

Clostridium perfringens, and *Campylobacter jejuni*, which cause food poisoning and *Clostridium botulinum*, *Staphylococcus aureus*, and *Bacillus cereus* are responsible for serious meat borne intoxication.

Slaughterhouses are such establishments where the respective authority gives license to slaughter animal under the inspections of the supervisory body for human consumption. In the Sylhet Sadar Upazila, having one City Corporation and 709 villages where 0.82 million people reside, meat vendors have established a good number of slaughterhouses cum meat shops in the city, suburbs, and even in rural areas to sell their products (BBS, 2015). However, Jahan et al. (2015) isolated different types of pathogenic bacteria from the raw meat sold in different markets of Sylhet Sadar and reported 115 bacterial isolates of five genera such as *Escherichia coli* (10%), *Salmonella spp.* (13.33%), *Klebsiella spp.* (20%), *Enterobacter spp.* (6.67%), and *Staphylococcus spp.* (26.67%). The presence of these pathogenic bacteria in fresh meat is undoubtedly alarming; hence a question rose regarding the quality of meat, specifically food safety and hygiene. Hence, we assumed that most of the slaughterhouses set up by meat vendors might lack standard design, modern facilities, and appropriate practices related to hygiene and operational policies. Therefore, the objective of the study was to determine the overall status of slaughterhouses in maintenance of standard of hygiene, facilities, and compliance of policies, in the Sylhet region of Bangladesh.

2. MATERIALS AND METHODS

Study area

The study area was Sylhet Sadar Upazila under the Sylhet district of Bangladesh, with geo-coordinate 24.8917°N to 91.8833°E covering a total area of 301.80 km². The Sylhet city is located within the center of this Upazila, which possesses a subtropical monsoon climate, with a hot and humid summer and a cool winter. The annual average highest and lowest temperatures are 23°C (August-October) and 7°C (January), respectively. Nearly 80% of the annual average rainfall of 3,334 mm occurs between May and September (Badsha et al., 2016; BBS, 2015).

Preparation of checklist

We developed a comprehensive checklist based on three sections with some modifications devised by Fasanmi et al. (2018) as hygiene, facility, and policy. Ultimately, we finalized a checklist consisting of 65 items after the deletion of repeat questions, and we categorized all items under three stated sections (hygiene (30), facility (22), and policy (13)).

Study design and sampling technique

We carried out a cross-sectional survey from January to February 2019. We selected 35 slaughterhouses randomly using a simple random sampling technique among 71 registered slaughterhouses under the study area for data collection.

Data collection, management, and analyses

We scored each item of the checklist as "non-existent to poor" (0-49%) and "good to very good" (50-100%) by observing the level of compliance of three stated sections. We collected data through a personal interview of the selected slaughterhouses workers and scored each item in percentage accordingly.

We entered scores of all items into Microsoft Excel and grouped them into two, either < 50% (non-existent to poor) or ≥ 50% (good to very good). Then we calculated the proportion of the group in percentage to show the binomial distribution for each item and remarked as "Poor (if percentage < 50)", "Fair (if percentage = 50)", and "Good (if percentage > 50)". We did scoring of the checklist, grouping category, and remarks, according to Fasanmi et al. (2018).

3. RESULTS

The overall results showed that most of the slaughterhouses located at Sylhet Sadar Upazila have poor hygiene and limited facilities with a lack of standard operational policies.

Hygiene related items of slaughterhouses

Among 30 items under the hygiene section, only 12 items scored good such as the cleanliness of

premises; washing floor, wall, and pillar; disinfection of floor, wall, and pillar; cleanliness of slaughtering point; disinfection of slaughtering points; washing hands before slaughter; disinfection of hands before slaughter; washing slaughtering tools and equipment before slaughter; washing hands after slaughtering; hands disinfection after slaughtering; washing of slaughtering tools and equipment after slaughter; and disinfection of slaughtering tools and equipment after slaughter. However, amid rest 18, ten items were non-existent – namely, disinfection of premises; cleaning of lairage; disinfection of lairage; use of footbath; strict maintenance of hygiene and sanitation measures for visitors before entry; Personal Protection Equipment (PPE) maintenance; safe disposal of condemned carcass; safe disposal of waste; use of modern condemned carcass disposal methods; and strict maintenance of hygiene and sanitation measures for visitors before exit and eight scored poor which were environmental cleanliness and disinfection of surrounding area; ventilation system; the presence of a crack in the floor, wall, and pillar; waterlogging in the floor; disinfection of slaughtering tools and equipment before slaughter; drainage system; garbage disposal services; and controlled access of rodents and other animals (Table 1).

Facility related items of slaughterhouses

Only two items, named facility to wash hand and facility to disinfect hand, amongst 22 scored good under facility section. The rest 20 items were non-existent to poor of which location of slaughterhouse; boundary around the slaughterhouse; lairage facility; water source; compartmentalization; availability and usage of cold chain; facilities of hygiene and sanitation for visitors, availability of hot water; facilities to take shower; and facilities of modern carcass disposal methods were very crucial (Table 2).

Policy related items of slaughterhouses

Under policy section, only one item that was all-in all-out policy of 13 scored good, and rest 12 items were non-existent to poor such as documentation of slaughtering; separation of different slaughtering species; isolation of sick animals; resting of animals before slaughtering; access to

veterinary inputs; ante-mortem examinations; post-mortem examinations; monitoring of slaughtering and processing stages; education level of workers; monitoring the health status of workers; following condemnation criteria; and compensation mechanism (Table 3).

4. DISCUSSION

FAO (1988) recommends that slaughterhouses' location should be far from the residential area, public institutions, religious establishments, but should have access to permanent road, available water supply, friendly waste disposal system, and electricity. Considering those criteria, we found that 33 out of 35 slaughterhouses located in an inappropriate area in this study. Moreover, 30 of 35 were adjacent to the residential area, which may lead the citizen exposure to the different types of pathogens causing zoonotic diseases, food poisoning, diarrhea, and other health outcomes (Hassan et al., 2015).

In the current study, we found that the environment and surroundings were very poor in term of cleanliness and disinfection at 29 slaughterhouses out of 35, even none of them (35 of 35) had specific protective boundaries. Therefore, such unhygienic surroundings may easily contribute to meat impurities by the residues deriving from environmental pollutants (Heinz, 2008). Though we observed the cleanliness of premises was satisfactory (29 of 35). However, there was no practice of disinfection of premises at any slaughterhouses (35 of 35), which could attribute increased load of microorganisms there and subsequently could contaminate raw meat through air or cross contact through foot wares of workers or visitors as there were no use of footbath (35 of 35), and no facilities or practice of hygiene and sanitation for the visitors during entry or exit into slaughterhouses (35 of 35). Lack of these practices not only causes a problem in meat safety but also exposes visitors to pathogens having zoonotic importance at slaughterhouses.

The condition of ventilation system was shocking at 32 slaughterhouses among 35 as they failed to maintain the internal temperature, which leads to the proliferation of unwanted microorganisms that makes the working environment unsuitable for producing hygienic meat (UKessays, 2019). We

Table 1: Items under the hygiene section observed at slaughterhouses

Sl. No.	Items	Score <50 (%)	Score ≥50 (%)	Remark
1	Environmental cleanliness and disinfection of surrounding area	29(82.9)	6(17.1)	Poor
2	Cleanliness of premises	6(17.1)	29(82.9)	Good
3	Disinfection of premises	35(100)	0(0.0)	Poor
4	Cleaning of lairage done routinely	35(100)	0(0.0)	Poor
5	Disinfection of lairage done routinely	35(100)	0(0.0)	Poor
6	Use of footbath	35(100)	0(0.0)	Poor
7	Strict maintenance of hygiene and sanitation measures for visitors before entry	35(100)	0(0.0)	Poor
8	Ventilation system	32(91.4)	3(8.6)	Poor
9	Washing floor, wall, and pillar	2(5.7)	33(94.3)	Good
10	Disinfection of floor, wall, and pillar	3(8.6)	32(91.4)	Good
11	Presence of crack in the floor, wall, and pillar	33(94.3)	2(5.7)	Poor
12	Waterlogging in the floor	34(97.1)	1(2.9)	Poor
13	Cleanliness of slaughtering point	1(2.9)	34(97.1)	Good
14	Disinfection of slaughtering points	2(5.7)	33(94.3)	Good
15	Washing hands before slaughter	0(0.0)	35(100)	Good
16	Disinfection of hands before slaughter	2(5.7)	33(94.3)	Good
17	Personal Protection Equipment (PPE) maintenance	35(100)	0(0.0)	Poor
18	Washing slaughtering tools and equipment before slaughter	0(0.0)	35(100)	Good
19	Disinfection of slaughtering tools and equipment before slaughter	30(85.7)	5(14.3)	Poor
20	Drainage system	33(94.3)	2(5.7)	Poor
21	Garbage disposal services	34(97.1)	1(2.9)	Poor
22	Safe disposal of condemned carcass	35(100)	0(0.0)	Poor
23	Safe disposal of waste	35(100)	0(0.0)	Poor
24	Use of modern condemned carcass disposal methods	35(100)	0(0.0)	Poor
25	Controlled access to rodents and other animals	34(97.1)	1(2.9)	Poor
26	Washing hands after slaughtering	0(0.0)	35(100)	Good
27	Disinfection of hands after slaughtering	1(2.9)	34(97.1)	Good
28	Washing slaughtering tools and equipment after slaughter	0(0.0)	35(100)	Good
29	Disinfection of slaughtering tools and equipment after slaughter	3(8.6)	32(91.4)	Good
30	Strict maintenance of hygiene and sanitation measures for visitors before exit	35(100)	0(0.0)	Poor

Scores: Non-existent to poor (0-49%) or < 50; Good to very good (50-100%) or ≥ 50

also observed that washing and disinfection of the floor, wall, and pillar were good at 33 and 32 surveyed slaughterhouses, respectively, amid 35. However, we found cracks in the floor, wall, pillar, and water logging in the floor at 33 and 34 slaughterhouses, respectively, out of 35, and the ceiling was absent everywhere. Within the cracked floor, wall, and pillar and at logged water in the floor, if not carefully disinfected, microorganisms may grow profusely, risking the possibilities of meat contamination (UKessays, 2019). We noticed

the acceptable practice of washing and disinfection of slaughtering point and washing of slaughtering tools and equipment at the start and at the end, which was good sign. However, we also observed lack of practice in the disinfection of tools and equipment before slaughtering at most of the slaughterhouses (30 of 35) and after slaughtering at some of the slaughterhouses (3 of 35), which may allow the chance of existence of pathogens on tools and equipment that could lead to contamination of carcass and meat (EC, 2001).

Table 2: Items under the facility section observed at slaughterhouses

Sl. No.	Items	Score <50 (%)	Score ≥50 (%)	Remark
1	Appropriateness of location of slaughterhouse	33(94.3)	2(5.7)	Poor
2	Isolation of slaughterhouse from the residential area	30(85.7)	5(14.3)	Poor
3	Boundary around the slaughterhouse	35(100)	0(0.0)	Poor
4	Standard slaughterhouse design	34(97.1)	1(2.9)	Poor
5	Enough space for future expansion	35(100)	0(0.0)	Poor
6	Compartmentalization of slaughterhouse	35(100)	0(0.0)	Poor
7	Availability of lairage facility	34(97.1)	1(2.9)	Poor
8	Lairage usage in the slaughterhouse	34(97.1)	1(2.9)	Poor
9	Availability of cold chain	35(100)	0(0.0)	Poor
10	Usage of cold chain	35(100)	0(0.0)	Poor
11	Location of water source	19(54.3)	16(45.7)	Poor
12	Facilities of hygiene and sanitation for visitors	35(100)	0(0.0)	Poor
13	Facility to wash hands	0(0.0)	35(100)	Good
14	Facility to disinfect hands	0(0.0)	35(100)	Good
15	Availability of sufficient clean water	21(60)	14(40)	Poor
16	Availability of hot water	35(100)	0(0.0)	Poor
17	Facility to take shower after slaughtering	35(100)	0(0.0)	Poor
18	Availability of toilets	34(97.1)	1(2.9)	Poor
19	Complete segregation of toilet	34(97.1)	1(2.9)	Poor
20	Adequate distance between the septic tank and water supply	34(97.1)	1(2.9)	Poor
21	Presence of a ceiling in the slaughterhouse	35(100)	0(0.0)	Poor
22	Facilities of modern carcass disposal methods	35(100)	0(0.0)	Poor

Scores: Non-existent to poor (0-49%) or < 50; Good to very good (50-100%) or ≥ 50

Table 3: Items under the policy section observed at slaughterhouses

Sl. No.	Items	Score <50 (%)	Score ≥50 (%)	Remark
1	Documentation of numbers of animals slaughtered	25(71.4)	10(28.6)	Poor
2	Education level of workers	35(100)	0(0.0)	Poor
3	Monitoring the health status of workers	35(100)	0(0.0)	Poor
4	Access to veterinary inputs	34(97.1)	1(2.9)	Poor
5	Performing ante-mortem examinations of animals	35(100)	0(0.0)	Poor
6	Performing post-mortem examinations	35(100)	0(0.0)	Poor
7	Monitoring of slaughtering and processing stages	35(100)	0(0.0)	Poor
8	Isolation of sick animals	35(100)	0(0.0)	Poor
9	Separation of different species of animal slaughtered	35(100)	0(0.0)	Poor
10	Resting of animals before slaughtering	35(100)	0(0.0)	Poor
11	All-in all-out policy in the slaughterhouse	1(2.9)	34(97.1)	Good
12	Following condemnation criteria	35(100)	0(0.0)	Poor
13	Compensation mechanism for condemned carcass	35(100)	0(0.0)	Poor

Scores: Non-existent to poor (0-49%) or < 50; Good to very good (50-100%) or ≥ 50

Hand washing and disinfection before and after slaughtering are vital and easy hygienic practices. Nevertheless, we observed at some of the slaughterhouses the workers ignored these habit specially hand disinfection despite having such facilities, even at all surveyed slaughterhouses (35 of 35) workers were not aware of using PPE during slaughtering and meat processing. These dangerous malpractices are closely conversant to the contamination of carcass and raw meat and contribute to the burden of occupational hazards of the workers by increasing the likelihood of exposure to notorious zoonotic pathogens like *E. coli*, *Salmonella spp.*, *Bacillus anthracis*, *Mycobacterium tuberculosis*, *Brucella spp.*, *Campylobacter spp.*, and other species (EC, 2001; Gomes-Neves et al., 2012).

Liquid and solid waste produced from slaughterhouses during slaughter, evisceration, and meat processing are the primary sources of bacterial, viral, and parasitic pathogens. Observations revealed that 33 and 34 slaughterhouses among 35 have poor drainage system and garbage disposal services, respectively. Furthermore, none of them had the facilities and use of modern methods like composting, anaerobic digestion, alkaline hydrolysis, rendering, incineration, and burning for disposal of waste and condemned carcass. Due to lack of such facilities, these wastes are littered directly to the environment and sometimes very close to natural water bodies. These misconducts are responsible for the contamination of water, soil, and the environment with those pathogens and allow the pathogens to spread over a wider area and thus elevate the risk of human and animal diseases in many folds (Kwadzah and Iorhemen, 2015).

Lairage, where the authority quarantine, rest, and inspect animals before slaughtering, is one of the essential facilities that a slaughterhouse must need to have (Heinz, 2008). This study observed a well-organized functional lairage only at one slaughterhouse out of 35 and partial lairage facilities at some locations. Due to space limitation, most of the slaughterhouses use their slaughtering points as a temporary lairage, which is neither routinely cleaned nor disinfected. Here lie the chances of contamination of slaughtering points with microorganisms animals shed through

their urine and dung that ultimately might pass to the carcass and raw meat. The current study also showed that there was no control of rodents and other animals like dogs and cats at any (35 Of 35) of surveyed slaughterhouses entering into their premises due to lack of protective boundaries. These rodents and animals may act as reservoirs of many infectious and zoonotic agents. They can spread them in the slaughterhouse environment (Bengtsson and Whitaker, 1988) or get infected from inside the slaughterhouses and spread the diseases in the community outside the slaughterhouses.

In the present study, we found only one slaughterhouse out of 35 has been set up with a minimum standard design, but at other settings were too poor to perform all activities in an organized way. In the study area, none of the slaughterhouses (35 of 35) had a compartmentalization facility, and it was a common practice to execute all the operations such as slaughtering, bleeding, skinning, evisceration, carcass splitting, and processing on the same spot. This type of operation and practice, for sure, could lead to contamination of carcasses and raw meat (Spickler, 2019). Another two essential arrangements of a slaughterhouse are the facility of taking a shower and toilets, but we got these facilities absent in most slaughterhouses. Besides, complete segregation of toilets and adequate distance between septic tank and water supply are vital. However, we noticed such types of settings were lacking. Therefore, every time for each slaughter, after accomplishing all operations from beginning to the end, most likely the workers get dirty and might catch many microorganisms and need to take shower but fail to do this. Ultimately, the absence of such facilities could attribute to occupational hazards and create such conditions that they might carry the pathogens to the home and different places, making their family members and other people exposed to pathogens. On the other hand, if the septic tank and water supply are closely attached, water may be impure by microorganisms from fecal contents, and such polluted water is dangerous to use for slaughterhouse activities that may cause contamination of carcass and raw meat with *E. coli* and other pathogens, even workers might get infected. Moreover, none of the slaughterhouses

(35 of 35) had adequate space for future extension. Therefore, we found that most of them lack many recommended settings are impossible to set up in the future, determining the advancement of hygiene, facilities, and policies will remain questionable.

The study disclosed that 19 of 35 slaughterhouses use water from hazardous locations, and 21 of 35 of them lack of availability of sufficient clean water supply needed for cleaning, washing of slaughtering tools, equipment, and related chores, even in some cases stream and pond water had been used, most of which are already contaminated with tons of pathogenic microorganisms. Besides, hot water use as disinfection was completely absent at all locations (35 of 35). Lack of these facilities may attribute the risk of contamination of carcasses and raw meat and occupational hazards. In the surveyed slaughterhouses, cold chain facilities were absent. Hence it favors the rapid growth of pathogenic microorganisms, which result in a risk to the public health and also increase the chance of spoilage of meat as it is a perishable product with a short shelf-life and short selling times (Nastasijević et al., 2017).

Resting of animals, for minimum 24 hours, before slaughtering is recommended, but the study surprisingly disclosed that all (35 of 35) surveyed slaughterhouses deliberately performed slaughtering without resting their animals. Resting allows muscle glycogen to be replaced, depleted during transportation, which has a connection to production and deposit of lactic acid in high concentration in the meat that eventually prevent spoilage of meat by restricting the growth of bacteria contaminating carcass while slaughtering and processing (Heinz and Srisuvan, 2001). Policies and regulations regarding the separation of different slaughter animal species and isolation of sick animals from healthy animals were absent at all (35 of 35) of the surveyed slaughterhouses. So, the risks of cross infection are very high among different slaughter species kept together, if they are diseased. Besides, it is imperative to detect diseased animals and to take initiatives to isolate and treat them, which help to reduce the burden of pathogens in the body of affected animals to lessen the amount of contamination of meat as well as to

prevent the chance of infection to healthy animals (Forde, 2015).

The present study also revealed that 25 out of 35 slaughterhouses do not maintain proper documentation of slaughtering animals, and 34 out of 35 were poor in veterinary inputs. Moreover, we noticed that there were no policies and practices of ante-mortem examinations, monitoring of slaughterhouse operations, and post-mortem examinations at any slaughterhouses (35 of 35), which are completely violation of recommended rules and regulations, but those policies are very crucial for determination of hygienic practices, detection of contaminated carcass, and identification of meat borne diseases (CAC, 2003; Komba et al., 2012). Due to the lack of those policies, it might happen that diseased animals or animals having pre-clinical or sub-clinical diseases are being slaughtered, which acts as a cause of carcass contamination and zoonosis (Brown et al., 2011).

The current study showed that at all slaughterhouses (35 of 35), the workers' level of education is very poor, even they lack fundamental training concerning hygiene, facilities, and policies recommended for running a slaughterhouse. Therefore, it is too tough to make them understand the importance of regular practices of those vital staff and their implications in the context of public health, occupational hazards, and environmental pollution. Thus, the lack of knowledge and training on those topics may finally deteriorate the raw meat quality by increasing microbial load in the carcass (Wamalwa et al., 2012; Alhaji and Baiwa, 2015). This study also revealed no policy of monitoring the health status of slaughterhouse workers at regular intervals, which is a significant threat because they might transmit infectious agents, if they are diseased or reservoirs, to meat and co-workers. The maintenance of all-in all-out policy was satisfactory at surveyed slaughterhouses (34 of 35), but we found no policy regarding carcass condemnation and its compensation package at any of them. So, there is a high chance of contracting zoonotic diseases through the purchase and consumption of contaminated meat from infected carcass or part, which is supposed to meet condemnation criteria (Qekwana et al., 2017).

5. CONCLUSIONS

From the findings of this study, we conclude that slaughterhouses under Sylhet Sadar Upazila are too poor in maintaining standard hygiene, adequate facilities, and in compliance of recommended policies. We found many laps and gaps responsible for different magnitudes of carcass contamination and environmental pollution, imposing severe public health issues. Slaughterhouse workers and other peoples associated with the slaughterhouse operations are also at high risk of zoonotic diseases, which even might transmit to their families, friends, and local communities. We advise that the concerning authority should only provide a license if the hygiene, facilities, and policies of a slaughterhouse are in accordance with recommended acts, rules, and regulations. The authority should abolish the license and enforce punishment if any violation and deviation observed in any slaughterhouse.

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