cameroon, stated that disinfecting facilities were not important in reducing the risk of carcass contamination.

For meat refrigeration, 75% and 82% of respondents in the slaughterhouses of sale and Meknes did not have enough information, respectively. In Rabat and Kenitra, most respondents were also conscious of the importance of refrigeration in storing and reducing meat contamination. A study conducted in Turkey by Baş et al. (2006) showed that 63.1% of the respondents knew the importance of the refrigerator temperature to minimize food safety risks since temperature handling is often the critical control point in a production process.

Misunderstanding temperature can impede the implementation of any Hazard Analysis Critical Control Point (HACCP) policy (Walker et al., 2003). The results of a study conducted in Turkey by Baş et al. (2006) suggested that 63.1% of the surveyed individuals were aware of the importance of temperature control in minimizing food safety risks. Walker et al. (2003) highlighted that a lack of knowledge regarding temperature handling in a production process could be a major obstacle in implementing any Hazard Analysis Critical Control Point (HACCP) policy.

The results dealing with the attitudes of meat handlers were generally standard. According to Abdullah Sani and Siow (2014) and Al-Shabib et al. (2016), attitude is a critical factor that can impact the food safety behavior and practices of food handlers by reducing the incidence of foodborne illness. Respondents in the four slaughterhouses surveyed were aware of general hygiene measures, such as mandatory hand washing with disinfectant after using the toilet, disinfection of slaughter areas, as well as the prohibition of the deposit of offal on the floor. In contrast, the majority of respondents failed to answer the question correctly. Handlers believed that working with lesions on their hands does not pose a risk of carcass contamination. In contrast to the present study, Zanin et al. (2015) identified that nearly 85% of their staff were conscious of the risk of touching food with cuts on their hands or fingers. The Food and Drug Administration (FDA) (2017) reported that food handlers with illnesses or cuts and injuries on their hands had to stop work immediately and leave the workplace to prevent the transmission of foodborne illness. In Rabat and Sale, food handlers found it unnecessary to wear personal protective equipment. Similarly, respondents in Sale and Kenitra believed that health checks were not required before hiring. This is in disagreement with Ansari-Lari et al. (2010), where 93.8% of the handlers at the meat processing factory in Fars, Iran, found that wearing personal protective equipment was an indispensable act to avoid carcass contamination.

According to Zanin et al. (2017), attitude plays a critical role in slaughter practices, as there is a key link between knowledge and practice; workers with an acceptable level of knowledge are more likely to translate it into practice if they have a positive attitude. Hand washing before each manipulation and after each use of the toilet by the majority of handlers remained among the most encouraging results. Similar results have been reported in previous studies by Al-Kandari et al. (2019), showing that 99.5% of respondents washed their hands before and during food handling. Moreover, lack of hand hygiene is a very important risk factor in food poisoning, according to the Codex Alimentarius Commission (2003). In the present study, 62.5%, 25%, 90.6%, and 69.4% of respondents in Rabat, Salé, Meknes, and Kenitra, respectively, reported direct contact with bare hands with the wall, floor, and equipment during slaughter operations. A previous study by Al-Kandari et al. (2019) stated that 51.7% of the handlers used bare-hand contact with ready-to-eat foods. The lack of cleaning devices in the workplace, the absence of training and awareness programs, and the low level of education of the participants in this study may explain this.

A significant positive correlation existed between the handlers' knowledge and their education level in all studied slaughterhouses. This is consistent with the work of Ansari-Lari et al. (2010), Martins et al. (2012), and Abdul-Mutalib et al. (2012). The correlation of attitudes with sociodemographic factors varied in each slaughterhouse. A positive correlation between attitudes and knowledge was observed in Meknes and Kenitra. Similarly, there was a positive correlation between attitudes, education level, and slaughter area in Rabat.

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The results of the correlation between practices and sociodemographic factors are presented in tables 15-19. A positive correlation was reported in the slaughterhouse of Rabat between the practices and the slaughter area, as well as with the education level in Meknes. A positive correlation was detected with the age of the meat handlers in Meknes. In Salé and Kenitra, the obtained results were similar to these of Matchawe et al. (2019), who reported no correlation between practices and sociodemographic factors. Effective education of workers about food safety can minimize the risk of bacteriological contamination throughout the food chain. Foodborne illness cannot be reduced without food handling procedures and knowledge of food safety practices (Salih et al., 2019). Bahir et al. (2022) showed that meat could easily be contaminated during the slaughtering process by a low level of knowledge and poor practices of handlers, as well as the high bacterial loads and some pathogenic bacteria isolated from most of the studied surfaces in slaughterhouses of Marrakech, Morocco.

CONCLUSION

This study complemented previous research compiled by the current study research team. The work constituted an inventory of the red meat slaughterhouses in Morocco to get a maximum of information on the slaughtering sector in the country. The present study indicated that training and awareness programs for handlers on health risks and hygienic handling of meat must be strengthened to improve food safety in the country. The obtained results showed that while the level of KAP is satisfactory in the four studied slaughterhouses, other hygienic aspects need to be highlighted. Also, sociodemographic factors can directly impact the handlers' knowledge, attitudes, and practices. Microbiological studies should complement the studies to link the level of awareness of handlers on good hygiene practices with the risks and the dissemination of pathogens on slaughter surfaces. The authors of the current study recommended this type of research to contribute to the understanding of the current situation of handlers in slaughterhouses in Morocco and to implement authorities to take actions to reduce the occurrence of toxic infections among consumers.

DECLARATIONS

Data availability and materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Consent to publish

Not applicable in this section.

Authors' contribution

Mohammed amine Bahir and Ikram Errachidi collected samples used in this Survey. Mohammed amine Bahir and Mohamed Alami contributed data analysis. Mohammed amine Bahir, Asmaa Tantane, and Bouchaib Sarhnae wrote the original draft. Bouchra Belkadi and Abdelkarim Filali-Maltouf revised and edited the draft and generated the final version of the manuscript. All authors contributed to the article and approved the submitted version.

Competing interests

All authors confirm that there are no conflicts of interest associated with this publication and that this work received no financial support.

Ethical consideration

Ethical considerations (including plagiarism, consent to publish, misconduct, fabrication and/or falsification of data, dual publication and/or submission, and redundancy) were checked by all authors.

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