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32 expansion (Alam et al., 2024a), and the same trend followed in Bangladesh In Bangladesh, beef
33 and dairy livestock are predominant and are increasingly shifting towards market-oriented
34 production system (BBS, 2023). The maintenance of beef cattle is considered a source of wealth
35 creation and a means of absorbing economic crises. Bangladesh ranks 25th in global beef
36 production and has achieved self-sufficiency in beef production (FAO-UNIDO 2019). The
37 subsector shares 50% of the rural economy and 20% of employment in Bangladesh's national
38 economy (BBS, 2023). Bangladesh has a considerable agri-food sector involved in the production
39 of animal-origin foods. The sector has grown significantly since independence, transitioning from
40 a vulnerable food supply to near self-sufficiency. Historically, the primary focus was on increasing
41 domestic food production, with food safety being a lower priority. However, in today's global
42 context, food safety has gained importance. Entrepreneurs in Bangladesh seeking to develop
43 export markets face challenges in complying with these markets' stringent food safety standards.

44 The industrialization of animal production is taking place in a much more rapid way where food
45 safety regulation and assurance Systems need to be a crucial factor. Food safety assurance systems
46 are structured protocols and practices designed to ensure that foods are safe for consumption.
47 These systems encompass various procedures, standards, and regulations to prevent contamination,
48 reduce foodborne illnesses, and guarantee the integrity of the food supply chain from production
49 to consumption. In Bangladesh, ensuring the safety of animal-origin foods presents significant
50 challenges due to the high risk of contamination, improper storage and handling, and inadequate
51 regulatory oversight. Addressing these issues is crucial for Bangladesh to achieve the United
52 Nations Sustainable Development Goals (SDGs), which target various challenges in the BVC,
53 including SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 12 (Responsible
54 Consumption and Production), SDG 15 (Life on Land), and SDG 17 (Partnerships for the Goals).

55 Therefore, it is imperative to mitigate food contamination and promote safe, environmentally
56 friendly production processes throughout the beef value chain.

57 The share of the South Asian countries of world's meat production is only 5.4% despite rearing a
58 large herd of animals while the share of Bangladesh is insignificant (Gurung et al., 2017). Most of
59 the ruminants and a considerable percentage of free-range poultry are kept near human habitation,
60 leading to a strong risk of transmission of zoonotic diseases between animals and humans. Formal
61 slaughtering of animals and meat processing is very limited in Bangladesh and occurs infrequently
62 (Gallo et al., 2024). Accordingly, the national meat inspection system is almost non-existent, and
63 most practices in the different stages of the meat value chain are traditional, with safety and
64 hygiene issues rarely addressed.

65 The Constitution of Bangladesh acknowledges the importance of food safety in Article 18 (1),
66 stating that raising the level of nutrition and improving public health is a primary duty of the state
67 ([Food Safety Act, 2013](#)). The Department of Livestock Services (DLS) is primarily responsible
68 for assuring safety and hygienic issues to the competent authority. Although there is no specific
69 regulatory act for assuring food safety for foods of animal origin, several acts and rules exist, such
70 as the Animal Disease Act (2005), the Animal Slaughter and Quality Control of Meat Act (2011),
71 the Bangladesh Animal and Animal Products Quarantine Act (2005), the Fish Feed and Animal
72 Feed Act (2011), and the Animal Welfare Act (2019) (Rahman,2023). The enforcement of these
73 acts could improve food safety compliance considerably. However, enforcement and compliance
74 with food safety legislative acts are low, and adherence to safe food production based on the
75 application of precautionary measures along the food value chain could eliminate most foodborne
76 diseases and protect human health. Food safety remains a lower priority in Bangladesh, particularly
77 for foods of animal origin. Due to the hot and humid climate and heat stressors (Alam et al., 2024b),

78 the use of antibiotics in beef farming became inevitable in Bangladesh. So, it is essential to
79 implement cutting-edge analytical methods (Alam et al., 2024c; Hashem et al., 2022) in the beef
80 industry of Bangladesh to ensure there are no antibiotic residues and harmful impurities present in
81 the meat before reaching consumers. However, Bangladesh has regulations regarding the use of
82 antibiotics in livestock, which include the requirement for a withdrawal period to ensure that
83 antibiotic residues are not present in meat, milk, or other animal products that enter the food chain.
84 However, limitations exist in terms of enforcement, farmer awareness, and monitoring, leading to
85 inconsistent adherence to these regulations. Special care is needed because improper use of
86 antibiotics can result in antibiotic residues in animal products, posing a significant risk to consumer
87 health and contributing to the global issue of antimicrobial resistance.

88 To address these issues effectively, it is crucial to identify gaps in food safety practices and develop
89 a nationwide value chain-based food safety system. This study aims to understand existing
90 practices and the current understanding of different beef value chain actors, and to develop
91 guidelines to help these actors comply with good standards of practice in the future. By focusing
92 on these objectives, the study seeks to enhance food safety in the beef value chain in Bangladesh,
93 ensuring safer consumption and alignment with global food safety standards.

94 **Materials and Methods**

95 The study was conducted in three distinct phases, each comprising several specific activities and
96 steps to achieve the research objectives.

97 **Phase I: Initial Work Plan and Preparation of Data Collection Tools**

98 The overall study was categorized into three phases. The study methodology has been illustrated
99 in Figure 1 for better understanding. In the initial phase, an extensive review of various secondary

100 sources, including government censuses, online searches, project reports, research articles,
101 relevant Acts and Rules, and international standards such as the World Organization of Animal
102 Health (WOAH), Codex Alimentarius Commission (CAC), Hazard Analysis and Critical Control
103 Points (HACCP), and Good Animal Husbandry Practices (GAHP), was undertaken. Additionally,
104 newspapers and magazines were also reviewed. Consulting meetings with subject matter experts
105 from competent authority and private sector were organized to map the beef meat supply chain.
106 Based on this mapping, checklists were prepared for different segments of the beef value chain,
107 including beef fattening farmers, butcher shops, transporters, and traders/sellers, these checklists
108 aimed to assess the existing understanding of current food safety practices. Expert opinions were
109 solicited to refine the checklists, which were then field-validated. Following expert feedback, the
110 checklists were incorporated into the mobile-based application ODK/Kobo Toolbox. The selected
111 sub-districts were chosen based on their high potential for beef farming practices, providing a
112 representative sample across key farming regions to effectively gather comprehensive food safety
113 data. In each subdistrict, 5 respondents for each actors were randomly selected, in this way 20
114 respondents for four actors were considered and finally from the 16 subdistricts, 320 respondents
115 were interview for the study.

116 **Phase II: Data Collection and Management**

117 In the second phase, 12 enumerators were deployed to collect data. A one-day debriefing session
118 was organized to orient them to the study's aims and objectives and to discuss the data collection
119 methodology using the Kobo Toolbox mobile application. After the debriefing, a four-day field
120 test was conducted to validate the actor-specific Kobo Toolbox checklists/questionnaires.
121 Feedback from this field test was harmonized through a Zoom meeting, followed by 15 days for

122 final data collection. Data collection activities were centrally monitored, and upon completion, the
123 collected data was downloaded from the Kobo Toolbox as Excel files for further analysis.

124 **Phase III: Report Preparation**

125 In the final phase, the downloaded Excel files were verified and analysed in terms of numbers and
126 percentages. Field observations were conducted to cross-check the collected food safety
127 information. To validate the findings on food safety practices across different beef value chains, a
128 stakeholders' meeting/workshop was organized. This workshop included expert panel discussions
129 to harmonize the information. Experts reviewed the collected data and resolved any discrepancies
130 through team discussions to generate accurate information. Additionally, field visits were
131 conducted to identify different actors in the beef value chain, observe their food safety practices,
132 and understand their communication of food safety information. Primary data was collected
133 through questionnaires and Focus Group Discussions (FGDs), focusing on various aspects such as
134 backward and forward linkages of the value chain, animal sourcing and identification, traceability,
135 disease control, biosecurity practices, hygiene, zoonoses control, environmental control, and
136 maintenance of the cool chain for meat products. The findings from the field visits and identified
137 food safety gaps were presented in a day-long workshop on the "Meat Value Chain," organized
138 into five groups with the aims of determining food safety gaps, mapping the meat value chain, and
139 identifying resources/support needed to mitigate food safety hazards. All observations and findings
140 were incorporated into the draft report, which was subsequently finalized.

141 **Result and Discussion**

142 **Existing Beef chain Value Chain**

143

144 The majority of animal-origin food (AoF) is produced by smallholder farmers and traded in formal
145 and informal value chains; production and trade of AoF constitute an important source of
146 livelihood in developing countries (Zavala Nacul and Revoredo-Giha, 2022). In Bangladesh, the
147 beef value chain comprises both mixed (dairy and beef) and specialized beef farmers. Mixed
148 farmers obtain some of their animals from their farms and purchase additional cattle from the
149 market. In contrast, specialized beef farmers acquire all their animals from the market. These
150 farmers sell their cattle to various buyers, including cattle traders, slaughterers, and directly to
151 consumers during festivals such as Eid ul-Fitr, Eid ul-Azha, and Shab-e-Barat.

152 A typical beef marketing channel in Bangladesh involves several key participants: primary
153 producers (farmers), cattle traders (both local and larger scale, known as Bepari), wholesale
154 butchers, retail butchers, and consumers (Figure 2).

155 Traders procure animals directly from farms or cattle markets and thereafter sell them to
156 slaughterhouses, roadside meat vendors, other traders, animal farmers, food chain stores, or
157 directly to consumers during festivals or family events. Roadside meat vendors typically obtain
158 their animals from traders in the cattle market. They slaughter the animals either on the roadside
159 next to their shops or at nearby slaughter facilities, supplying meat primarily to common people
160 and hotels.

162 The meat supply chain in Bangladesh suffers from weak regulatory provisions, necessitating
163 compliance with standard procedures aligned with the CAC, WOA, and HACCP standards for
164 the entire supply chain and slaughterhouses. Bengal Meat Processing Industries stands out as a
165 fully compliant slaughterhouse in Bangladesh. They engage farmers to supply safe and quality
166 cattle by their specifications and requirements. Their facility features a well-organized lairage, a

167 top-notch slaughter and processing facility, effective effluent and waste disposal systems, skilled
168 manpower, and a comprehensive traceability system. Bengal Meat procures animals from contract
169 farmers as well as the open market and sells their products to retail chains, grocery shops, and
170 directly to consumers through its outlets. In contrast, slaughterhouses such as Sadeek Agro have
171 less adherence to compliance standards and slaughter animals from their farms, primarily catering
172 to the hotels.

173 Local government organizations, mandated by the Local Government (City Corporation Act 2009)
174 and the Local Government (Municipality Act 2009), are responsible for establishing
175 slaughterhouses. Efforts to establish slaughterhouses in Dhaka, such as in Hazaribag and
176 Mahakhali, have been unsuccessful because of insufficient food safety protocols. In conjunction
177 with local government organizations, the DLS is accountable for meat inspection, ensuring the
178 establishment and enforcement of standard slaughter procedures. During religious festivals,
179 particularly Eid-ul-Azha, a significant number of cattle, buffalo, and goats are slaughtered, with
180 an estimated 50 percent of the annual cattle slaughter occurring during this festival. Most animals
181 are slaughtered in home yards, posing considerable food safety issues.

182 Traditionally, butchers in Bangladesh sell fresh meat by slaughtering animals on-site, aiming to
183 sell the entire meat stock within the day. Occasionally, unsold meat portions (about 10%) are sold
184 at discounted rates (6-10% off) to contracted restaurants or temporarily stored in domestic
185 refrigerators for sale the following day. This practice helps butchers recoup some value from
186 unsold meat, although the quality, including physical and microbiological conditions, is not
187 considered.

188 While the traditional model has supported the meat industry in Bangladesh, modern cold chain
189 technology offers the potential to preserve meat quality during the selling period, reduce waste,

190 extend shelf life, and improve efficiency by maintaining a temperature of 4-5 degrees Celsius to
191 inhibit bacterial growth and spoilage Based on field visits, Key Informant Interviews (KII), and
192 consultations with different stakeholders in the Meat Value Chain, a comprehensive business
193 model is proposed to address these issues (Figure 3).

194

195 **Food Safety Regulation in the Beef Value Chain of Bangladesh**

196 . Bangladesh encounters substantial challenges in adhering to global food safety and sanitary
197 regulations, particularly those mandated by major importers such as the European Union (EU), the
198 Middle East, and the United States. Adhering to these stringent regulations is essential for
199 accessing these lucrative markets. Hence, it is imperative Therefore, Bangladesh must develop
200 adequate infrastructure for beef farming, slaughtering, processing, storing, and transporting meat
201 products while adhering to international standards.

202 Kok et al. (2021) found that a significant majority of agricultural producers and other actors in the
203 beef supply chain, ranging from 78-95%, were not familiar with the regulations in the beef sector.
204 This lack of familiarity, coupled with adversarial relationships between regulators and value chain
205 actors, results in unnecessary transaction costs and missed opportunities for improving livelihoods,
206 food safety, and food security, as highlighted by Blackmore et al. (2022).

207 Bashar AI (2017) observed that the legal framework of food safety in Bangladesh is currently
208 governed by at least 16 laws, which include The Food Safety Act, 2013; Penal Code, 1860; Voktan
209 Odhikar Songrokkhon Ain, 2009; Bangladesh Standards and Testing Institution Ordinance, 1985;
210 and the Special Powers Act, 1974, among others. According to Section 13 (1) of the Food Safety
211 Act, the Bangladesh Food Safety Authority (BFSA) is responsible for regulating and monitoring
212 activities related to the manufacture, import, processing, storage, distribution, and sale of food

213 through appropriate scientific methods. However, the safety of food of animal origin at the farm
214 level is not addressed in the Food Safety Act of 2013.

215 Meats are highly nutritious and crucial for both the physical and intellectual development of
216 humans. However, they can become dangerous if they are unhealthy, potentially spreading serious
217 diseases. Therefore, Bangladesh needs to lead in creating a safer meat brand for domestic
218 consumption as well as for export. After the Modi government came to power in India in 2014,
219 the flow of Indian cattle into Bangladesh stopped, which led to a boom in beef production within
220 Bangladesh. Now, Bangladesh is not only self-sufficient in cattle but has also started exporting
221 beef. Halal meat export is a high priority in the government's import policy for 2021-2024. A
222 circular issued by the Foreign Exchange Policy Department of Bangladesh Bank provides cash
223 assistance at the rate of 20 percent to encourage the export of halal meat to the global market,
224 effective from June 30, 2022, throughout the financial year. The Ministry of Commerce (MoC)
225 has promulgated a series of Import Policy Orders, the most recent of which is the Import Policy
226 Order (2021-2024).

227 Several companies in Bangladesh process meat and export it abroad, including processed meat,
228 commutated meat, mince, nuggets, balls, rolls, smoked, and salted meat. These products are mainly
229 exported to various Middle Eastern countries, Malaysia, Hong Kong, and the Maldives, where
230 demand is increasing. The government has decided to provide incentives to encourage the export
231 of these products. The Fisheries and Livestock Minister stated that meat production in the country
232 has now reached an unprecedented level and that the livestock sector will be one of the largest
233 foreign exchange-earning sectors of the country (The Daily Prothom-Alo, 30 June 2020).

234 However, Bangladesh lacks a government-to-government (G2G) agreement with foreign countries
235 for exporting frozen meat and does not have a certificate from the World Organization for Animal

236 Health (OIE), whose approval is mandatory for meat export (The Bangladesh Post, 7 September
237 2020). To address this, the government of Bangladesh needs clear guidelines to export meat while
238 maintaining international standards.

239 The Bangladesh Standard Testing Institute (BSTI) is the sole regulatory body overseeing the
240 quality of animal-originated food products, while local government institutions such as city
241 corporations and municipalities conduct antemortem and post-mortem examinations of animals.
242 However, inadequate regulatory functions and evaluations by sanitary inspectors from the health
243 department pose significant problems in ensuring quality standards and protecting consumer
244 interests (Gazi et al., 2019).

245 Farmers, market operators, and live animal transporters in Bangladesh are subject to the
246 requirements of the Animal Disease Act 2005, Animal Welfare Act 2019, Animal Slaughter and
247 Meat Quality Control Rules 2021, Paurashava Act 2009 (local government ordinance), Local
248 Government (City Corporation) Act 2009, and Bangladesh Environment Conservation Act 1995.
249 These regulations cover responses to contagious diseases, prevention of cruelty on farms, animal
250 waste management, and basic requirements for farms and markets. However, most of these
251 regulations do not apply to the transporters of live animals, creating legislative and standard gaps
252 in the meat chain.

253 Local government organizations are responsible for establishing slaughterhouses by law [Local
254 Government (City Corporation Act 2009), Local Government (Municipality Act 2009), and Local
255 Government (Union Parishad Act 2009)]. The Department of Livestock Services (DLS) is solely
256 responsible for meat inspection. The execution of the Animal Slaughter and Meat Quality Control
257 Act 2011 and the Animal Slaughter and Meat Quality Control Rules 2021 should ensure dual
258 responsibilities between the DLS and local government bodies.

259 The regulatory framework for ensuring the safety of food of animal origin in Bangladesh is
260 currently hampered by fragmented oversight and insufficiently defined roles among the various
261 involved ministries, as highlighted by Rahman (2023). The use of multiple laws for a single
262 purpose often leads to confusion among stakeholders, including enforcement authorities, which
263 can fail to identify the relevant law for a particular issue. This lack of clear delineation creates gaps
264 and overlaps in food safety management, leading to inefficiencies and potential risks in the
265 livestock value chain.

266 Addressing these issues necessitates a holistic and coordinated approach. Rahman (2023)
267 advocates for forming an inter-ministerial coordination committee, bringing together a
268 multidisciplinary team of experts under the leadership of the DLS. Such a committee could
269 facilitate streamlined communication and decision-making, reduce regulatory redundancies, and
270 ensure that food safety measures are uniformly applied across the entire livestock value chain. By
271 leveraging the expertise and resources of multiple ministries and stakeholders, this approach could
272 significantly enhance the robustness of food safety controls, thereby protecting public health and
273 boosting consumer confidence in animal-origin food products.

274 **Food Safety Practices in the Beef Value Chain**

275 The study investigated food safety protocols throughout the entire meat production process,
276 incorporating many parties with an interest in the industry. Out of the practices that were examined,
277 17% were resolved by engaging in expert panel discussions, while the rest of the practices agreed
278 with the conclusions reached during the expert conversations. The findings identified significant
279 areas of concern and adherence within the value chain.

280 **Beef Farms Registration and Housing Conditions**

281 Registration of beef farms with the Department of Livestock Services (DLS) has commenced but
282 requires greater urgency. Notably, 80% of beef farms had separated dedicated houses with sufficient
283 space (70%) for the animals however, 30% of animals were not housed according to the code of
284 animal welfare. Adequate ventilation was found in 90% of the sheds, with most floors constructed
285 from RCC and brick. Despite these conditions, none of the farmers fully maintained standard
286 biosecurity measures such as foot baths, gates, and fencing to prevent disease entry. Reducing
287 animal welfare and overcrowding, either by providing inadequate space allowance or forming huge
288 group sizes, increases the risk of disease within animal populations. This can subsequently lead to
289 poor food quality as indicated by Losinger and Heinrichs (1997). For example, research has
290 demonstrated that housing dairy calves in large groups resulted in higher mortality rates and an
291 increased incidence of respiratory disease (Losinger and Heinrichs 1997).

292 **Feeding management and traceability**

293 Islam et al. (2012) reported that 78% of respondents among the interviewed farmers used feed
294 additives for cattle fattening purposes, and 58% of respondents used anabolic steroids during a 3
295 to 6-month-long cattle farming program. In the present study, 13% of farmers used feed additives
296 in the compound feed, but 97% of farmers did not test their prepared feed in any laboratory to
297 identify any chemical/pesticide/other contaminants. Additionally, based on the present study, 38%
298 of farmers believed the feed package was properly labeled for selling feed mix, considering the
299 common name of the feed ingredient, chemical composition, the name and address of the company
300 who manufactured it, production date, expiry date, and a lot code or another unique identifier to
301 trace the feed. However, 51% thought it was not at all properly labeled, and 9% did not see any
302 issues with it. Felmer *et al.* (2006) emphasize the global importance of animal identification and

303 traceability technologies, including electronic ear tags and retinal scanning, for ensuring food
304 safety, while Yeping *et al.* (2014) highlight the necessity of incorporating premises numbers and
305 animal identification numbers to comprehensively track feed, livestock, and animal products, our
306 study found that Bangladesh is still far behind in implementing comprehensive traceability systems,
307 with only some progress noted in the manufacturing of meat products and insufficient traceability
308 in animal feed.

309 **Biosecurity and Health Management**

310 The findings reveal several critical lapses in farm management practices that pose significant food
311 safety risks in animal-derived foods. Most farmers (80%) isolated sick animals on the farm, but all
312 farms provided deep tube well water while maintaining inadequate record-keeping practices.
313 Specifically, the records covered animal numbers (31%), vaccination schedules (30%), drug use
314 (16%), feed origins (11%), health regimes (8%), feeding changes (3%), and disinfectant use (1%)
315 (Figure 4A). Moreover, only 40% of farmers were advised against selling animals during and after
316 medical treatments, and 50% lacked proper storage for medicines and vaccines. Disposal practices
317 for syringes and residual medicines were poor, often involving pits, drains, or ponds. Additionally,
318 the quarantine period for introducing new animals to the herd was not adequately practiced.

319 Sayers *et al.* (2013) and Renault *et al.* (2018) emphasize the potential for disease, including
320 zoonotic diseases, to spread between herds when proper biosecurity measures are not followed.
321 This risk is further intensified by the absence of a pest control program and insufficient utilization
322 of disinfectants, which was noted in only 50% of farmers who employed them on a weekly basis.
323 Alelign *et al.* (2019) and Solomon *et al.* (2019) argue that it is crucial to educate farmers about the
324 dangers of introducing new animals to their herds without following a quarantine period or

325 allowing new animals to graze alongside existing herds in shared pastures, as this can lead to the
326 transmission of livestock diseases.

327 **Meat Shops and Butcheries**

328 Meat shops and butcheries, although holding commercial trade licenses from Pauroshova/Union
329 Parishad, were unregistered. Sanitary Inspectors from the Upazila Health Office occasionally
330 visited these establishments. Only 33% of butchery shops had permanent stalls with walls, while
331 66% operated without walls. All shops had electricity, but only 63% had refrigeration units. Sixty
332 percent lacked locked facilities, and none had piped water, although all had access to potable water.
333 Drainage facilities were inadequate in 53% of shops. Regular health check-ups for slaughterhouse
334 workers were rare, with only 7% reporting such practices. Furthermore, only 47% of butcheries-
335 maintained cleanliness to prevent meat spoilage due to dirt, dust, and flies. That discussion also
336 aligns with the findings of Kok et al. (2021), who stated that food safety is not well taken care of
337 and that current slaughtering practices raise food safety concerns since mainstream slaughtering is
338 carried out without supervision or inspection. According to Legese et al. (2014), urgent
339 improvements are necessary in slaughterhouse practices, including training workers on humane
340 stunning techniques and meeting international standards.

341 **Transportation and Slaughtering Practices**

342 The Animal Slaughter and Meat Quality Control Rules 2021 mandate washing vehicles used for
343 transporting animals. The study found that 40% of vehicles were washed with clean water and
344 disinfectant before and after transporting live animals. During the study, 32% of farmers were
345 advised not to sell animals or produce (milk/meat) during and after treatment with certain
346 medicines.

347 The above graph (Figure 4B) demonstrates the execution level of the Animal Slaughter and Meat
348 Quality Control Rules 2021 in the case of washing vehicles using the transportation of animals. It
349 was seen that forty percent of vehicles were washed with clean water and disinfectant before and
350 after carrying live animals. During the study period under selected areas, a total of 40% of farmers
351 responded that they got advice NOT to sell an animal or meat/milk produced during and after
352 treatment with certain medicines (Figure 4C).

353 **Compliance with Disease Prevalence Records**

354 In Bangladesh, zoonosis diseases such as Foot and Mouth Disease (FMD), Hemorrhagic
355 Septicemia (HS), Anthrax, Brucellosis, Tuberculosis, Black Quarter (BQ), and Fascioliasis are not
356 only fatal for animals but also transmissible to humans (Gazi et.al., 2019). According to the Animal
357 Slaughter and Meat Quality Control Act 2011 and the Animal Slaughter and Meat Quality Control
358 Rules 2021, it is essential to know the disease prevalence record for 30 days prior in the farm area.
359 However, the study revealed that 85% of live bird shops never complied with this requirement,
360 and compliance was non-existent for cattle slaughtering. This non-compliance raises significant
361 food safety concerns, as highlighted by Kok et al. (2021), who found that slaughtering practices
362 often lack adequate supervision or inspection supported to the present study Figure 4D explains,
363 the information based on this act and rules, need to know the disease prevalence record for 30 days
364 (thirty) before in the farm area; cattle brought for slaughter. Are any health records available from
365 the source of animals/birds being presented for slaughter?

366 **Animal Welfare Compliance**

367 De Passillé and Rushen (2005) propose that enhancing animal welfare potentially mitigate on-farm
368 food safety hazards by reducing stress-induced immunosuppression, lowering the prevalence of
369 infectious diseases among farm animals, decreasing the shedding of human pathogens, and

370 minimizing antibiotic use and antibiotic resistance. The Animal Welfare Act 2019, referencing
371 standards from the WOAH, mandates humane methods for euthanizing diseased animals. The
372 issue of humane treatment of food animals is very important and should receive increased attention
373 worldwide (Grandin, 2006). Ensuring the humane treatment of animals is crucial and should be
374 adhered to by all involved in animal handling, as stress can have detrimental effects on the food
375 quality and can also heighten the risk of infection (Yepinga, et. al., 2014). The study's findings
376 suggest a gap in compliance with these standards, further underscoring the need for improved
377 practices across the meat value chain. Animal Welfare Act 2019 refers to the standards of the
378 WOAH in identifying the humane ways in which a diseased animal may be put to rest. The findings
379 (Figure 5) indicate that in slaughterhouses, when an animal feels sick, the most common practice
380 is to slaughter the animal (46.67%), followed by isolating and treating the animal (20%), putting
381 the diseased animal to rest (13.33%), and informing a veterinarian (13.33%). A smaller percentage
382 of cases do not inform a veterinarian (6.67%), and none of the cases involve treating the animal
383 without isolation (0%). To improve animal welfare by the Animal Welfare Act 2019 and WOAH
384 standards, it is recommended to prioritize informing a veterinarian and isolating the sick animal
385 for treatment. This approach ensures proper medical care and humane treatment, potentially
386 reducing the need for immediate slaughter.

387 **Compliance actions in the beef value chain**

388 The investigation revealed several deficiencies in food safety measures at every stage of the value
389 chain, encompassing beef farms, beef cattle trade, shipping, slaughtering, and marketing. In the
390 specified categories, the degree of compliance did not meet the acceptable norm.

391 Some good practices were observed, but in general, the compliance level was not satisfactory and
392 most likely due to a lack of, or insufficient training, guidance, follow-up, and monitoring along

393 the chain including beef farmers, beef animal transport and trade, roadside slaughter and meat
394 selling, formal slaughterhouse, and meat shops. Compliance actions required at each level of the
395 value chain are discussed below:

396 **Beef farmer**

397 Beef farmers are required to follow a thorough set of compliance procedures to sustain their farm
398 operations and guarantee the well-being of their animals. Enrollment and compliance with
399 regulatory obligations are essential. Farms should have sufficient personal hygiene and sanitary
400 facilities in place and should enforce stringent hygiene rules for both staff and guests.

401 Farmers are responsible for providing appropriate personal protective equipment (PPE) and
402 enforcing biosecurity measures to prevent disease transmission. Vehicle and equipment hygiene
403 protocols are crucial to control the spread of pests and diseases. Effective pest control measures
404 must be in place to prevent wild and domestic animal access to livestock areas. Biosecurity
405 measures should encompass the animals and their facilities, supported by robust cleaning and
406 disinfection programs. Waste management practices must be hygienic and environmentally
407 friendly, ensuring safe disposal. To safeguard animal health, farmers must maintain detailed
408 records of vaccinations and treatments, ensuring all animals are identifiable through unique
409 identification systems (ear tags, tattoos, microchips or any other kind of identification system).
410 These actions collectively contribute to a healthy and compliant beef farming operation.

411 **Beef animal transport**

412 Compliance with regulations for beef animal transport involves several critical actions to ensure
413 the welfare of the animals and the safety of the meat supply. Licensed vehicles and drivers
414 specifically trained for animal transport must be used to guarantee that they meet all legal and

415 welfare standards. Animals must be in good health and fit for transport, with pre-transport health
416 checks being essential. Methods to reduce the presence of fecal material and prevent the spread
417 of contamination include utilizing floor gratings, crates, or similar equipment, as well as
418 implementing rigorous cleaning and sanitization procedures for the transportation vehicles. It is
419 imperative to refrain from introducing additional risks during transportation, necessitating
420 meticulous preparation to minimize unnecessary strain on the animals. To accomplish this, it is
421 necessary to prevent congestion and ensure that animals have access to food, water, and rest
422 throughout extended journey.

423 Additionally, efficient loading and unloading practices help minimize the risk of injury. Finally,
424 maintaining proper animal identification linked to their place of origin is vital for traceability and
425 managing disease control. Compliance with these actions ensures that beef animal transport is
426 conducted safely, humanely, and by regulatory standards.

427 **Beef animal traders**

428 Beef animal traders are required to follow multiple compliance measures to guarantee the secure
429 and morally upright trade of livestock. Initially, they must get and uphold a legitimate license for
430 animal trade, which guarantees their compliance with regulatory criteria.

431 They are required to implement stringent hygiene practices to minimize soiling and cross-
432 contamination with fecal material, thereby reducing the risk of disease transmission. Accurate
433 identification of each animal's place of origin must be maintained to ensure traceability and
434 accountability. Before buying and selling, a thorough health check is mandatory to confirm the
435 animals are free from diseases. Traders must diligently collect and relay information about any
436 diseases or treatments from the seller to the buyer, ensuring transparency and informed decision-

437 making. Finally, animals that are either diseased or have recently received veterinary drugs should
438 not be transported to markets or abattoirs, preventing the spread of illness and ensuring food safety
439 standards are met. These compliance actions collectively uphold animal welfare, public health,
440 and food safety within the beef trading industry.

441 **Traditional roadside slaughter/meat shop**

442 The compliance actions for traditional roadside slaughter/meat shops based on the provided
443 guidelines involve several key measures to ensure hygiene, safety, and environmental
444 responsibility. Firstly, obtaining licensing from the DLS ensures that slaughter practices are halted
445 and only hygienic meat selling is permitted. This involves complying with the minimal hygiene
446 standards outlined in the licensing requirements and establishing environmentally sustainable
447 waste disposal facilities to handle waste. Regular sanitation of equipment and facilities before and
448 following operations is essential for upholding cleanliness. Furthermore, it is imperative to avoid
449 leaving meat exposed to room temperatures for prolonged periods to prevent contamination.
450 Enforcing a ban on open-air stores decreases the likelihood of dust and contamination. Moreover,
451 training workers on Good Hygienic Practices (GHP), cleaning, disinfection, and proper disposal
452 practices ensures that hygiene standards are upheld throughout operations, promoting food safety
453 and public health.

454 **Slaughtering practices**

455 Adhering to slaughtering methods requires following a complete set of rules and laws to guarantee
456 the safety and cleanliness of meat manufacturing processes. Initially, animals intended for
457 slaughter must adhere to meat hygiene requirements to prevent the inclusion of diseased animals
458 in the food supply. Slaughterhouse operations, facilities, and equipment are required to adhere to
459 hygiene requirements to ensure cleanliness and prevent infection. It is important to build lairages,

460 slaughter areas, and dressing spaces in a way that guarantees the segregation of different
461 procedures. Additionally, these areas should have specific facilities to accommodate animals who
462 are suspected to be ill or injured, to avoid any potential risks to food safety. Sufficient water
463 provision and amenities for maintaining personal cleanliness are crucial. Process control systems,
464 such as Hazard Analysis and Critical Control Points (HACCP), must be established to identify and
465 reduce possible risks at crucial stages. It is essential to have regulatory processes, such as recall
466 procedures and product tracing, in place, along with personnel who are well-trained. It is essential
467 to adhere closely to hygiene regulations during all stages of the slaughter and dressing operations,
468 including post-mortem inspection and subsequent control measures, to preserve the integrity of the
469 product. Adhering to these measures guarantees the creation of beef products that are both safe
470 and hygienic for consumers, while also satisfying regulatory requirements.

471 **Meet shop**

472 Meet Shop appears to be implementing thorough procedures to ensure adherence to food safety
473 and hygiene regulations. Their production site is meticulously maintained to minimize the dangers
474 of contamination, and they offer potable water and sufficient hygiene facilities for cleaning and
475 handwashing. They guarantee that all packaging materials are of food-grade quality to avoid any
476 possibility of contamination. Implemented cleaning and disinfection programs have been
477 established, in addition to pest control methods. They implement suitable food safety protocols
478 during the process of handling, storing, and transporting food, safeguarding it from potential
479 sources of infection. Temperature surveillance is employed to ensure the preservation of food
480 safety, and efficient protocols for recalling products are established in case of necessity. In addition,
481 they possess a product identification system that is interconnected with animal identification
482 systems to ensure traceability. Prioritizing the maintenance of personal hygiene and medical well-

483 being of food handlers is essential, in addition to offering the requisite training for the proper
484 handling of food in a hygienic manner. In general, Meet Shop has a conscientious commitment to
485 following food safety regulations in all facets of their business.

486 **Summary**

487 The results indicate significant gaps in compliance with food safety and animal welfare standards
488 across the meat value chain. While some progress has been made in farm registration and housing
489 conditions, critical areas such as biosecurity measures, record-keeping, and slaughtering practices
490 require urgent attention. Addressing these gaps is essential for enhancing food safety and animal
491 welfare, thereby ensuring the health and safety of consumers and animals alike. Bangladesh has
492 laws and regulations to cover some areas of animal-origin food safety, but the regulatory
493 frameworks and implementation are still weak. The acts need to be revised/updated according to
494 demand that addresses the food safety practices. Stricter regulations and more robust enforcement
495 mechanisms are needed to prevent the sale of adulterated or contaminated animal-origin foods.
496 This includes the need for more rigorous inspections of slaughterhouses and markets. Bangladesh
497 should invest in research and technology to modernize the food supply chain. This includes the
498 development of systems for traceability, cold storage, and efficient transportation to reduce
499 contamination and foodborne illnesses.

500 **Conclusion**

501 In conclusion, addressing the food safety gaps in animal-origin foods in Bangladesh necessitates
502 the implementation of multiple efforts. A comprehensive strategy involving various aspects such
503 as enhanced infrastructure, especially in rural regions, for storage, transportation, and processing
504 facilities is necessary to prevent contamination and spoilage of animal-origin foods. It is crucial to

505 improve monitoring and control of diseases that can be transmitted from animals to humans.
506 Additionally, strict measures must be implemented to prevent the sale of adulterated or
507 contaminated animal-origin foods. Rigorous inspections of slaughterhouses and butcher shops are
508 essential. Encouraging compliance with international standards for Good Animal Husbandry
509 Practices (GAHP) and Good Hygiene Practices (GHP) is also important to reduce the risk of drug
510 residues in meat products. These efforts require the involvement of government initiatives,
511 industry compliance, and public awareness.

512 **Conflicts of Interest**

513 The authors declare that they have no conflicts of interest.

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523 Jahan Ara Monti, Young-Hwa Hwang, and Seon-Tea Joo.

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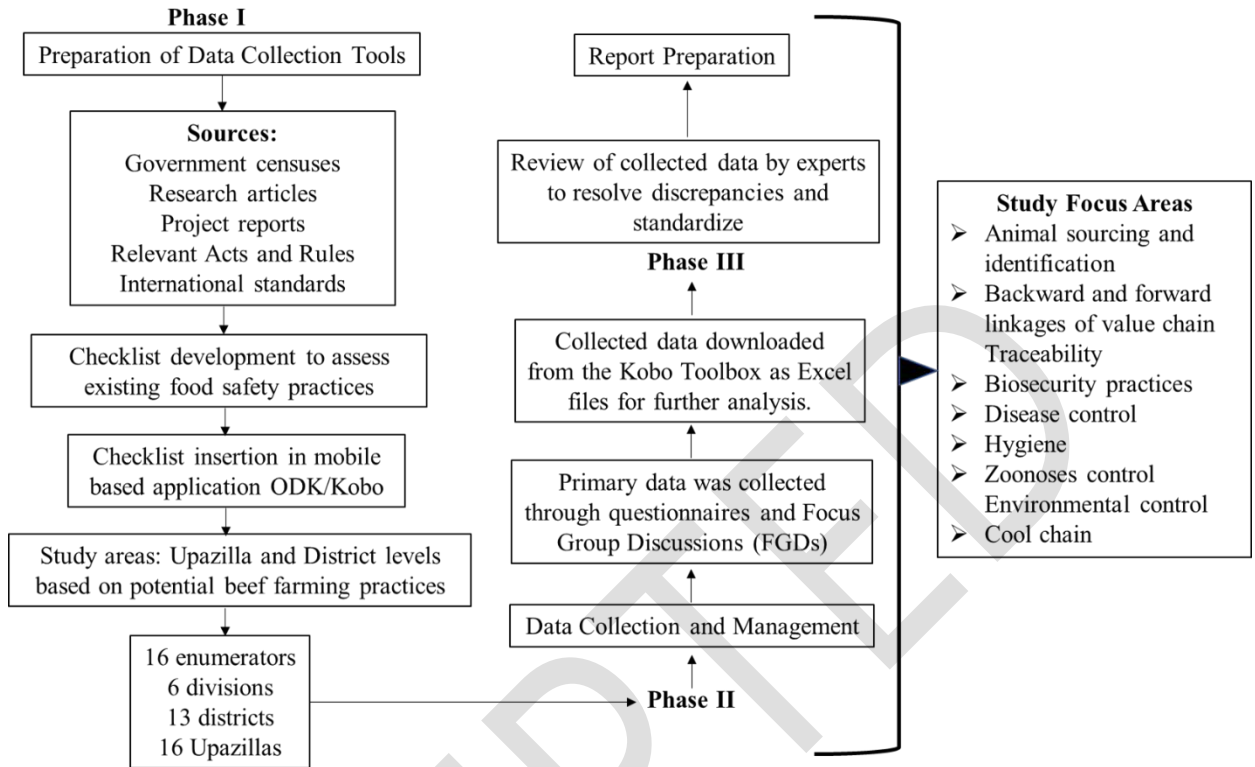
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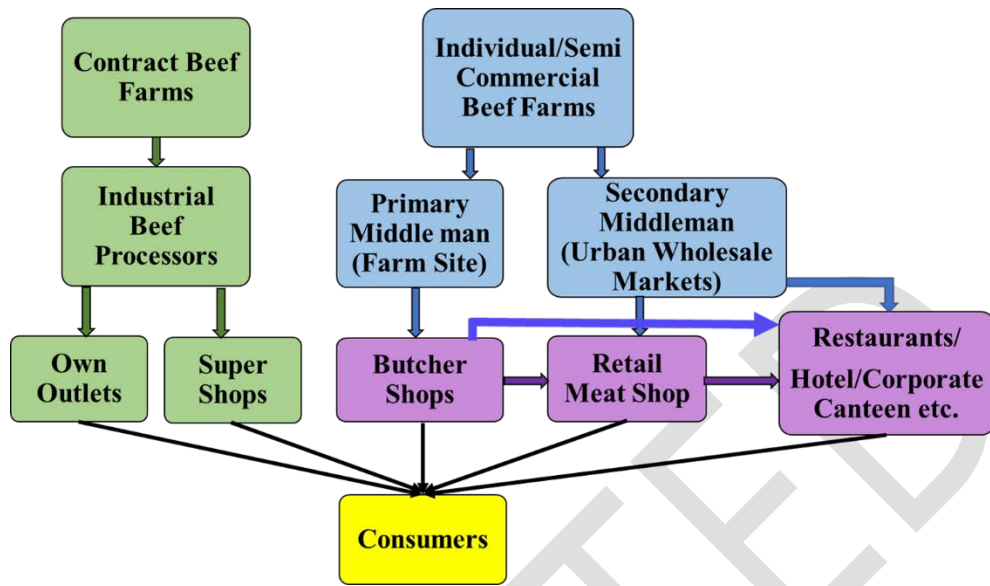
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631 **Figure 1. Study methodology**

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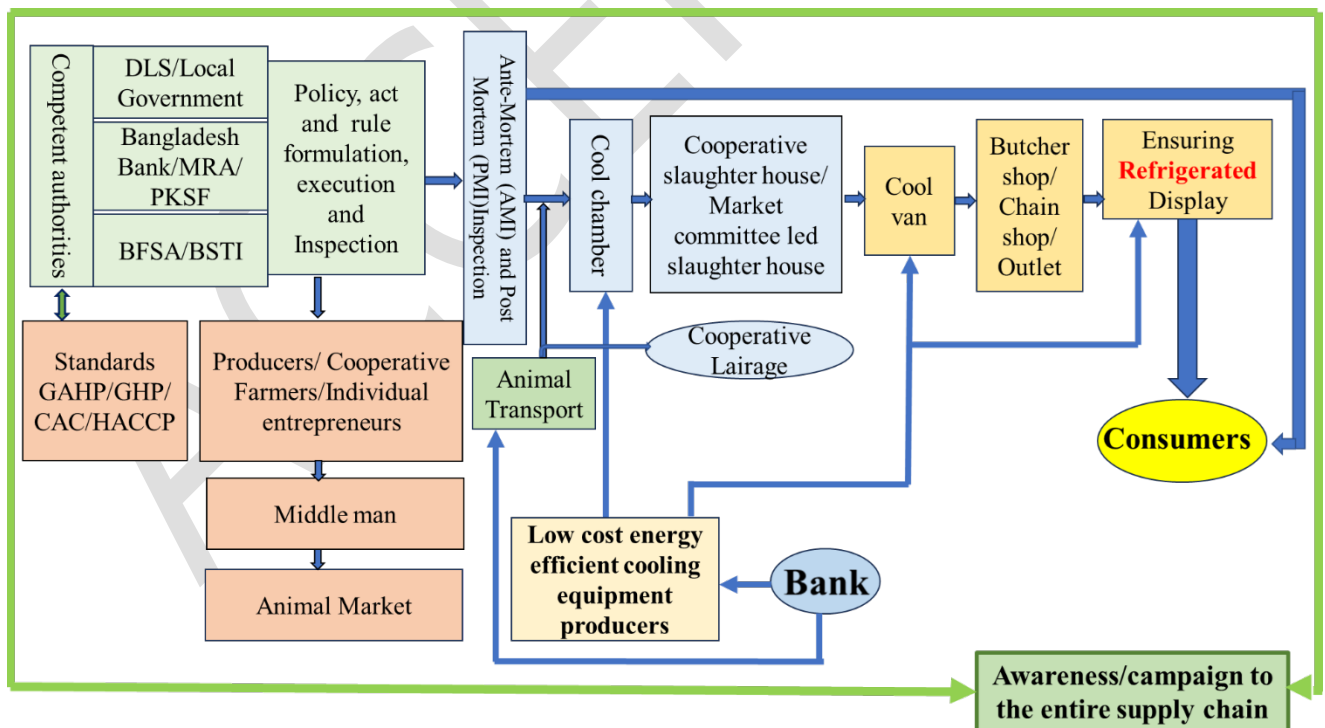
634 **Figure 2: Marketing channel of beef cattle in Bangladesh.**

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637 **Figure 3. Diagram of the proposed business model of the meat supply chain in Bangladesh**
638 **(Field observation 2024)**

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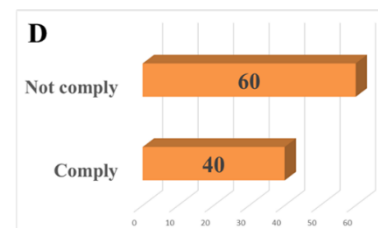
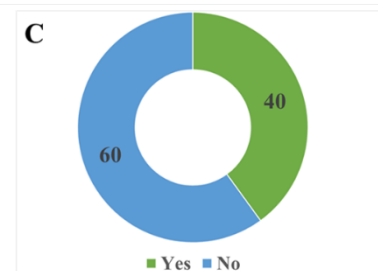
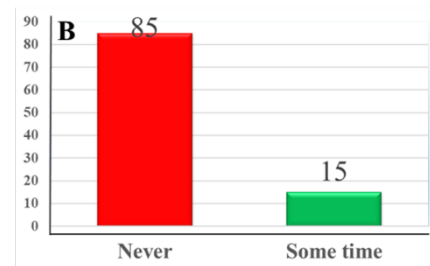
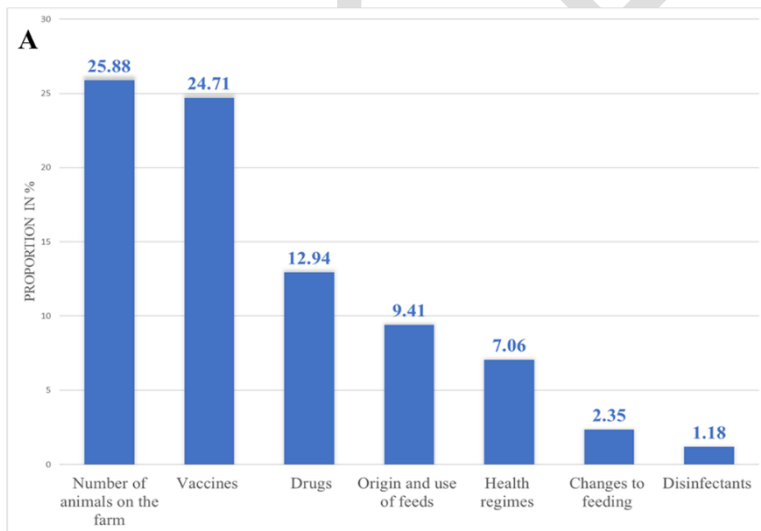
642 **Figure 4. An overview of good farming practices and safety practices in connection to the**
643 **rules and regulations in Bangladesh**

644 **A. Percentage record keeping relating to animal farm practices.**

645 **B. Wash vehicles with clean water and disinfectant before and after carrying live animals**
646 **[Animal Slaughter and meat quality control rules, 2021: 18, 2(1)].**

647 **C. Person advises farmer NOT to sell an animal or milk/eggs produced during and after**
648 **treatment with certain medicines.**

649 **D. Availability of health records from the source of animals before slaughter.**



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652 **Figure 5. Existing practice is when the animal feels sick in the slaughterhouse.**

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