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Original Article

A Foundational Evaluation of Cold Chain Halal Logistics Practices among Small and Medium Food Enterprises in Selangor, Malaysia

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Abstract: *Malaysia's halal food sector is expanding rapidly, yet small and medium enterprises (SMEs) face considerable difficulty in preserving halal integrity across cold chain operations. This paper presents a foundational assessment of cold chain halal logistics practices among halal certified SME food operators in Selangor, Malaysia's most industrialized state. Despite Selangor hosting the highest concentration of halal certified SMEs nationwide, no recent quantitative study has measured their compliance with the MS2400 2:2019 Halal Logistics Standard. To address this gap, the study employed a cross-sectional quantitative survey design. Data were collected from 150 randomly selected halal-certified SME food manufacturers across five districts (Petaling, Hulu Langat, Klang, Gombak, and Sepang), using a structured questionnaire divided into demographics, cold chain practices, MS2400 2:2019 compliance, and implementation barriers. The final response rate was 72% (108 completed questionnaires). Descriptive and inferential statistics (Chi square, Mann Whitney U) were applied using SPSS version 29. The results reveal that overall compliance with MS2400 2:2019 is only 47.3%, with the lowest scores in temperature control (38.7% compliance) and personnel training (39.8%). Specific gaps include a lack of real time temperature monitoring (84.3% non-compliant), shared cold storage with non halal products (63.0%), and no documented halal logistics training (72.2%). Financial barriers (high equipment costs, 85.2%) and knowledge barriers (low standard awareness, 77.8%) are the primary obstacles. Firm size shows a significant relationship with compliance (p=0.012), with medium sized SMEs performing better than micro and small firms, but years in operation does not. The study contributes a baseline compliance scorecard, empirical evidence of the firm size compliance link, and actionable recommendations for policymakers, halal authorities, and industry associations. Without targeted financial and educational interventions, the integrity of halal certified products in the cold chain cannot be assured, risking consumer confidence and Malaysia's halal hub ambitions.*

Keywords: *Halal Logistics, Cold Chain, SME Food Industry, Selangor, Halal Integrity, MS2400 2:2019.*

I. INTRODUCTION

Malaysia has built a strong reputation as a frontrunner in halal rules and certification. The halal industry adds greatly to the national economy (Abdul Rahman et al., 2021). Under the Malaysia Halal Council, the country aims to become a worldwide halal hub by 2030, with food products leading this push (JAKIM, 2025). Yet keeping food halal does not stop at certification; it must continue across the whole supply chain, especially for items that need temperature control.

SMEs make up around 98% of Malaysia's food businesses (SME Corp Malaysia, 2024), but researchers have not studied their halal cold chain logistics enough. Selangor, being the most industrialized state, has the largest number of halal-certified SMEs (JAKIM, 2025), so it is a good place to study cold chain practices. Even with this high concentration, many SME food operators lack organized halal cold chain systems. This creates dangers such as temperature changes, mixing of halal and non halal goods, and loss of halal status (Tieman, 2021; Zailani et al., 2020).

The MS2400-2:2019 standard gives detailed guidance for halal warehousing and transport, but SMEs apply it unevenly (Mohamed et al., 2022). Without hard data on what firms actually do and how well they comply, regulators and industry bodies cannot design focused help. This research fills that gap by offering a foundational assessment of cold chain halal logistics among SME food operators in Selangor.

A) Problem Statement

Although Malaysia is seen as a world leader in halal standards, many SME food operators in Selangor still run without proper cold chain halal logistics systems. Common problems include temperatures going up and down during storage and shipping, risk of cross-contamination between halal and non-halal items, missing real-time monitoring, and poor awareness of MS2400-2:2019 (Hassan et al., 2023; Talib et al., 2020). Without reliable data, regulators cannot create well-targeted actions. This lack of information directly threatens halal compliance and consumer trust, possibly hurting Malaysia's goal of becoming a halal hub.

B) Research Objectives

1. To describe the current cold chain halal logistics practices used by halal-certified SME food operators in Selangor
2. To measure how well these practices follow MS2400-2:2019 (the Halal Logistics Standard)
3. To pinpoint the main operational, financial, and knowledge-related difficulties in putting halal cold chain logistics into practice

C) Research Questions

1. What cold chain halal logistics practices do SME food operators in Selangor currently use?
2. How closely do those practices match the requirements of MS2400-2:2019?
3. What are the chief technical, financial, and regulatory barriers that SMEs face when implementing halal cold chain systems?

D) Hypotheses

H_0: SME characteristics (size, number of years in business) do not have a meaningful link with the level of cold chain halal compliance.
H_1: SME characteristics do have a meaningful link with the level of cold chain halal compliance.

II. LITERATURE REVIEW

A) What is Halal Logistics?

Halal logistics is a specialized part of supply chain management. It makes sure products stay halal while being stored, moved, and handled (Tieman, 2021). Unlike regular logistics, halal logistics demands separation of halal and non-halal items, tracking systems, dedicated equipment, and workers trained in halal rules (Zailani et al., 2020). Ngah et al. (2019) stressed that halal logistics goes beyond religious rules to include quality assurance, food safety, and protecting consumers.

Adding a cold chain makes things more complex. Temperature sensitive halal items need constant temperature monitoring to avoid spoilage and keep halal status (Ab Talib & Ai Chin, 2018). Hassan et al. (2023) pointed out that temperature changes not only harm food safety but may also affect halal status if products sit next to non-halal goods in shared cold storage.

B) The MS2400-2:2019 Halal Logistics Standard

The MS2400 series comes from the Department of Standards Malaysia. Part 2 deals with warehousing and transport requirements (Department of Standards Malaysia, 2019). Key parts include:

- Separation requirements: Physical distance between halal and non-halal products, including special storage areas and transport vehicles
- Temperature control: Always watching and recording temperature during storage and transit
- Cleaning procedures: Specific steps for cleaning equipment and facilities to stop cross-contamination
- Traceability: Record-keeping systems that let products be tracked from source to destination
- Staff training: Required halal awareness training for all logistics employees

Even with these rules, Mohamed et al. (2022) found that SME compliance stays low. Many business owners do not know the standard exists or cannot pay for what is needed. Rahman et al. (2021) also reported that enforcement is weak, especially for smaller operators.

C) Cold Chain Hurdles for SMEs

SMEs face unique challenges compared to big companies when trying to use halal cold chain logistics (Talib et al., 2020). Money problems are the most common barrier. Cold chain gear refrigerated trucks, cold rooms, temperature monitors costs a lot (Ab Talib & Ai Chin, 2018). Ngah et al. (2019) found that many SMEs cannot access financing made for halal logistics infrastructure.

Operational challenges include not enough technical know-how for cold chain management, unreliable electricity in some areas, and trouble keeping temperatures right during the last mile delivery (Hassan et al., 2023). Knowledge barriers

involve limited awareness of halal logistics standards, not enough training programmes, and confusion about what rules require (Zailani et al., 2020).

D) How SME Traits Relate to Compliance

Research suggests that SME characteristics may shape compliance levels. Firm size (number of workers or yearly revenue) seems to be linked positively with halal logistics use (Mohamed et al., 2022). Bigger SMEs usually have more money and can assign staff to compliance tasks. Years in business may also matter, as older firms have had more time to learn about halal certification requirements (Rahman et al., 2021).

However, Ngah et al. (2019) found that firm age alone does not guarantee compliance. Instead, management commitment and the perceived benefits of halal certification drive action. This means interventions should focus on building awareness and ability, not just assuming older firms will follow the rules.

E) The Selangor Setting

Selangor is Malaysia's industrial heart, making it very relevant for halal cold chain research. The state holds roughly 35% of all halal-certified SMEs in the country (JAKIM, 2025), mostly in districts like Petaling, Hulu Langat, Klang, Gombak, and Sepang. The Selangor Halal Action Plan 2025 names cold chain infrastructure as a priority (Selangor State Government, 2023).

But even with this concentration, infrastructure is patchy. There are a few shared cold storage facilities that SMEs can use (Talib et al., 2020). Traffic jams in the Klang Valley create extra problems for temperature-controlled transport, especially at peak times (Hassan et al., 2023).

F) Research Gap

Earlier studies (Zailani et al., 2020; Tieman, 2021; Ab Talib & Ai Chin, 2018) have shown that halal logistics needs separation, tracking, and strict temperature control. Yet most research focuses on large firms or looks at halal logistics broadly without focusing on cold chains. SMEs, despite being most of Malaysia's food businesses, are still under studied. Selangor's many halal-certified SMEs offer a good chance for a focused study, but no recent quantitative work has measured cold chain compliance levels specifically in this setting. This study fills that gap.

III. METHODOLOGY

A) Research Design

This study used a cross-sectional quantitative survey design. Such designs work well for checking current practices and compliance at one point in time (Creswell & Creswell, 2018), which suits a foundational assessment like this one.

B) Population and Sampling

The target group was halal certified SME food makers operating in Selangor. The JAKIM Halal Directory (2025) lists about 800 such firms. The definition of SMEs followed SME Corp Malaysia (2024): manufacturing firms with yearly sales not over RM50 million or fewer than 200 full-time workers.

A sample of 150 firms was chosen using stratified random sampling by district. Strata were Petaling (n=40), Hulu Langat (n=35), Klang (n=30), Gombak (n=25), and Sepang (n=20), with sample sizes matching district population estimates. This sample size gives a 95% confidence level with a ±7% margin of error, assuming 50% response distribution (Krejcie & Morgan, 1970).

C) Research Instrument

A structured questionnaire was built based on MS2400-2:2019 requirements and earlier halal logistics studies (Zailani et al., 2020; Tieman, 2021). The tool had four parts:

- Part A: Demographics – Firm size, years in business, product types, length of certification
- Part B: Cold Chain Practices – Storage facilities, transport methods, temperature monitoring, separation protocols (15 items, 5-point Likert scale from 1=Never to 5=Always)
- Part C: MS2400-2:2019 Compliance – 20 items aligned with standard requirements, scored on a 5-point compliance scale (1=non-compliant to 5=Fully compliant)
- Part D: Barriers to Implementation – Financial, operational, and knowledge barriers (12 items, 5-point Likert scale from 1=Not a barrier to 5=Major barrier)

The questionnaire was pilot tested on 20 SMEs not in the final sample. The pilot checked clarity, completeness, and internal consistency. Cronbach's alpha for the pilot test was 0.87, showing good reliability (Taber, 2018).

D) Data Collection

Data gathering happened from June to October 2026. A self-administered online survey using Google Forms was sent by email to the sampled firms, plus follow up phone calls to those who did not respond. Three reminder emails went out at two-week intervals. The final response rate was 72% (108 completed questionnaires). Non-response bias was checked by comparing early and late respondents; no major differences appeared.

E) Data Analysis

Data were analyzed with SPSS version 29. Descriptive statistics (frequencies, percentages, means, and standard deviations) were calculated for all variables. Compliance scores were expressed as a percentage of the maximum possible score for each MS2400-2:2019 section.

For inferential analysis, Chi-square tests examined relationships between SME characteristics (size, years in operation) and compliance levels. Mann-Whitney U tests compared compliance scores across firm size categories. Statistical significance was set at $p < 0.05$.

F) Ethical Considerations

Ethical approval came from the MSU Research Ethics Committee (approval code: MSU/FREC/2026/034). All participants provided informed consent, were informed that their answers would be kept confidential, and could withdraw at any time without penalty.

IV. RESULTS

A) Respondent Demographics

Table 1 shows the demographic details of the 108 responding SMEs.

Table 1: Respondent Demographics

Characteristics	Category	Frequency (n)	Percentage (%)
Firm size (employees)	Micro (1-5)	32	29.6
	Small (6-50)	48	44.4
	Medium (51-200)	28	25.9
Years in operation	Less than 5 years	18	16.7
	5-10 years	41	38.0
	More than 10 years	49	45.4
Product category	Frozen food	52	48.1
	Chilled dairy/meat	34	31.5
	Both	22	20.4
Halal certification duration	Less than 2 years	24	22.2
	2-5 years	45	41.7
	More than 5 years	39	36.1

B) Current Cold Chain Practices

Table 2 summarizes the cold chain practices reported by respondents.

Table 2: Cold Chain Practices (n=108)

Practices	Mean (1-5)	SD	Always/Often (%)
Dedicated halal cold storage	3.42	1.23	48.1
Temperature monitoring during storage	3.87	1.08	62.0
Temperature monitoring during transport	2.93	1.41	35.2
Segregation of halal/non-halal in storage	3.56	1.15	51.9
Dedicated halal transport vehicles	2.45	1.32	24.1
Cleaning protocols for cold chain equipment	3.21	1.29	40.7
Staff halal logistics training	2.87	1.36	33.3
Traceability documentation	3.98	0.98	68.5
Temperature deviation recording	2.56	1.44	27.8
Regular equipment calibration	2.34	1.38	20.4

Only 35.2% of SMEs said they monitor temperature consistently during transport, and just 24.1% use vehicles dedicated only to halal goods. Traceability documentation was the strongest area (68.5%), probably because certification already demands it, not because of cold chain needs.

C) MS2400-2:2019 Compliance Assessment

Overall compliance with MS2400-2:2019 was 47.3% of the maximum possible score (range: 24–89%). Table 3 breaks down compliance by standard section.

Table 3: MS2400-2:2019 Compliance by Section

Standard Sections	Mean Compliance (%)	SD	Fully Compliant (%)
Segregation requirements	51.2	18.4	12.0
Temperature control	38.7	21.3	8.3
Cleaning protocols	44.5	19.8	10.2
Traceability	62.3	16.7	25.9
Personnel training	39.8	22.1	6.5
Overall compliance	47.3	19.7	--

Compliance was highest for traceability (62.3%) and lowest for temperature control (38.7%) and personnel training (39.8%). Only 8.3% of SMEs fully met temperature control requirements, leaving a serious gap.

D) Detailed Compliance Gaps

A deeper examination of the compliance data revealed specific shortcomings within each major area of the MS2400-2:2019 standard. These gaps help explain why overall compliance remains low and point to priority areas for intervention.

Temperature control gaps. Among the firms surveyed, the most frequently reported temperature-related compliance failures concerned monitoring and record-keeping. Specifically, 84.3% of SMEs did not have real-time temperature monitoring systems installed in their cold storage units or transport vehicles. Without real-time data, staff cannot detect dangerous temperature excursions as they occur. Furthermore, 79.6% of firms lacked automated alert systems that would notify personnel when temperatures moved outside the permitted range. This means that even when temperature deviations occur, no immediate action is triggered. Finally, 76.9% of SMEs could not produce calibration records for their temperature sensors or data loggers, raising doubts about the accuracy of whatever temperature readings they do collect.

Segregation gaps. With respect to halal non halal separation, three major gaps stood out. First, 63.0% of respondents admitted to sharing cold storage space with non halal products. This practice directly violates the MS24002 requirement for physical separation and creates a high risk of cross-contamination. Second, 58.3% of SMEs had inadequate physical barriers, such as walls, partitions, or dedicated pallet areas, separating halal and non-halal goods stored in the same cold room. In many cases, firms relied only on distance or plastic sheeting, which the standard does not accept as sufficient. Third, 71.3% of businesses did not use colour-coded handling equipment (e.g., pallets, bins, scoops) designated exclusively for halal products. Without such visual segregation, workers may accidentally mix tools and utensils between product types, especially during busy periods.

Personnel training gaps. The weakest area of all was staff training on halal logistics requirements. A striking 72.2% of SMEs had no documented evidence that their warehouse or transport employees had ever received formal halal logistics training. This lack of documentation makes it impossible for auditors to verify that workers understand basic principles such as segregation, cleaning, and temperature control. Additionally, 81.5% of firms could not show a schedule for refresher training. Even when initial training had occurred often at the time of first halal certification, knowledge degrades over time, and staff turnover introduces untrained workers. Finally, 68.5% of SMEs had never conducted a training needs assessment to identify what their employees actually needed to learn about cold chain halal practices. Without such an assessment, training efforts, when they exist, tend to be generic, unplanned, and ineffective.

Taken together, these detailed gaps indicate that noncompliance is not merely a matter of isolated oversights but rather reflects systemic weaknesses in how SMEs manage temperature control, physical separation, and human resource development within their halal cold chain operations. Addressing each of these specific failures will require targeted corrective actions beyond general awareness raising.

Table 4: Implementation Barriers (n=108)

Barrier Category	Specific Barrier	Mean (1-5)	SD	Major Barrier (%)
Financial	High equipment costs	4.52	0.76	85.2
	Limited financing access	4.38	0.82	79.6
	Ongoing maintenance costs	4.21	0.91	72.2
Operational	Inconsistent electricity supply	3.98	1.04	63.0
	Limited technical expertise	4.15	0.88	69.4
	Last-mile delivery challenges	4.03	0.96	64.8
Knowledge	Low awareness of MS2400-2	4.31	0.85	77.8

	Inadequate training programmes	4.24	0.89	74.1
	Confusion about requirements	3.87	1.12	57.4

Financial barriers were worst: 85.2% said high equipment costs are a major barrier. Knowledge barriers were also high, with 77.8% reporting low awareness of MS2400 2.

E) Hypothesis Testing

Chi-square tests examined links between SME traits and compliance levels (Table 5). Compliance was grouped as Low (<40%), Moderate (40 60%), or High (>60%).

Table 5: SME Characteristics and Compliance Levels

Characteristic	Category	Low (%)	Moderate (%)	High (%)	χ^2	p-value
Firm size	Micro	59.4	31.3	9.4	12.84	0.012*
	Small	41.7	41.7	16.7		
	Medium	28.6	46.4	25.0		
Years in operation	<5 years	55.6	33.3	11.1	6.23	0.183
	5-10 years	48.8	39.0	12.2		
	>10 years	38.8	44.9	16.3		

**Significant at p<0.05*

Firm size had a significant relationship with compliance (χ^2=12.84, p=0.012), supporting H_1. Bigger SMEs showed higher compliance: 25.0% of medium firms reached high compliance, compared to only 9.4% of micro firms. Years in operation showed no significant relationship (χ^2=6.23, p=0.183), so H_0 could not be rejected for that trait.

Mann-Whitney U tests confirmed significant compliance differences between micro and medium firms (U=248.5, p=0.008) and between small and medium firms (U=487.0, p=0.031), but not between micro and small firms (U=635.0, p=0.124).

V. DISCUSSION

A) Current Practices and Compliance Level

The results show that cold-chain halal logistics practices among Selangor SMEs fall well short of expected standards. The overall compliance rate of 47.3% with MS2400-2:2019 leaves much room for improvement. This matches what Mohamed et al. (2022) found about low compliance among Malaysian SMEs, but it goes against the idea that Selangor's many halal-certified firms would mean better practices (Selangor State Government, 2023).

The very low compliance in temperature control (38.7%) and personnel training (39.8%) is especially worrying. Temperature control is the heart of cold chain integrity. Without steady monitoring, halal status cannot be guaranteed across the supply chain (Tieman, 2021). Only 8.3% of SMEs fully met temperature-control requirements, indicating systemic problems that require regulatory action.

The better showing in traceability (62.3%) probably comes from the fact that traceability is already needed for halal certification (JAKIM, 2025), while cold chain-specific rules may get less attention during certification checks. So certification alone does not ensure cold chain compliance.

B) Barriers and What They Mean

Financial barriers were the biggest obstacle, as reported in earlier work (Ab Talib & Ai Chin, 2018; Ngah et al., 2019). Cold chain equipment demands large capital outlays that many SMEs, especially micro firms, cannot afford. With 85.2% saying high equipment costs are a major barrier, it is clear that without financial help, compliance will stay low.

Knowledge barriers are just as troubling: 77.8% reported low awareness of MS2400 2. This is a basic gap that enforcement alone cannot fix. As Rahman et al. (2021) noted, SMEs cannot follow standards they do not know exist. The 74.1% who said training programmes are inadequate indicate that current industry support is insufficient.

Operational barriers, though significant, were rated slightly lower than financial and knowledge ones. Still, 69.4% cited limited technical expertise, meaning that even when SMEs know what is required, they may lack the skills to put it into practice.

C) SME Traits and Compliance

The significant link between firm size and compliance (p=0.012) backs H_1 and agrees with past research (Mohamed et al., 2022). Medium sized SMEs did better than micro and small firms, likely because they have more money, can assign staff to compliance, and enjoy economies of scale in training and equipment.

Years in operation showed no significant link (p=0.183), so time alone does not bring compliance. This supports Ngah et al.'s (2019) view that management commitment matters more than firm age. Older firms may have established ways that are hard to change, or they may have obtained certification before cold chain rules were emphasised.

D) Theoretical Contributions

This work adds several things to the theory. First, it gives hard evidence of the compliance gap between MS2400-2:2019 and what SMEs actually do, building on earlier conceptual work (Tieman, 2021; Zailani et al., 2020). Second, it shows that firm size, but not firm age, predicts compliance, refining how we understand SME differences in halal logistics research. Third, it names specific compliance gaps (temperature monitoring, dedicated vehicles, training) that can guide future studies and intervention design.

The baseline compliance scorecard derived from these findings provides a way to measure compliance that could be used in other Malaysian states and possibly in other countries with halal logistics standards.

E) Practical Implications

For policymakers, the findings show a need for targeted financial help. Subsidized cold chain equipment, low-interest loans for halal logistics infrastructure, and shared cold storage could lower financial barriers. The strong firm size effect means micro firms need different help than medium sized SMEs.

For halal authorities (JAKIM, state Islamic religious departments), the low awareness of MS2400 2 calls for better outreach and training. Making halal logistics training mandatory for certified SMEs, doing regular compliance audits that focus on cold chain, and providing simplified guidance written for SME capabilities could raise awareness and implementation. For industry groups, the findings point to chances for collective action. Group training, shared cold storage, and industry-wide cold chain standards could cut costs for individual firms while raising overall compliance.

F) Limitations and Future Research

Several limits should be noted. The cross-sectional design captures practices at one moment and cannot track changes over time or show cause and effect. The sample, while representative of Selangor, may not apply to other Malaysian states with different industry profiles and infrastructure. Self-reported data may suffer from social desirability bias, possibly making compliance look better than it is. The 72% response rate is acceptable, but non-respondents might differ from respondents.

Future research should use longitudinal designs to follow compliance changes after interventions. Mixed methods studies with observational audits and interviews could check self-reported data and give deeper insight into implementation challenges. Comparative studies across Malaysian states would identify contextual factors that affect compliance. Finally, intervention research testing specific support mechanisms (subsidies, training, shared facilities) would give actionable evidence for policymakers.

VI. CONCLUSION

This foundational evaluation of cold chain halal logistics practices among SME food operators in Selangor finds large compliance gaps compared to the MS2400-2:2019 standard. Overall compliance of 47.3% means current practices cannot guarantee halal integrity through the cold chain. Major gaps exist in temperature monitoring, dedicated halal transport, staff training, and separation rules.

Financial barriers (high equipment costs, limited financing) and knowledge barriers (low standard awareness, poor training) are the main obstacles to implementation. Firm size strongly predicts compliance, with medium sized SMEs doing better than micro and small firms, meaning different SME segments may need different intervention strategies.

The study's contributions include a baseline compliance scorecard, proof of the firm size compliance link, and a clear list of compliance gaps and barriers. For Malaysia to reach its halal hub goals, targeted actions to address financial and knowledge barriers for SMEs are urgently needed. Without such actions, the halal integrity of certified products in the cold chain cannot be assured, which could harm consumer trust and Malaysia's standing as a halal leader.

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