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FOOD SAFETY MANAGEMENT ON MERCHANT SHIPS: AN ORGANISATIONAL ANALYSIS

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Purpose: The purpose of this paper is to assess how food safety management systems (GHP/HACCP) function in practice on merchant ships operating as closed organisational environments. The study aims to identify strengths, systemic weaknesses, and managerial challenges in the implementation of hygiene practices under maritime operational constraints.
Design/methodology/approach: The study adopts a qualitative case study approach based on participatory observation conducted on two sister container vessels operating under the Maltese flag. Data were collected through methodological triangulation, including participant observation, informal interviews with crew members, photographic documentation, and analysis of onboard catering and hygiene records. The findings were analysed thematically and evaluated against international guidelines for shipboard food safety management (WHO, EMSA), within the broader framework of organisational and quality management.
Findings: The results indicate that while basic structural elements of GHP/HACCP systems are in place, their effectiveness is limited by gaps in corrective action documentation, inconsistent process enforcement, and informal deviations from established procedures. Temperature monitoring, hygiene routines, and access control provide a functional safety baseline; however, weaknesses in CAPA implementation, thawing practices, product labelling, and supplier communication reduce overall system reliability.
Research limitations/implications: The study is limited by its qualitative design and focus on two vessels operating under a single flag state, which restricts the generalisability of the findings. The participatory nature of observation may also introduce observer bias. Future research should expand this approach through cross-national comparative studies and examine the influence of organisational culture, economic constraints, and management policies on the long-term effectiveness of food safety systems at sea.
Practical implications: The findings highlight the need for managerial interventions focused on strengthening documentation discipline, corrective action tracking, and procedural consistency rather than introducing additional formal requirements. Low-cost organisational tools—such as standardised CAPA records, controlled thawing procedures, hygiene supply checklists, and structured supplier evaluation—may significantly improve food safety performance and operational resilience on merchant ships.
Social implications: Improving food safety management on merchant ships contributes to the protection of seafarers' health and well-being in environments with limited access to medical services. Enhanced organisational control of hygiene practices may also reduce the risk of foodborne disease transmission across international maritime routes, supporting broader public health objectives and responsible maritime operations.

Originality/value: This paper provides original empirical insights into the real-world functioning of food safety management systems on merchant ships using participatory observation. By framing food hygiene as an organisational and managerial issue rather than solely a technical or microbiological problem, the study offers practical value for shipowners, safety managers, and researchers interested in quality management within closed and resource-limited occupational environments.
Keywords: food safety management, quality management, risk management, organisational practices, closed systems.
Category of the paper: research paper.

1. Introduction

According Food safety on merchant ships poses a significant challenge due to limited access to resources, extended supply chains, and working conditions within an environment isolated from land-based sanitary infrastructure. From an organisational and management perspective, shipboard food safety represents a complex system of interrelated processes requiring continuous supervision, coordination, and risk control. International organisations, such as the World Health Organization (WHO) and the European Maritime Safety Agency (EMSA), emphasise the need to comply with Good Hygiene Practice (GHP) principles and implement Hazard Analysis and Critical Control Points (HACCP) systems in maritime settings, where lapses may lead not only to health consequences but also to operational disruptions and organisational inefficiencies (WHO, 2011a). An essential sanitary supervision tool onboard is the Ship Sanitation Control Certificate (SSCC), issued by authorised bodies following an inspection assessing hygiene conditions, water safety, waste management, and food handling. This document aims to prevent the spread of communicable diseases via international maritime transport and is required under the International Health Regulations (IHR).

Compliance with the requirements necessary for positive SSCC inspection outcomes involves both appropriate infrastructure and the effective functioning of food safety management systems based on the ongoing application of GHP/HACCP principles (WHO, 2011b). From a food technology perspective, it is crucial to ensure cold chain continuity, proper storage conditions, and strict time-temperature control throughout the entire cycle - from loading goods to preparation and serving. However, the effectiveness of these technical controls depends largely on organisational practices, staff accountability, and the consistency of monitoring procedures. As Skawińska and Zalewski (2022) point out, temperature standards in the cold chain are critical to food quality, and failure to maintain appropriate conditions results in economic losses and increased microbiological risk. Merchant ships operate as closed environments where the quality of food and hygiene is vital not only for crew health and performance but also for overall operational safety. Proper food handling,

storage, and preparation become especially important during long voyages with limited access to fresh supplies (Grappasonni et al., 2013, 2018).

Outbreaks of acute gastroenteritis affect millions worldwide and are often transmitted through contact with infected individuals, contaminated food or water, and unclean surfaces. Such scenarios are particularly common in semi-closed environments such as ships (Jenkins, 2021). In these settings, weaknesses in organisational control mechanisms may amplify the consequences of individual procedural errors. The *Handbook for Inspection of Ships and Issuance of Ship Sanitation Certificates*, published by WHO, provides guidance on sanitation practices and the assessment of health conditions on board both passenger and cargo vessels (WHO, 2011b). The document underscores the importance of maintaining hygiene standards in food handling, waste disposal, water quality, and prevention of cross-contamination in enclosed kitchen spaces.

Research by Grappasonni et al. (2018) found that catering staff on merchant ships answered 68% of food hygiene knowledge survey questions correctly, with trained individuals scoring significantly higher in areas such as personal hygiene, temperature control, cross-contamination prevention, and awareness of foodborne pathogens. These findings suggest that formal training alone is insufficient if not supported by effective organisational oversight, routine supervision, and practical reinforcement of procedures.

Merchant ships typically lack medical personnel, may remain at sea for several weeks, and operate in a confined, hermetic environment. Despite relatively small crew numbers, seafarers are exposed to a relatively high risk of infection, including foodborne illnesses (Mouchtouri et al., 2010). Disruptions in the microbiological stability of food may lead to the growth of pathogens such as *Salmonella spp.*, *Listeria monocytogenes*, or *Bacillus cereus*, especially when storage conditions are inadequate, thawing is done improperly, or clean and dirty areas are not clearly separated (Bintsis, 2017; Kaur, Yemmireddy, 2023). From a management perspective, such risks highlight the importance of preventive system design rather than reactive intervention, particularly in environments with limited access to external medical support (Scuri et al., 2019).

Despite the existence of detailed guidelines from WHO and EMSA regarding food hygiene on ships, their translation into everyday organisational practice and managerial decision-making remains insufficiently documented. There is a lack of current analyses focusing on the actual functioning of food safety management systems, including hygiene practices, temperature logging, thawing methods, supplier feedback mechanisms, and the management of critical deviations (Corrective and Preventive Actions-CAPA) aboard merchant vessels (Karkori, 2024). Importantly, few studies employ participatory observation as a methodological tool for evaluating quality and risk management in real operational conditions, despite its potential to reveal organisational gaps and procedural oversights that may not be captured during formal inspections.

The objective of this study was to conduct an on-site evaluation of selected food hygiene practices as elements of food safety and risk management systems implemented on two sister container vessels. The analysis focused on compliance with GHP/HACCP principles and international maritime hygiene regulations, with particular emphasis on refrigeration records, thawing procedures, galley organisation, CAPA documentation, procurement protocols, and supplier evaluation systems. Using a qualitative, participatory observational approach, the study aimed to identify organisational and procedural weaknesses that may compromise the effectiveness of food safety management in closed maritime environments. By highlighting real-world hygiene challenges and organisational shortcomings, this research contributes to the understanding of quality and risk management in isolated work systems and provides practical insights for improving food safety governance aboard merchant ships.

2. Materials and methods

This study was designed as a qualitative participatory observational case study focusing on the practical functioning of food safety and quality management systems in closed maritime environments. The research was conducted on two sister container ships flying the Maltese flag, classified in the AIS system as Cargo Ship (HAZ-C). Each vessel is 197 m long and 30 m wide, with a gross tonnage of 26,342 GT, and was built in 2003. The ships operate regular commercial routes in the Mediterranean and Middle East regions. The selection of the vessels was purposive, based on their identical technical specifications, catering infrastructure, flag state, and operational profile, allowing for a comparative organisational analysis under comparable management conditions. Additionally, the choice of the studied units was determined by the author's opportunity to conduct long-term participatory observation and access onboard operational documentation on these sister vessels, which enabled in-depth analysis under real working conditions. Full food provisioning typically takes place in the home port (Valletta, Malta), with partial replenishment at selected transhipment ports. Each vessel has a similar catering infrastructure comprising the galley, reefer room, dry provision store, dishwashing area, and two mess rooms. The crew consists of 24 members, mainly of Filipino and European nationalities (including Polish, Romanian, and Ukrainian). The cook and steward (messman) are Filipino nationals.

2.1. Research tools and data sources

Data collection was based on methodological triangulation, combining participant observation, informal interviews, photographic documentation, and document analysis. Participant observation was conducted over two consecutive periods of approximately three

weeks each. The researcher adopted a dual role as observer and participant, being involved in daily catering-related activities such as meal preparation and distribution, cleaning routines, and food storage. Observations focused on organisational practices and procedural compliance, including thawing procedures, use of protective gloves, temperature recording practices, and the cleanliness and layout of the dishwashing area. A total of 70 photographs were collected as visual evidence of system functioning, documenting kitchen infrastructure (12), cold and frozen storage rooms with temperature records (35), defrosting practices (6), and additional elements such as mess rooms and meals served (17). Photographs were treated as qualitative data supporting the verification of observed practices rather than as illustrative material only. Additionally, informal, non-structured interviews were conducted with selected crew members (cook, steward, chief officer, chief engineer, able seaman, and captain). Interviews focused on organisational routines and decision-making processes, including ordering and return procedures, hygiene practices, availability of personal protective equipment, experiences with foodborne illness, and subjective assessments of food quality. Shipboard documentation was analysed as part of the system-level assessment and included temperature control logs, supplier evaluation forms, inventory reports (OSERV Inventory Report), monthly menu plans, purchase orders, and supplier comment sheets.

2.2. Data analysis

Qualitative data analysis followed a thematic categorisation approach, integrating field notes, interview content, photographic records, and documentation. Data were systematically organised into the following analytical categories:

(i) personal and process hygiene,
(ii) cold chain safety and thawing procedures,
(iii) stock management and HACCP documentation,
(iv) supplier quality and communication,
(v) crew health symptoms and potential sources of risk.

The analysis was iterative and comparative, allowing for cross-validation between data sources (triangulation). Observations were evaluated against GHP/HACCP requirements, WHO recommendations for ship sanitation (WHO, 2010a, 2010b), and formal inspection criteria included in the Ship Sanitation Control Certificate, such as temperature records, potable water analyses, and food handler certification.

2.3. Responsibilities of Catering Personnel (Catering & galley, 2022; Steward / waiter / messman, 2023; Cook – Duties, 2023)

Clear allocation of responsibilities among catering personnel constitutes a key organisational element of onboard food safety management. Defined roles and formal task descriptions support accountability, procedural compliance, and the effective implementation of GHP/HACCP principles in closed maritime environments.

Chief Cook:

- Prepares meals for both crew and officers.
- Monitors food stocks, forecasts demand, and reports requirements to the captain.
- Ensures compliance with sanitary standards and reports any irregularities.
- Maintains documentation (weekly menus archived for 12 months, temperature records).
- Oversees disinfection of the galley, storerooms, and equipment.
- Implements FIFO principles and separates raw and ready-to-eat foods.
- Holds STCW certification and culinary training; authorised to contact the Designated Person Ashore (DPA) on safety and environmental matters.

Steward (Messman):

- Serves meals and maintains cleanliness of the mess rooms and associated areas.
- Assists the cook in receiving and storing provisions.
- Participates in food labelling and monitoring stock rotation.
- Fulfils EMS/QM 5.10 documentation requirements.
- Holds valid STCW certification and may report directly to the DPA.

In the absence of the chief cook, the captain may appoint another crew member to assume catering duties, provided that certified training in food hygiene and occupational safety has been completed, with the decision documented using form QM 613a.

2.4. Hygiene plan and cleaning schedule

Cleanliness in the galley area is maintained according to a formal document titled "517a Hygiene Plan", which constitutes part of the food safety management system (Hygiene plan, 2023). The schedule includes four cleaning frequency levels (Table 1), with responsibilities assigned to the relevant departments. Oversight of plan implementation rests with the chief cook and steward, while deviations must be reported to the chief officer. The cleaning schedule functions as an operational control tool within the HACCP system, supporting routine compliance and accountability.

Table 1.
Cleaning schedule

Frequency	Type of work	Example areas	Responsible parties*
Daily	Waste removal; dry and wet cleaning	Mess rooms, cabins, galley, public lavatories	Crew / MM / CC / DD
Weekly	Dry and wet cleaning of surfaces, floors, equipment	All mess rooms, galley, dry provision store	Crew / MM
Monthly	Washing curtains and towels; thorough cleaning of walls and ceilings	Cabins, galley, reefer room, garbage store	Crew / DD
Quarterly	Washing walls and ceilings; cleaning of furniture and appliances	Mess rooms, recreation rooms, reefer room	DD/ED

*Crew = crew member; M-M = steward/messman; C-C = Chief Cook; DD = Deck Dept.; ED = Engine Dept.

Source: own research.

Overall, the hygiene plan and cleaning schedule formalise routine sanitation activities by linking task frequency with clearly assigned responsibilities. From an organisational perspective, this documentation supports accountability and facilitates verification of hygiene compliance during internal and external inspections.

2.5. Procurement system and catering budget

Food procurement is managed primarily under budgetary constraints, with supplier selection driven mainly by economic criteria. The average daily allowance for food and beverages (PMD – Provisions, Messing, Drinks) is €9.35 per person. For a crew of 24 members, this equates to €224.40 per day, or approximately €9425 for a six-week voyage cycle. Main provisioning occurs at the home port in Malta to benefit from wholesale pricing and minimise additional purchases at transhipment ports. Cost pressure favours long-shelf-life products, such as frozen foods and canned goods, which may reduce access to fresh produce during extended voyages. Supplier evaluation focuses largely on compliance at the point of delivery, with sensory quality and transport conditions assessed upon receipt rather than during supplier selection.

3. Results

3.1. Observations of process and hygiene practices

Observations focused on the functioning of routine organisational practices related to hygiene and food handling. Galley personnel (chief cook and messman) had only basic training in HACCP/GHP principles, documented through brief introductory courses. In organisational terms, catering duties were occasionally assigned to personnel promoted internally from deck or engine departments, although the cooks observed on the assessed vessels had prior experience from previous voyages. Despite limited formal preparation, visual management tools recommended by WHO, such as *How to Hand Wash*? and *Five Keys to Safer Food*, were displayed in the galley, together with pictograms (Prevent Cross-Contamination), supporting behavioural standardisation and procedural awareness (figure 1).

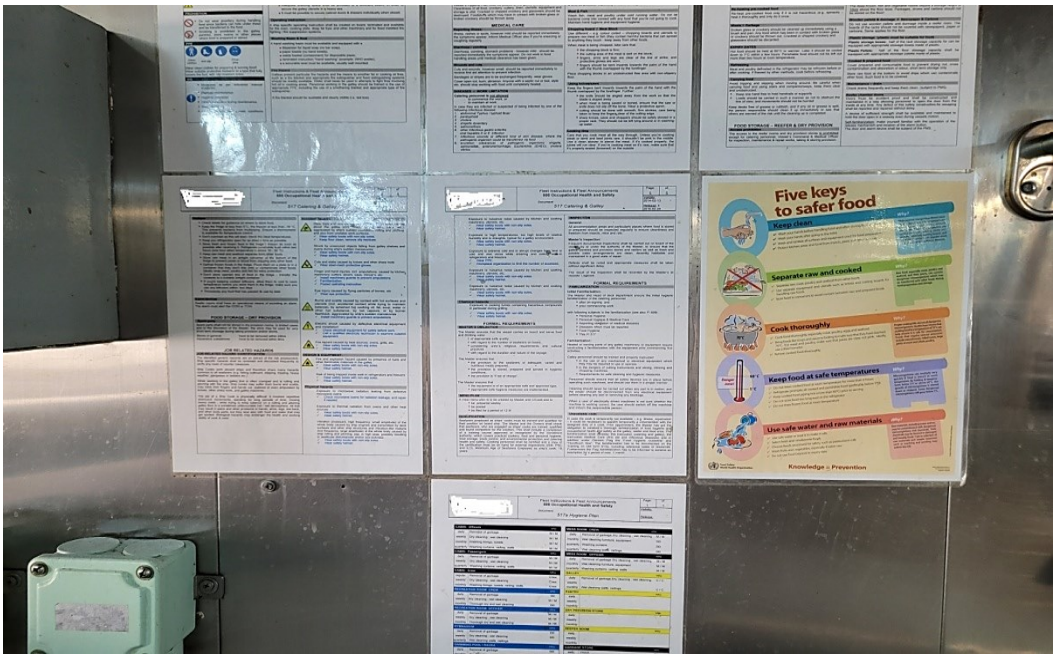

Figure 1. Educational materials.

Source: own research.

Observations confirmed correct handwashing techniques and routine use of disposable gloves; a single temporary lapse in glove use by the messman was immediately corrected, indicating informal peer control mechanisms. In terms of process hygiene, a consistent colour - coded chopping board system was applied (red - raw meat, blue - fish, yellow - poultry, green - vegetables/fruit, brown - cooked meat, white - bread/dairy), serving as an intuitive organisational control tool to minimise cross-contamination risk (figure 2).

Figure 2. Colour-coded cutting boards and knives for food type.

Source: own research.

The dishwashing area followed a linear "dirty-to-clean" layout. Dirty dishes were placed to the left and washed in an industrial dishwasher with a final rinse at 85°C, using detergent and disinfectant specified in the Catering & Galley Manual. Key procedural documents (Hygiene Plan, Catering & Galley Manual, Garbage Management Plan) were visibly displayed, facilitating procedural compliance. Waste was segregated (paper, plastic, metal & glass, food waste) throughout the vessel in accordance with MARPOL Annex V. Food was primarily thawed in refrigerated conditions (≤ 5°C); however, ambient-temperature thawing in the galley was also observed as a routine operational shortcut, representing a potential critical control point (figure 3).

Figure 3. Incorrect thawing at ambient temperature, outside recommended safety range.
Source: own research.

Opened shelf-stable products (e.g. oil, peanut butter, jam) were occasionally stored at ambient temperature, reflecting inconsistencies in post-opening storage practices. In contrast, cheese and cold cuts were properly refrigerated after breakfast (figure 4).

Figure 4. Shelf-stable foods (e.g. oil, peanut butter, jam) stored at ambient temperature throughout the day.

Source: own research.

During observation, leftover soup served at 12:00 remained in the serving pot until dinner at 17:00, resulting in prolonged exposure within the microbial danger zone (>2 h) and deviating from WHO recommendations on safe food holding temperatures. Several crew members reported mild gastrointestinal symptoms (diarrhoea, nausea) after consuming seafood. Additionally, crew members aged 37, 50, and 63 recalled previous hospitalisations due to salmonellosis on other vessels, likely associated with raw egg-based desserts or steak tartare. Overall, these findings indicate that while preventive procedures exist, organisational enforcement and corrective documentation remain inconsistent, particularly regarding temperature control, thawing practices, and the mandatory use of protective gloves.

3.2. Monitoring record analysis

Temperature monitoring data covered 25 consecutive operational days on each vessel, with one entry per day recorded in control sheets and verified through thermometer photographs (Table 2).

Table 2.
Temperature monitoring

Area	Target range (°C)	Average (°C)	Limit exceedances*
Meat room	-20 to -5	-18.4	1 (defrost – -5 °C)
Fish room	-18 to -9	-17.6	1 (defrost – -9 °C)
Dairy room	3-8	5.0	3 (> 5 °C)
Vegetable room	3-8	4.6	1 (> 5 °C)
Lobby area	10-12	10.1	1 (> 10 °C)

*Limits adopted: ≤ −18 °C for freezers; ≤ 5°C for refrigerated rooms; ≤ 10 °C for lobby areas.

Source: own research.

The temperature log contained a complete set of 25 entries per ship (n = 50) (Galley fridge…, 2025; Weekly/monthly cleaning…, 2025) (figure 5).

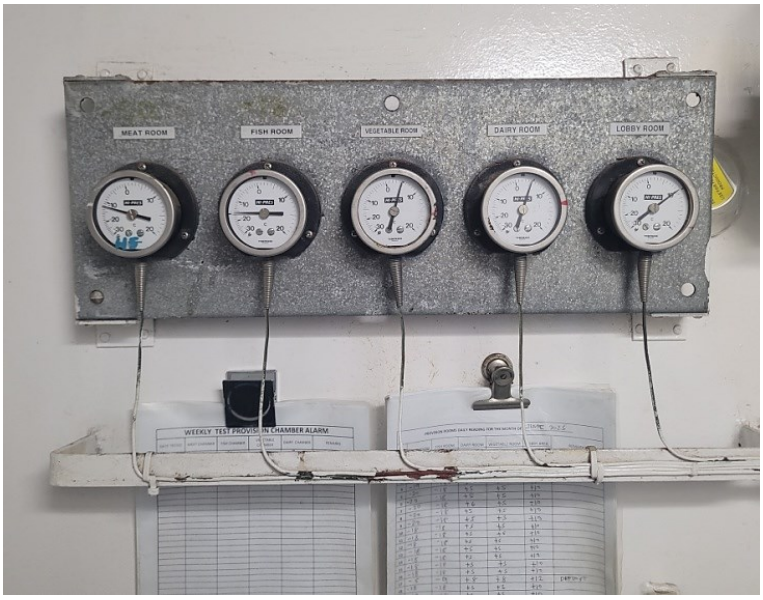

Photo 4. Temperature in individual storage units.

Source: own research.

Recorded temperature exceedances were infrequent and primarily associated with automatic defrost cycles. These short-term deviations did not affect the core temperature of stored products and therefore did not pose an immediate food safety risk. However, the absence of documented corrective or preventive actions following limit exceedances highlights a structural weakness in CAPA implementation, indicating limited feedback between monitoring and management response.

3.3.Communication with the catering company

The shipowner routinely reminds crew members of their obligation to report inventory status and submit the Supplier Evaluation Form within 72 hours after delivery (Reminder on inventory…, 2025). Analysis of two purchase orders from May 2025 showed that supplier communication was largely transactional and reduced to brief technical annotations in the "Comment from Supplier" column. Common entries referred to substitutions, changes in units

of measure, packaging size modifications, or product unavailability. Due to operational time constraints during loading, most deviations were accepted by the crew. However, these changes were rarely documented in the Supplier Evaluation Form, limiting the organisation's ability to assess delivery accuracy, supplier reliability, or cumulative quality deviations. When critical discrepancies were identified (e.g. near-expiry products, thawed ice cream, damaged packaging), immediate returns were initiated and recorded in the receiving log. Nevertheless, the lack of systematic feedback documentation weakened supplier quality management and traceability. These findings illustrate how informal acceptance of deviations can gradually erode control mechanisms within the food supply chain, particularly for perishable products.

3.4. Cost analysis of provisions and consumption

Inventory data for May 2025 indicated an initial food stock value of €10,300 and deliveries totalling €7535. With a final inventory of €10,110, actual consumption amounted to €7725 over 830 man-days, resulting in a daily catering cost (PMD) of €9.30 per person-slightly below the €9.35 budget limit. Budget compliance was primarily achieved through procurement strategies favouring long-shelf-life products, including frozen, canned, and dry goods. While economically efficient, this approach may reduce access to fresh ingredients during longer voyages. Frozen products accounted for 26% of total food expenditure (Table 3), confirming that a substantial share of resources was allocated to temperature-sensitive items, thereby increasing operational reliance on refrigeration systems, as reflected in the monitoring analysis.

Table 3.
Top 5 Cost Categories (May 2025)

Rank	Category	Cost (EUR)	Share (%)
1	Frozen meat	1 950	26 %
2	Dairy	1 200	16 %
3	Fresh vegetables	1 050	14 %
4	Canned goods	900	12 %
5	Soft drinks & juices	750	10 %
	Total (Top-5)	5 850	78 %

Source: own research.

Overall, the observed cost structure highlights a management trade-off between budget control and operational dependence on refrigeration systems, linking economic decisions with food safety requirements.

3.5. Weekly Menu Diversity

Three meals per day were prepared on a seven-day rotational menu. Although individual dishes varied between cycles, the structural composition of the menu remained consistent, as summarised in Table 4. The menu provided at least 14 servings of vegetables or salads per week (≥ 2 per day). Fish or seafood dishes were served three times weekly, accounting for approximately 12% of main meals, while about 70% of animal protein originated from poultry

or beef. Desserts were offered twice weekly, and fresh fruit was routinely available during lunch and dinner. Although dietary diversity was maintained, the relatively low frequency of fish/seafood and dairy-based dishes may limit the intake of omega-3 fatty acids and calcium, indicating a potential nutritional trade-off linked to procurement and cost-management strategies.

4. Discussion

Foodborne disease outbreaks on ships are widely recognised as the result of systemic weaknesses in food safety management, particularly in temperature control, prevention of cross-contamination, staff hygiene, raw material quality, and potable water management (WHO, 2010a; Mouchtouri et al., 2010). In closed organisational environments such as merchant vessels, these risks are amplified by extended supply chains, limited external supervision, and constrained corrective capacity, increasing the importance of effective internal control mechanisms. The assessment of two sister container vessels demonstrated that basic structural elements of GHP/HACCP systems were in place, confirming formal compliance with international requirements. However, the findings indicate a gap between documented procedures and their operational enforcement, a phenomenon frequently described in studies of safety management systems operating under resource and time constraints. The following discussion interprets the results in relation to WHO and EMSA guidance, with a focus on organisational effectiveness rather than procedural description.

4.1. Strengths of the hygiene management system

The presence of clearly defined hygiene routines and visual management tools represents a notable strength of the assessed system. Training in basic infection prevention and hygiene principles, combined with WHO educational materials displayed in the galley, contributed to a baseline level of procedural awareness, consistent with findings by Codreanu et al. (2021), who highlighted the importance of training in mitigating outbreak risks in closed environments. Effective separation of raw materials and the use of colour-coded chopping boards reflect well-established organisational controls designed to reduce cross-contamination through intuitive task allocation, rather than reliance on detailed instructions alone (WHO, 2006). As reported by Starovoytova (2019), such visual systems are particularly effective in confined working environments with limited staff rotation and variable levels of formal training. The structured layout of the dishwashing area and the restricted access to food preparation zones further illustrate the role of physical organisation and access control as risk mitigation measures, supporting earlier observations by Open Textbook BC (2020) that environmental design and

process flow are critical components of effective hygiene management. These practices suggest that even simplified GHP/HACCP tools can provide a functional safety baseline when embedded within clear organisational routines, reinforcing the importance of system design over individual compliance alone.

4.2. Organisational gaps and control weaknesses

From an organisational perspective, the identified shortcomings can be broadly divided into managerial and behavioural control failures. Managerial failures primarily concern enforcement and oversight mechanisms, including incomplete CAPA documentation, limited follow-up after recorded deviations, and insufficient use of feedback loops within monitoring and supplier management systems. Behavioural failures, in contrast, relate to everyday operational practices such as ambient-temperature thawing, inconsistent labelling of opened products, and deviations from recommended food holding procedures, often shaped by time pressure and routine work patterns.

Despite the presence of formal monitoring procedures, the study identified weaknesses in the feedback and corrective response mechanisms, particularly in relation to CAPA documentation. While temperature deviations were recorded, the absence of documented corrective actions indicates a decoupling between monitoring and managerial response, reducing the preventive value of control records. Similarly, deviations from recommended thawing and food holding practices reflect operational shortcuts driven by time pressure, a pattern also reported by Grappasonni et al. (2018). Such behaviours do not necessarily result from lack of knowledge, but from competing operational priorities, underscoring the need for management tools that support decision-making under real working conditions. Inconsistent labelling and storage of opened long-life products further highlight gaps in procedural standardisation and accountability, which may increase exposure to microbiological hazards, as supported by Durack et al. (2012). These findings point to a broader issue of process drift, where informal practices gradually diverge from formal procedures without triggering corrective intervention. Deficiencies in waste container sanitation and supplier communication similarly reflect limitations in cross-functional coordination and documentation, rather than isolated technical failures. As noted by Mafe et al. (2024), inadequate control during storage and transport stages significantly contributes to pathogen proliferation, reinforcing the need for integrated quality management across the supply chain.

4.3. Implications for crew health and operational safety

Reported gastrointestinal symptoms among crew members (diarrhoea, nausea) indicate vulnerabilities in the shipboard food safety management system rather than isolated incidents. Deviations such as improper defrosting, missing date labelling of opened products, and prolonged holding of ready-to-eat foods at ambient temperature increase microbiological

risk, particularly when foods remain within the 5-60°C "danger zone", which favours rapid pathogen proliferation (*Salmonella* spp., *Staphylococcus aureus, Escherichia coli*) (Singh et al., 2019). Inadequate temperature control, improper thawing, and extended storage are recognised as major contributors to foodborne illness risk (Bintsis, 2017). In maritime settings with limited medical access, the consequences of such deviations are amplified. Crew accounts of previous hospitalisations due to salmonellosis linked to raw egg or meat-based dishes are consistent with reports identifying *Salmonella* spp., *Listeria monocytogenes, E. coli, Clostridium perfringens,* and *S. aureus* as the most common pathogens associated with improper storage and heat treatment (Mafe et al., 2024). Additional risks arise from deficiencies in waste management and sanitation, which may lead to secondary contamination and pest attraction, as highlighted in WHO guidelines. Similar patterns of inadequate temperature control, labelling, and pest management have been reported during ship hygiene inspections by Mouchtouri et al. (2010) and Grappasonni et al. (2013). Although no major outbreaks were observed during the study period, the identified irregularities represent a relevant health and operational risk during long voyages, underscoring the need for consistent application of hygiene procedures and ongoing crew training.

4.4. Managerial and operational implications

Based on the conducted analysis, improvements to the existing GHP/HACCP system on the assessed vessels are deemed necessary. First and foremost, it is recommended to standardise the Corrective and Preventive Actions (CAPA) procedure by mandating the documentation of every intervention taken in response to critical limit deviations - such as cold storage temperatures exceeding 5°C or freezer temperatures above -15°C. The absence of such records weakens the effectiveness of monitoring and hampers trend analysis. According to WHO (2006) guidelines and the recommendations of the European Maritime Safety Agency (EMSA), defrosting procedures should take place either at temperatures below 6°C or in water not exceeding 21°C for a maximum duration of four hours. To ensure compliance with these standards, it is advisable to designate a dedicated defrosting area within the cold storage facility and implement simple time-monitoring tools (e.g., kitchen timers or automated reminders) to control the duration of defrosting and the thermal exposure of foods. Regarding the storage of opened long-life products (such as jams, mayonnaise, horseradish), it is recommended to introduce mandatory labelling of the opening date and to reinforce procedures for storing such items in refrigerated conditions for no longer than five days, in accordance with WHO guidance on high-risk foods. This control should be documented using a simple logbook or dedicated form. To ensure the continuity of personal and workplace hygiene, it is advised to introduce a hygiene supplies checklist including disposable gloves, protective headgear, aprons, cleaning agents, and disinfectants. Ongoing monitoring of this list will help prevent shortages that could compromise adherence to proper hygiene practices. It is also essential to reinforce the procedure

for cleaning waste containers, which - according to WHO - should be washed and disinfected after each emptying. The presence of uncleaned containers increases the risk of biological contamination and pest attraction.

In the area of supplier quality management, the implementation of supplier evaluation forms is recommended to allow systematic assessment of raw material quality, transport conditions, and the sensory status of delivered products. This will also facilitate complaint procedures and decisions regarding supplier rotation. To enhance the accountability of support staff (e.g., messmen), the development of a simplified set of visual instructions (e.g., for product labelling, glove and headgear usage) is suggested, alongside the delivery of a short refresher training session on basic hygiene practices. This should be aligned with WHO's "Five Keys to Safer Food" recommendations.

Conclusions

This study demonstrates that the effectiveness of GHP/HACCP systems on merchant ships depends less on the formal existence of procedures and more on their consistent organisational enforcement. Even under conditions of limited resources, basic food safety controls can provide a functional level of protection when embedded in clearly defined responsibilities and routine practices. The findings highlight that the main challenges arise from gaps in corrective action documentation, process accountability, and operational consistency rather than from a lack of technical knowledge. Strengthening managerial oversight, documentation discipline, and simple control mechanisms may therefore significantly improve food safety performance in closed maritime environments. From a broader organisational perspective, the study contributes to understanding how food safety management systems operate under real-world constraints at sea and offers practical insights applicable to other closed or resource-limited occupational settings. Future research should expand this qualitative approach through comparative studies across different flag states, organisational cultures, and economic conditions to better assess the transferability and long-term sustainability of shipboard food safety management systems.

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