

FOOD SAFETY KNOWLEDGE, ATTITUDES AND PRACTICES OF FISH HANDLERS IN KIRINYAGA COUNTY MARKETS, KENYA

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32 **ABSTRACT**

33

34 Fish and fish products have high nutritional value and are important in
35 supplementing human diet. Fish products have little or no cholesterol and
36 saturated fat, but instead have omega 3 and low-fat content essential for human
37 health. Despite the high nutritional value of fish products, their consumption is
38 hindered significantly by setbacks such as spoilage and foodborne diseases that
39 spread through contamination in the fish supply chain. The objective of this study
40 was to evaluate fish vendors' attitudes, knowledge, and practices on food safety in
41 selected markets in Kirinyaga County that included Sagana, Tebere, Mwea, Ndia,
42 Kianyaga, and Kerugoya markets. A structured questionnaire was administered to
43 54 fish vendors to collect information on fish safety, spoilage, risk factors, personal
44 hygiene, food contamination, type of hazards, foodborne diseases and attitudes
45 towards training on food safety. Statistical Package for Social Sciences (SPSS)
46 version 22.0 was used to analyse the data from the respondents. The relationship
47 between fish vendors' demographic characteristics and risk factors was assessed
48 using Spearman's rank correlation coefficient. The majority of the fish vendors had
49 a positive attitude towards education in hygiene practices (56%). There was a
50 positive correlation between education and fish vendors' awareness of fish
51 foodborne diseases at $p < 0.05$. The study revealed that fish foodborne diseases
52 awareness was positively influenced by respondents' level of experience and age.
53 Moreover, there was also a significant ($p < 0.05$) positive correlation on the
54 awareness of fish foodborne diseases with hygiene and food safety. Majority of the
55 fish handlers had average level of knowledge, attitude and hygiene practices for
56 food safety. These findings presented a foundation for formulating policies to
57 increase food safety and hygiene practices of fish handlers in the region, thereby
58 preventing foodborne diseases and postharvest losses. The results of this study
59 can also form a basis for an indepth research for students and researchers in
60 verious disciplines scuh as public health, marketing, community development and
61 more.

62

63 **Key words:** Fish products, Food Safety, Knowledge and Attitude, Foodborne
64 diseases

65



66 INTRODUCTION

67

68 Fish and fish products have high nutritional value that is essential in the human
69 diet [1,2]. These products are rich sources of minerals such as potassium, calcium,
70 sodium and phosphorus, biomolecules including polyunsaturated fatty acids and
71 protein [3]. Besides, they have relatively low-fat content, cholesterol, omega 3 and
72 saturated fat. These nutritional benefits present better alternatives for consumers
73 facing food insecurity challenges, especially in developing countries. Apart from
74 dietary benefits, fish products are an essential source of revenue, especially for
75 exporting [4]. In Kenya, fish products are a major source of income for fish vendors
76 [5].

77

78 Currently, world fish production is estimated at 53.4 million tonnes accounting for
79 47.7 % of total aquaculture products [6]. Out of these, approximately 46.3 million
80 tonnes are for human consumption [6]. It is also projected that the world's supply of
81 fish for human consumption will decline significantly by the year 2050 due to
82 population growth and the effects of climate change. Kenya has a long fishing
83 history, with approximately 180,000 metric tonnes of annual consumption leading
84 to importation to meet the domestic demand [7]. It is estimated that Kenya per
85 capita annual consumption of fish is at 4.5 kg and is expected to increase in future
86 [7]. Despite the high demand and increased handling of fish products, fish and fish
87 products handling and safety guidelines in Kenyan markets are not adhered to,
88 leading to public health threats [8].

89

90 According to Grace [9], food safety is vital and should be prioritized since fish and
91 fish products are highly prone to rapid contamination. The safety concerns of fish
92 and fish products include: unhygienic handling of the fish and fish products,
93 insufficient refrigeration, substandard processing and poor packaging [10].
94 According to Torell *et al.* [11], the inability to adhere to fish safety measures
95 negatively impacts fish and fish products because of spoilage losses. The losses
96 that result from poor handling of the fish and fish include physical losses, nutritional
97 value loss and economic losses [11]. Moreover, the poor safety measures when
98 handling fish and fish products result in reprocessing large quantities of fish into
99 different types of feeds used by different animals instead of availing them for
100 human consumption [12]. Besides, poor safety measures result in fish-borne
101 illnesses and fish and fish product export restrictions [13]. Fish-borne illness may
102 lead to a financial burden on the healthcare systems and families due to increased
103 hospital admission rates [14]. According to Wanga *et al.* [15], consumption of
104 poorly handled fish and fish products accounts for approximately 30% of the global
105 reported foodborne illnesses.



106

107 Under normal circumstances, the potential risk factors predispose fresh and lightly
108 preserved fish and fish products to microbial activity, enhancing the degradation of
109 fish and fish products' freshness and quality [16]. After harvesting, fish
110 contamination mostly occurs along the fish marketing and supply chain. This is due
111 to increased exposure to poor hygienic conditions [17]. The contamination of fish
112 and fish products by microorganisms is a threat to human health and public health
113 [18]. The microbial contamination in fish can be minimized using diverse strategies.
114 One of the strategies is cooling and freezing the fish immediately after harvesting
115 [19]. Also, fish and fish product preservation methods such as chilling, salting,
116 canning, drying and smoking reduce contamination of the harvested fish by
117 microbial pathogens [20,21]. Similarly, fish and fish product contamination can be
118 reduced by maintaining high personal hygiene when handling these products in
119 fish retail stores and during processing [22]. On the other hand, locally available
120 spices such as garlic can be used to increase the shelf life and enhance the aroma
121 and flavour of the fish and fish products [23]. Furthermore, techniques that
122 increase the shelf-life of the fish and fish products should be considered in the
123 preservation of fish and fish products [24].

124

125 The safety of fish and fish products in Kenyan markets plays a significant role in
126 shaping the harvesting and use of fish. Consequently, fish safety significantly
127 impacts food security and food safety [25]. Understanding the vendors' knowledge,
128 attitudes and practices provides vital insights necessary in formulating new policies
129 that are aimed at ensuring fish safety is adhered to in the fish supply chain. This
130 can be achieved through the generation of adequate information which can be
131 used to model interventions that can guarantee safety of fish and fishery products.
132 Therefore, this paper aimed to evaluate the knowledge, practices and attitudes
133 toward fish and fish products' safety among fish vendors in Kenyan markets.

134

135 MATERIALS AND METHODS

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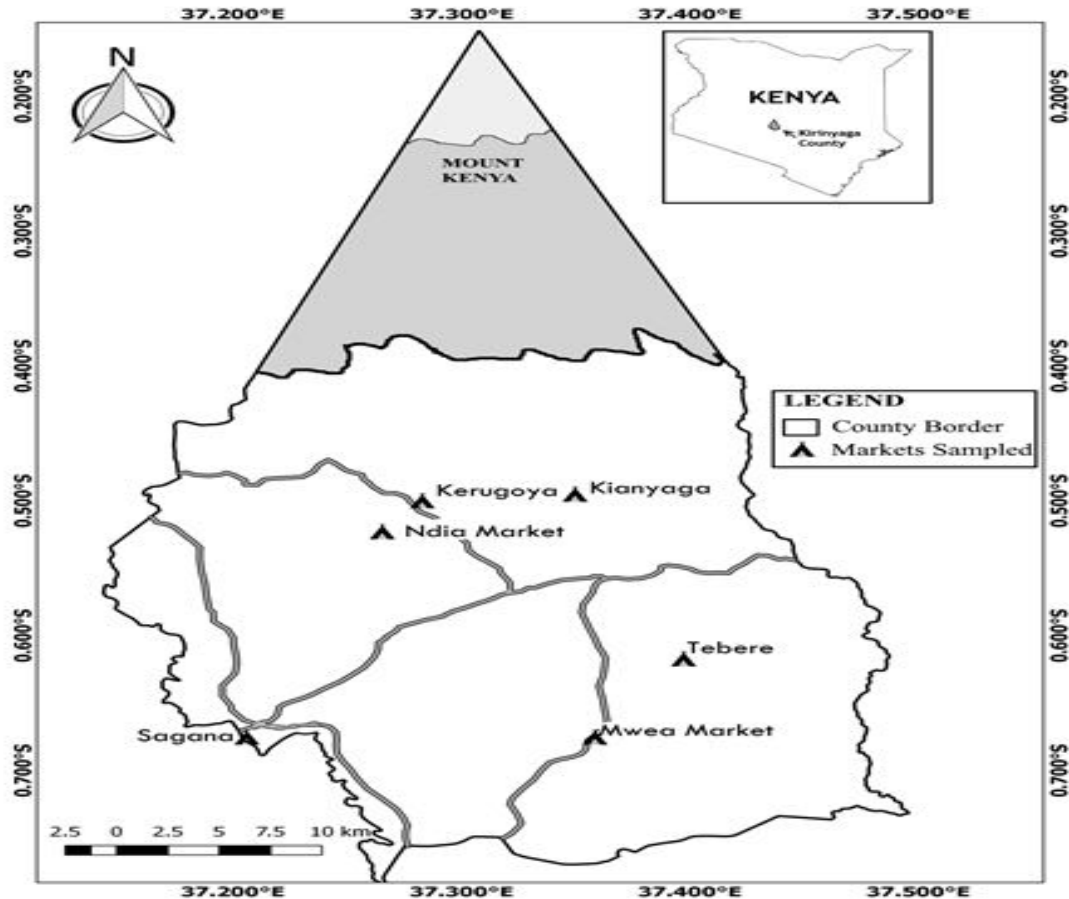
137 Study site

138 The study was carried out in Kirinyaga County (0°34'23.43"S; 37°19'31.7"E),
139 Central Kenya (Figure 1). Kirinyaga County covers an area of 1,478.1 square
140 kilometers with a population of 610,444 persons and an annual growth rate of 1.5%
141 (Kenya National Bureau of Statistics, 2019). The respondents included in this study
142 were from Kerugoya, Ndia, Kianyaga, Mwea, Sagana and Tebere fish markets.
143 Apart from fish farming, the main economic activity in the study area is livestock
144 and crop farming.

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Figure 1: A map of Kirinyaga County where samples were obtained (Source: Google maps)

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Study validation and sampling design

A team of six experts from fisheries and health authority validated the study questionnaire where they proposed to group questions. A pilot study followed to evaluate acceptability, comprehension and answer time of the questions by a group of 21 fish vendors from Nyeri town market. The selected markets were only considered if: they sold fish and a minimum of three associated fish products, sold products directly to consumers, had an established location for vending the products and were consistent with the county operation regulation. The selected markets comprised of Tebere, Mwea, Ndia, Kerugoya, Sagana and Kianyaga. The relationship between microbial contamination of fish products and identified risk factors was established using a descriptive research design. The livelihood and the nature of fish handling in the selected markets within Kirinyaga County were determined using a stratified sampling design. To ensure equal representation,

166 each market was divided into two strata (fish vendors with established premises vs
167 fish vendors with temporary setup) and participants were selected equally from
168 each stratum. Within each stratum, transects were randomly selected and used in
169 the sampling of fish handlers. The acceptability of the questionnaire, determined by
170 the response rate, content validity and reliability was good and answer time ranged
171 between 12 and 20 minutes. Some terms and grammatical modifications were
172 made to improve clarity based on difficulties and suggestions made.

173

174 **Sample size determination**

175 The sample size determination was based on the Snedecor and Cochran [26]
176 formula as follows:

177

$$178 N = 4pq/(L)^2$$

179

180 Where, N is sample size; p, proportion of the target population; L, accepted error (5
181 %); and $q=1-p$.

182

183 According to Kenya Marine and Fisheries Research Institute (KMFRI), Sagana, the
184 number of fish vendors in Kirinyaga County was 5246. There were 173 fish
185 vendors in the selected markets within Kirinyaga County. Therefore, the sample
186 size of this study was 54 respondents.

187

188 **Data collection**

189 Face-to-face interviews were used to administer semi-structured questionnaires to
190 collect the data from the randomly selected fish vendors. The questionnaires were
191 administered within seven days. The interviews focused on fish safety, knowledge
192 of fish foodborne diseases, fish species handled, microbial contamination, types of
193 fish products, food health standards, target consumers and other risk factors
194 associated with fish products.

195

196 **Statistical data analysis**

197 The data gathered from market surveys was coded in excel sheets and analysed
198 using Statistical Package for Social Sciences (SPSS) version 22.0. The normality
199 of the collected data was determined using Shapiro-Wilk's test while Levene test
200 was used to confirm the homogeneity of the variance. The categorical data from
201 the study was presented in proportions (%) along with frequencies (N) while
202 continuous variables were described using means with their standard deviation.
203 The Likert scale was used for knowledge scoring criterion where the scores ranged
204 from 1-5 (5 = Highest score, 4 = satisfactory, 3 = average, 2 = unsatisfactory, 1 =
205 least score). However, a minimum score of 3 or more (>50%) was used to



206 determine the acceptable practical knowledge among the fish vendors and higher
207 scores represented better knowledge. Acceptable practical knowledge was scored
208 as one (1) while lack of practical knowledge was scored as zero (0) for the
209 incorrect answers. The mean knowledge scores of the respondents across various
210 social demographic factors were determined using t-tests and analysis of variance.
211 Spearman's rank correlation coefficient assessed the association of identified risk
212 factors and demographic factors of fish vendors.

213

214 RESULTS AND DISCUSSION

215

216 Demographic conditions of respondents

217 Among the respondents, 66% were male while 34% were female (Table 1). The
218 respondents' level of education varied with 44% having secondary school
219 education training as their highest academic qualification while 22% had attained
220 college and university education. Besides, 72% of the respondents operated self-
221 employed businesses while 16% were in formal employment and had self-
222 employed businesses other than farming while 8% were farmers. The majority of
223 the fish handlers had a monthly income of between Kenyan Shillings 16000 –
224 30000 and experience of working in the fish industry of 5 years and below.

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226 Types of fish and their sources

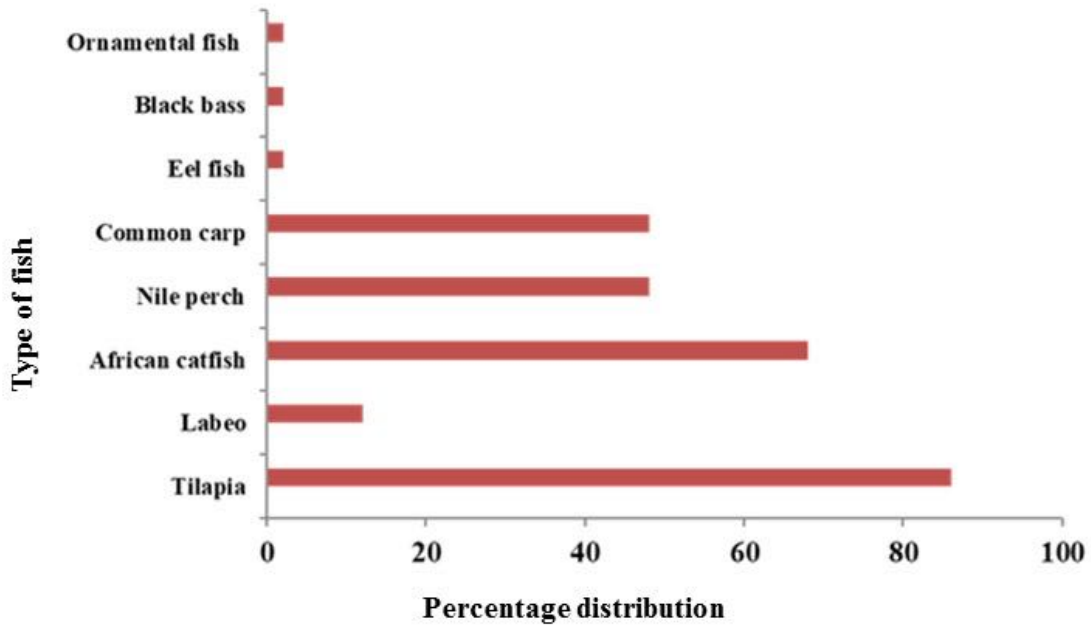
227 In this study, eight different fish species were identified from the fish markets. The
228 distribution of the fish species significantly varied from one market to another
229 (Figure 2). The most dominant and abundant fish species was Tilapia
230 (*Oreochromis niloticus*) and was cited by 86% of the sampled respondents,
231 followed by African catfish (*Clarias gariepinus*) cited by 68% of the respondents.
232 Nile perch (*Lates niloticus*) and Common carp (*Cyprinus carpio*) were equally cited
233 by 48% of the respondents. The least cited fish species were Labeo/Ningu (*Labeo*
234 *victorianus*) cited by 12% of the respondents, while Eel fish (*Anguilliformes*),
235 ornamental fish and Black bass (*Micropterus salmoides*) were also least reported
236 (2%).

237

238 Majority of the Nile perch and tilapia fish species were reported to come from Lake
239 Victoria to Kirinyaga County fish markets. However, a small percentage of the
240 Tilapia fish species were sourced from local rivers and dams and from local fish
241 farmers in the rural areas (Figure 3). Similarly, African catfish, common carp and
242 other fish species were also supplied from Lake Victoria. Riverine from Kirinyaga
243 County was reported to be the source of Labeo fish and some species of African
244 catfish. (Figure 3). Fish fillets were also very abundant (26%) in Kirinyaga fish
245 markets compared with other fish products. However, fish fingers and fish balls

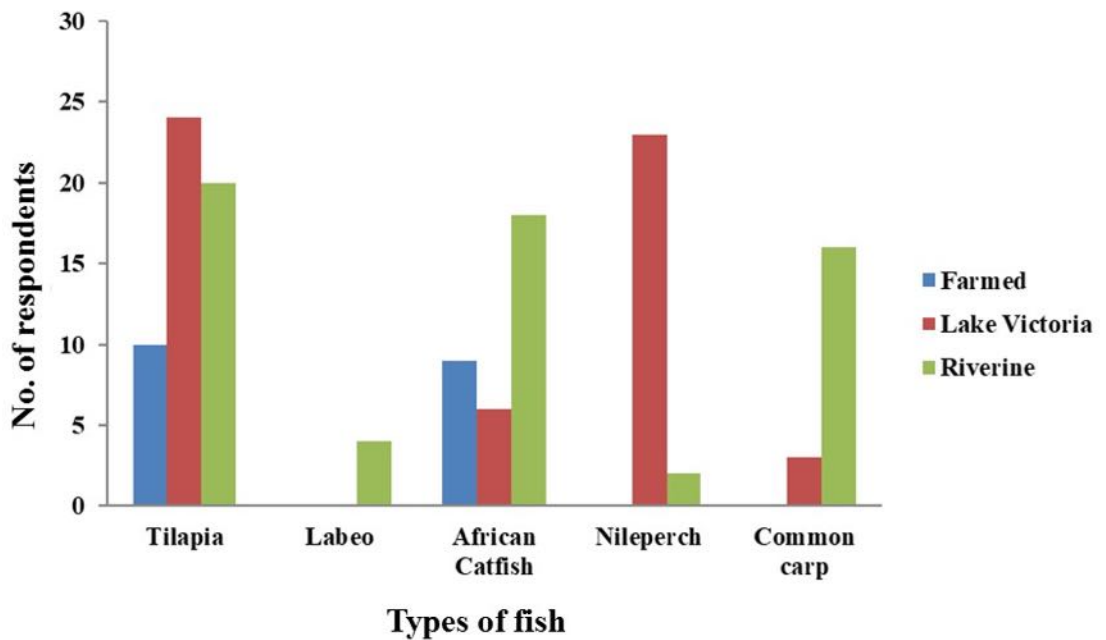


246 were also preferred by the vendors and were reported by 19 % and 15 % of the
247 sampled respondents, respectively. Smoked fish was the least preferred fish
248 product where only 7 % of the respondents confirmed they sold this product to their
249 clients.
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Figure 2: Types of fish in selected markets in Kirinyaga County



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Figure 3: Sources of fish present in the markets in Kirinyaga County

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258 **Assessment of fish quality by fish vendors**

259 The study revealed that the quality of fish products was assessed using different
260 methods. Fish vendors used various methods to assess the quality of the fish and
261 fish products. In this study, 30 % of the fish vendors established fish safety and
262 quality by pressing the fish and then making a decision on their safety. Besides,
263 76% of the sampled respondents indicated that the fish color was the most reliable
264 method to establish the fish quality while 68% of the respondents focused on the
265 gills' appearance. Out of the total sampled respondents, 8% indicated that white
266 eyes in the fish suggested that the fish were affected by foodborne disease-
267 causing pathogens. Similarly, smelling of fish products was prominent among
268 some fish vendors (14%) as a method of assessing fish quality. A change in odour
269 indicated contaminations by foodborne disease-causing pathogens (Table 2). Also,
270 68% of the sampled respondents refrigerated their fish and fish products. In
271 contrast, the use of open shelves and display units without ice were the least
272 popular methods of fish preservation with 4 % and 6 % of the respondents
273 indicating they use the method.

274

275 **Fish vendors' hygiene practices**

276 This study revealed that 32% of the fish vendors were cautious and sensitive on
277 use of hand gloves while handling fish (Table 3). However, 42% of the respondents
278 never used gloves while handling fish food products and were unaware why they
279 should use clean gloves and of any associated risk of cross-contamination
280 between already cooked fish products and raw fish.

281 In addition, high percentage of the respondents (82%) observed the hygienic
282 importance of handwashing after and before dealing with fish products.
283 From the study, it was also noted that 76% of the participants considered it
284 unhealthy to handle fish whenever they were sick and were cautious whenever they
285 experienced foodborne disease -related symptoms. However, 8% of the
286 respondents stated they handled fish and fish products even they were unwell. This
287 is because they prioritized their daily income. Similarly, 98% of the respondents
288 indicated that they used disinfectants and detergents to clean their hands, fish
289 containers, utensils, processing equipment and work surfaces (Table 3).

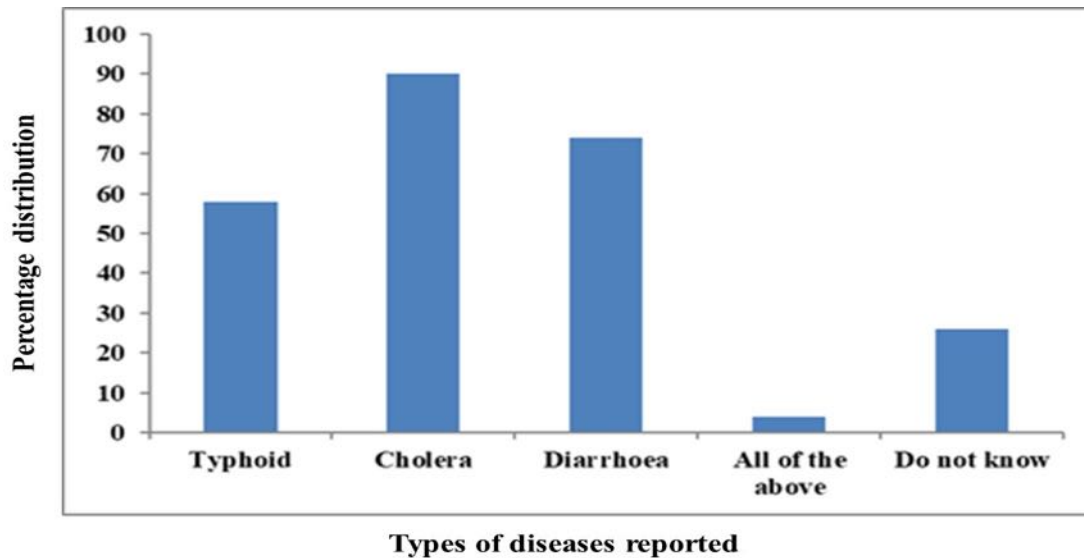
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291 **Common foodborne diseases**

292 In this study, 89% of the respondents indicated that cholera was the most
293 commonly known foodborne disease, followed by diarrhoea and typhoid related
294 illnesses (74% and 48%, respectively). In addition, 22% of the sampled
295 respondents indicated that they were unaware of complications that could emanate
296 from the consumption of contaminated fish products (Figure 4).



297



298 **Figure 4: Knowledge of common foodborne diseases**

299 **Fish handlers' knowledge on safety**

300 The descriptive statistics concerning fish safety knowledge revealed that personal
301 hygiene was the most prominent practice to ensure fish safety with the highest
302 score of 3.84 ± 0.35 out of 5 (Table 4). However, the respondents demonstrated
303 excellent mean knowledge scores (90 % and above) on the risk of contamination
304 due to mixing of cooked and uncooked fish. Majority of fish handlers also reported
305 that it was inappropriate to store dangerous food for consumers and it was their
306 responsibility to maintain good personal hygiene. Some respondents had a
307 satisfactory score on knowledge of fish safety in areas such as wearing protective
308 clothing (85.19%), consistent knowledge of fish safety (86.19%), cooking fish to
309 reduce contamination (81.48%), and cleaning of chopping boards and kitchen
310 towels (85.19 %) (Table 4). In contrast, not wearing of rings, watches and
311 necklaces to minimize contamination had the least mean knowledge score of 2.11
312 ± 0.97 out of 5 together with evaluation of the health status of fish and fish product
313 handlers. In addition, knowledge of ideal fish storage conditions was the least
314 scored with only 53.70%.

315 The study revealed that the respondents were aware that high temperatures
316 promoted bacterial growth, creating the need to refrigerate their fish products.
317 However, some of the fish vendors could not freeze their fish and fish products due
318 to inadequate resources to purchase refrigerators. This is in agreement with
319 Lokuruka [28], who reported that financial constraints limited majority of fish
320 vendors to preserve the fish products in cold boxes and even during the
321 transportation to prevent spoilage and growth of pathogenic bacteria. Previously, it
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323
324

325 was demonstrated that in Bangladesh, authorities tried to reduce fish foodborne
326 disease and post-harvest losses through the provision of cold storage facilities to
327 fish handlers [29]. Moreover, from this study it was evident that some fish handlers
328 preferred not to use open shelves and displays without ice to cut on cost. This
329 explains why there were many cases of foodborne associated problems from the
330 selected markets in the region. The high levels of fish contamination call for proper
331 food storage to prevent contamination [21].

332

333 Symptoms of common foodborne disease were well known to majority of the
334 participants. The most known symptom by the respondents in the study area was
335 diarrhoea. The respondents indicated they took precautionary measures whenever
336 they experienced the signs and symptoms of foodborne disease. However, the fish
337 vendors may prepare and sell the fish and fish products without necessarily
338 consuming them and hence, they cannot be relied on in determining foodborne
339 infection outbreaks [30]. This calls for awareness targeting the fish vendors and
340 consumers on the required standards and measures that improve fish and fish
341 safety. Besides, information on the signs and symptoms of foodborne diseases is
342 important to the fish vendors because the information helps them take action to
343 prevent the spread of foodborne diseases through the consumption of
344 contaminated fish and fish products [31]. Similarly, the majority of the sampled
345 respondents reported that they were familiar with cholera, its cause and symptoms
346 and that they could take precautionary measures to prevent the spread of this
347 disease. This finding is in agreement with a study by Akabanda *et al.* [8], where
348 knowledge of the current fish and fish products preservation practices among the
349 fish vendors was reported to reduce possible risks of spreading foodborne
350 diseases.

351

352 The respondents in this study reported a high knowledge score on fish safety. This
353 demonstrated that the fish handlers in Kirinyaga County have adequate information
354 that consumption of contaminated fish and fish products poses a risk of foodborne
355 diseases. As a result, they have put measures in place such as maintaining
356 hygiene while handling fish and fish products. This finding is in agreement with a
357 previous study by Ncube *et al.* [32] where the fish handlers had high knowledge
358 scores on food safety because they understood the risks associated with food
359 contamination, consumption of contaminated food and the impact of unhealthy
360 food handling on food safety.

361

362 In addition, a high percentage of the fish handlers in Kirinyaga County reported
363 that proper hand hygiene, wearing of protective gloves, caps, appropriate outfits
364 and masks help in reducing fish contamination. This agrees with Faour-Klingbeil *et*



365 *al.* [33] where 96.2% of the respondents indicated that hand hygiene and personal
366 protective equipment reduce food contamination and increase food safety. In
367 addition, the fish handlers in this study had high knowledge scores on separating
368 cooked fish from uncooked fish, adequate cooking of fish and handlers' cleaning of
369 chopping boards before using them. This shows that the fish vendors in Kirinyaga
370 County are aware that cooking fish and fish products exposes the foodborne
371 pathogens to high temperatures hence reducing the chances of these pathogens
372 surviving, and hence it is one of the strategies for reducing foodborne pathogens in
373 food. According to Al-Kandari *et al.* [34], temperatures significantly contribute to
374 reducing foodborne disease -transmission hence adequate cooking kills the
375 pathogens making it safe for human consumption. On the other hand, the fish
376 handlers indicated high scores (52%) on the fact that it is crucial to know the ideal
377 fish storage conditions to prevent spoilage of the fish and fish products and prevent
378 microbial contamination of the fish and fish products. This finding corroborates with
379 Sheng and Wang [35], who indicated that knowing the ideal temperatures of fish
380 and fish product storage help in reducing microbial contamination and enhances
381 fish product safety.

382

383 In this study, the fish handlers indicated that handling fish and fish products while
384 having physical injuries or abrasions should not be allowed. Also, healthy fish
385 handlers, chopping boards and knives are potential carriers of foodborne diseases.
386 This is in agreement with Augustin *et al.* [36] who indicated that food handling
387 practices and materials such as knives, and chopping boards significantly
388 contribute to foodborne infectious diseases. The fish handler's health status should
389 be evaluated before they are allowed into the fish and fish product business. This
390 is because they could be agents of foodborne pathogens because they have little
391 knowledge and experience in handling these products.

392

393 Poor personal hygiene practices among the food handlers have been reported to
394 be the source of contamination of fish and fish products [37]. One of the
395 precautions used to prevent the high contamination in fish and fish products is by
396 maintaining high personal hygiene through the use of clean gloves. However,
397 some fish handlers do not consider using gloves when handling fish and fish
398 products. This could be attributed to inadequate information on the cross
399 contaminations in the handling of food products such as fish [38]. This is a risk
400 hazard especially when the fish handlers are the carriers of the potential human
401 pathogenic microbes[39]. Besides, this finding collaborates with a comparative
402 study in Ghana on the use of bare hands versus gloves which showed that the use
403 of bare hands in handling ready to eat food increases contamination levels [40].
404 Studies have shown that some bacteria such as *Salmonella typhi* and other entero-



405 pathogens can survive on bare hands for hours [39,40]. A similar observation was
406 reported in Saudi Arabia where the majority of vendors were ignorant of proper
407 hygiene in the handling of fish [16]. Besides, it agrees with a previous study by
408 Lues *et al.* [20] where the source of fish and fish product contamination was as a
409 result of uncleaned and uncovered hands, especially during processing and fish
410 handling in vending areas.

411

412 Additionally, a high percentage of the respondents washed their hands before
413 handling fish and fish products. This is very crucial since hand washing reduces
414 the bacterial load in the hands, thus minimizing cross-contamination of the fish and
415 fish products [38]. According to Hashanuzzaman *et al.* [38], many street fish
416 vendors are aware of standards of hygienic practices, nevertheless, many of them
417 do not practice them and are negligent in complying with the required hygiene and
418 health standards sometimes due to inadequate infrastructural support [39].

419

420 **Fish handlers' food safety attitudes**

421 In this study, the respondents' attitude toward food safety was positive (3-5 scores
422 out of 5) with percentages on yes/no questions ranging from 59%-96% (Table 5).
423 Besides, 96.29% of the respondents were willing to learn basic hygiene to increase
424 their knowledge of food safety. In addition, 95.44% of the respondents suggested
425 that their superiors ought to organize trainings to improve the fish handler's
426 knowledge on hazards that contaminate fish and fish products. Similarly, 90.74%
427 of the respondents indicated that spoiled or contaminated fish and fish products
428 should not be consumed. In contrast, the respondents reported least scores in the
429 following statements: I will always use hand gloves when handling no packed fish
430 products 18.52% and I need some incentives to prevent fish contamination 14.81%
431 (Table 5).

432

433 The attitude of the fish handlers in Kirinyaga County was positive towards fish and
434 fish product safety, willingness to learn about fish safety, fish handling, improving
435 personal hygiene and cooking fish within the recommended duration. The positive
436 attitude demonstrates that the fish handlers in this study had information on the
437 importance of fish safety procedures when handling fish and fish products. This
438 finding corroborates with previous findings where fish handlers reported a positive
439 attitude toward fish safety and they would request their supervisors to be exempted
440 from work should they have diarrhoea, wounds and cuts [38]. Also, the attitude of
441 the fish handlers enables them to be curious and willing to learn diverse ways of
442 enhancing fish safety [22]. Besides, the attitude of the food handlers in this study
443 could be due to the fish handlers understanding that they have the responsibility to
444 prevent food spoilage and contamination. Previously, *Pham-Duc et al.* [26]



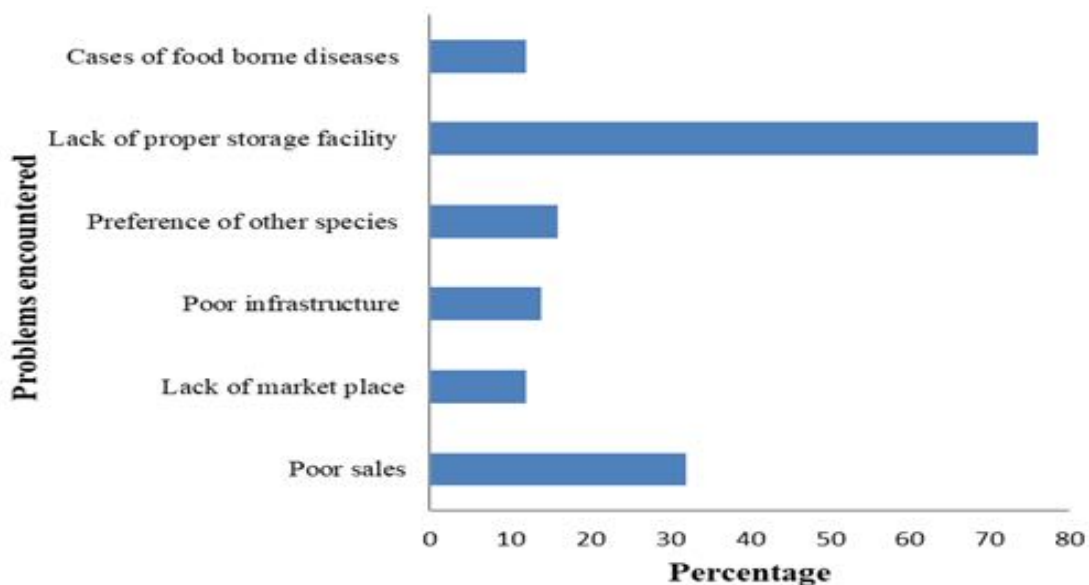
445 indicated that the positive attitude of fish handlers towards fish safety is inculcated
446 by them taking responsibility for protecting the public from foodborne diseases.

447

448 **Fish handlers' challenges in the selected markets**

449 The respondents from Kirinyaga County indicated diverse challenges associated
450 with fish businesses. The absence of ideal fish product storage facility was
451 reported by majority (76 %) of the respondent as a major challenge due to the
452 nature of the food on perishability (Figure 5). However, 16 % of the respondents
453 indicated that changes in consumer preferences for different fish species, changes
454 in seasons and changes in fish consumers' attitudes and behaviours were the main
455 challenges they experienced in fish and fish product businesses in Kirinyaga
456 County. Moreover, 32 % of the respondents reported that poor sales and unstable
457 prices occurred, simultaneously affecting the growth of their fish businesses. In
458 contrast, 12% of the respondents reported that the main challenge they faced was
459 the entry of many fish handlers who increase competition which negatively affects
460 the growth of the fish businesses (Figure 4).

461



462

463 **Figure 5: Challenges encountered by fish handlers in selected markets**

464

465 Despite the efforts that they have put in place, the fish vendors in Kirinyaga face a
466 few challenges. In most instances, the fish vendors were aware and had the
467 willingness to adhere to food health standards. However, these fish vendors were
468 limited by inadequate materials and resources required to comply with the set
469 hygiene standards. These include handwashing points with clean water, waste
470 management and disposal systems, good drainage and portable water [27]. In this
471 study, the respondents indicated that even if they experienced symptoms of

472 foodborne diseases known to them, they would continue with their business as
473 usual. This could be attributed to the fear of losing daily income and a bridge of
474 trust from the consumers due to inconsistency in the supply of the fish products.
475 The study finding is in agreement with Eltholth *et al.* [17] who established that food
476 vendors fear the risk of losing current customers and also incurring losses if they
477 are not operating while still avoiding additional costs of hiring more personnel if
478 they fail to be in the market for different reasons including being sick. Ethically, it is
479 not right to handle food in the market when sick because the disease- causing
480 pathogens can be spread to the healthy population [38]. Despite handling the fish
481 without gloves, the selected respondents indicated they used detergents which are
482 important in reducing microbial contamination. To clean fish containers, processing
483 equipment, work surfaces and utensils, detergents are commonly used [29].
484

485 The sampled respondents reported transporting fish products using open crates
486 and buckets to the market. The severity of contamination during transportation can
487 also be exacerbated by the nature of packaging for both processed and raw fish.
488 The majority of fish vendors were from rural areas and were unable to possess the
489 required equipment for fish and fish product storage and hence subjecting the
490 product to post-harvest losses and foodborne diseases.
491

492 **Nexus of fish vendors' sociodemographics, awareness of risk causing** 493 **factors and biophysical factors**

494 The fish vendors' biophysical factors and risk factors awareness had significant
495 correlation based on Spearman's correlation coefficient (Table 6). There was a
496 positive correlation between education and fish vendors' awareness of fish
497 foodborne diseases at $p < 0.05$. There was positive correlation ($r = 0.152$, $p < 0.05$)
498 of fish foodborne awareness by age of fish vendors (Table 6). Training on hygiene
499 and food safety on the other hand significantly affected the level of awareness of
500 foodborne associated diseases with a positive correlation coefficient of $r = 0.314$ (p
501 < 0.05). However, the gender of fish vendors had no significant effect on the level
502 of awareness of risk factors such as foodborne diseases.
503

504 There was a positive relationship between the level of education and fish vendors'
505 awareness of foodborne diseases in this study. The educated fish vendors knew
506 about the possible contamination of fish and fish products. Also, they were aware
507 that fish contamination increases the risk outbreak of foodborne diseases hence
508 there is a need for improved personal hygiene when handling the fish and fish
509 products in the market. Similarly, there was a significant relationship between
510 foodborne awareness and age. With the increase in age, the fish vendors gain
511 insights into foodborne contamination and foodborne related diseases. This finding

512 corroborates with Alejandra *et al.* [22], who reported that education level and age
513 were significant factors in determining knowledge and foodborne disease
514 awareness levels among fish vendors. Correlation analysis of professional training
515 on hygiene revealed a significant effect on the level of awareness. Training
516 increases knowledge of fish safety and foodborne disease prevention [13].

517

518 CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

519

520 The study showed that the respondents from Kirinyaga County had an average
521 level of knowledge, attitudes and practices towards fish safety and hygiene. The
522 main reason for this is that most of the fish vendors in Kirinyaga County had no
523 formal training on fish safety. Besides, there was no robust system for assessing
524 the quality and the safety of fish and fish products in Kirinyaga County. In the study
525 area, there were different types of fish species. However, the availability and
526 consumer preference varied from one fish species to another. Moreover, there
527 were no standards on the hygiene level of the fish vendors hence, there was a
528 possibility of high fish and fish product contamination. Therefore, there is a need
529 for training and safety regulation of fish and fish product business in the county to
530 prevent a future outbreak of foodborne diseases spread through consumption of
531 contaminated fish and fish products.

532 Explain here how the findings were used and if there are any plans for follow-up
533 work??

534

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538

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541

542 Competing interest

543 The authors declare no conflict of interest.

544



545

Table 1: Fish vendors' demographic information

	parameter	Frequency (n=54)	Proportion (%)
Gender	male	36	66
	female	18	34
Age	<18	1	2
	18-25	9	16
	26-45	34	64
	>45	10	18
Education	Primary	18	34
	Secondary	24	44
	Certificate	1	2
	Diploma	9	16
	University degree	2	4
Occupation	Self-business	39	72
	Employed	4	8
	Farming	2	4
	Employed and Self-business	9	16
Monthly Income	Below 15000	17	32
	16000-30000	27	50
	Above 30000	10	18
Work experience in fish industry	≤ 5 years	31	56
	6 - 15 years	18	34
	16-25 years	4	8
	Above 25 years	1	2

546

547

548



549 **Table 1: Quality assessment of quality of fish and fish products in the**
550 **selected markets**

Method	N (%)
Color	41(76)
Looking at gills	37(68)
By pressing	16(30)
Odour	8(14)
White eyes	5(8)

551 N: Number of individuals

552

553

554 **Table 2: Fish vendors hygiene practices (N = 54)**

	Never N (%)	Rarely N (%)	Sometimes N (%)	Often N (%)	Always N (%)
Handling fish while having symptoms of foodborne diseases	41(76)	4(6)	5(8)	1(2)	4(8)
Use of clean gloves when handling fish products	23(42)	12(22)	2(4)	0	16(32)
Cleaning of tools, work surfaces and equipment with detergent/ disinfectant/sanitizer.	0	0	1(2)	0	53(98)
Washing of hands after touching contaminated objects (dirty objects) before handling fish	0	0	1(2)	9(16)	44(82)

555

556



557 **Table 4: Knowledge of fish handlers on food safety in Kenyan markets**

	Agree n (%)	Score Mean \pm SD
Wearing of protective gloves, caps, appropriate outfits, and masks can minimized risk if fish adulteration	46 (85.19)	3.45 \pm 1.52
The safe operating temperature for a refrigerator is 1–5°C	36 (66.67)	2.94 \pm 1.23
Fish management is related to food safety	41 (75.92)	3.05 \pm 0.85
It is inappropriate to store dangerous food for consumers	45 (83.33)	3.49 \pm 1.21
Practices such as not wearing necklaces, watches and ornamentals can reduce fish contamination	28 (53.84)	2.11 \pm 0.97
It is crucial to know ideal fish storage conditions	29 (53.70)	2.57 \pm 0.87
Cooked and raw fish should be kept separate to reduce risk of contamination.	50 (92.59)	3.67 \pm 0.98
Fish handlers' knowledge of food safety should be consistent	46 (85.19)	3.45 \pm 1.52
It is my personal work duty for harmless food management	49 (90.74)	3.67 \pm 0.98
Fish handlers with physical injuries or abrasions should not contact fish without packaging.	40 (74.07)	2.95 \pm 1.14
Proper hand hygiene can reduce risk of fish contamination.	51 (94.44)	3.84 \pm 0.35
Well cooked fish and fish products are free from microbial contamination.	44 (81.48)	3.25 \pm 1.13
Fish handlers' health status should be evaluated before employment.	28 (51.85)	2.11 \pm 0.68
Chopping boards and knives should be properly cleaned to prevent contamination.	45 (83.33)	3.24 \pm 1.23
Dish towels can be a potential source of contamination	41 (75.93)	3.05 \pm 0.85
A healthy food handler can be a carrier of infectious foodborne diseases	36 (66.67)	2.75 \pm 1.66

558 Key: SD, standard deviation. Scores (1-5), 5 = Highest score, 4 = satisfactory, 3 = average, 2 =
 559 unsatisfactory, 1 = least score

560

561



562 **Table 5: Attitude of fish handlers on food safety in Kenyan markets**

Statement	Disagree n (%)	Neutral n (%)	Agree n (%)
I am ready to learn fish safety and hygiene basics	2 (3.70)	0 (0.00)	52 (96.29)
My superior should organize trainings such as hazard analysis for fish handlers	0 (0.00)	3 (5.56)	51 (94.44)
I should take sick leave if I have cuts, wounds, or diarrhea.	8 (14.81)	2 (3.70)	44 (81.48)
It is my key responsibility to prevent fish spoilage and contamination.	8 (14.81)	4 (7.41)	32 (59.26)
Spoiled or expired fish products should never be consumed.	0 (0.00)	5 (9.26)	49 (90.74)
I will always use hand gloves when handling no packed fish products.	42 (77.77)	12 (22.22)	10 (18.52)
I need some incentives to prevent fish contamination.	38 (70.37)	8 (14.81)	8 (14.81)
Assessing fish handlers' personal hygiene is crucial to minimizing fish products contamination.	9 (16.67)	5 (9.26)	40 (74.07)
Fish should be cooked for the recommended duration.	4 (7.41)	4 (7.41)	46 (85.16)
To assess the importance and the effectiveness of handwashing, one can swab nails and palms of fish vendors	12 (22.22)	6 (11.11)	36 (66.67)

563 Key: Scores (1-5), 5 = Highest score, 4 = satisfactory, 3 = average, 2 = unsatisfactory, 1 = least
564 score

565

566 **Table 6: The association of demographic factors on fish vendors risk factors**
567 **based on Spearman's correlation coefficient (r)**

	Education level	Age of fish vendors	Gender of fish vendors	Training on food safety and hygiene	Awareness of any foodborne disease
Education	1				
Age	0.030	1			
Gender	-0.111		1		
Training on food safety and hygiene	-0.256	-0.027**	0.041	1	
Awareness of any food-borne disease-causing microbes	0.585**	0.152**	0.069	0.314**	1

568 * Correlation is significant at the 0.05 level (two-tailed)

569 ** Correlation is significant at the 0.01 level (two-tailed)

570



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