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Veterinary laboratories as a strategic mechanism for public health protection and halal industry development in Brunei Darussalam

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Abstract

The concept of *halalan toyyiban* emphasises that food products must not only comply with halal requirements but also be safe, wholesome, and of good quality. Veterinary laboratories contribute to this principle through scientific testing that supports food safety, public health, and halal assurance. This study aimed to examine the role of Veterinary Laboratory Services (VLS) in safeguarding public health and supporting halal assurance in Brunei Darussalam. A qualitative approach was used, involving semi-structured interviews with six participants, including VLS personnel and an industry representative. Thematic analysis revealed that VLS supports public health through disease surveillance, microbiological testing, molecular analysis, and food safety assessment. Although VLS does not perform halal certification, its laboratory services provide scientific evidence that strengthens halal integrity. Challenges related to human resources, resources, equipment, and accreditation were also identified.

1. Introduction

The concept of *halalan toyyiban* is deeply rooted in food safety standards and Islamic jurisprudence (Musfirah *et al.*, 2015; Maulana, 2020). It emphasises that food must not only be halal according to Islamic guidelines but also *toyyib*, meaning it must be clean, safe, wholesome, and not harmful to human health (Al-Teinaz *et al.*, 2020). Hence, food safety is seen as both a scientific concern and a religious requirement, particularly in Muslim-majority countries such as Brunei Darussalam. To meet these expectations, it is essential to adhere to safe food practices and have credible quality control procedures.

In modern food governance, assurance systems increasingly rely on scientific evidence generated through laboratory testing. Veterinary laboratories play an important role in this framework by supporting disease surveillance, diagnostic testing, and food safety assurance at the interface between animal and human health. Beyond disease detection, veterinary laboratories provide analytical services, including microbiological testing, chemical residue analysis, and contaminant monitoring of animal-derived products, thereby contributing to public health protection and the One Health approach (WHO, 2023). Through these functions, veterinary laboratories serve as important components of national health security systems by enabling early detection, risk assessment, and prevention of foodborne and zoonotic hazards.

The role of veterinary laboratories is also increasingly relevant within halal food systems as global consumers demand products that are not only religiously compliant but also safe, authentic, and of high quality. Laboratory testing complements halal certification by providing scientific evidence for verifying product safety, authenticity, and potential contamination risks. Techniques such as microbiological analysis, chemical residue testing, and PCR-based species identification can detect food safety hazards and species substitution, thereby strengthening traceability, transparency, and consumer confidence in halal products.

In Brunei Darussalam, Veterinary Laboratory Services (VLS) serves as the country's national veterinary laboratory under the Veterinary Laboratory Section, Division of Livestock Industry, Department of Agriculture and Agrifood (DoAA), Ministry of Primary Resources and Tourism (MPRT). VLS supports animal health, livestock development, food safety, and public health through specialised services including animal diagnostics, veterinary public health, feed and biotechnology, and Salmonella reference testing. Its laboratory services include microbiological analysis, molecular testing, serological testing, chemical residue detection, nutritional analysis, and disease surveillance. VLS is accredited under ISO/IEC 17025:2017 for selected chemical and biological testing scopes by SAC-SINGLAS, Singapore, a recognition it has maintained since 2012 (VLS Testing Booklet, 2021).

According to the VLS Testing Booklet (2021), VLS is organised into several specialised sub-units, each focusing on a specific

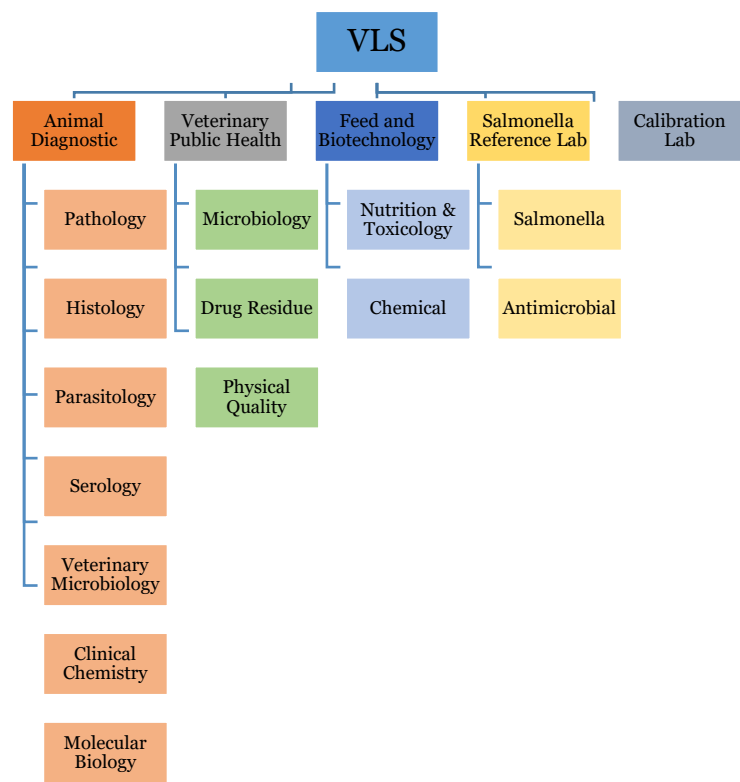


Figure 1: Organisational structure and functional areas of VLS.

aspect of veterinary diagnostics and public health support. The organisational structure and functional areas of these specialised sub-units are illustrated in Figure 1.

Although VLS does not directly conduct halal certification, its laboratory services indirectly support halal assurance by providing scientific evidence related to food safety and product authenticity. Within Brunei's halal governance system, halal certification is administered by the Halal Food Control Division (BKMh), which operates under policies issued by the Ministry of Religious Affairs (Kifli, 2023), while the technical and scientific support is provided by institutions such as VLS, the Department of Scientific Services (DSS), and the Brunei Darussalam Food Authority (BDFA) (VLS Testing Booklet 2021; BDFA, 2022). This demonstrates that halal assurance involves collaboration between religious authorities, regulatory agencies, and scientific institutions.

Despite the recognised importance of veterinary laboratories in food safety and public health, existing studies on halal assurance have largely focused on certification systems, regulatory compliance, consumer behaviour, and food safety management. Meanwhile, veterinary laboratory research has mainly focused on disease surveillance, animal health, and diagnostic services within the One Health framework. Limited attention has been given to veterinary laboratories as scientific institutions that indirectly strengthen halal assurance through laboratory verification, surveillance, and food safety testing. This gap is particularly relevant in Brunei Darussalam, where VLS serves as the country's only national veterinary laboratory supporting animal health, food safety, and public health.

Given the limited empirical evidence on the institutional role of veterinary laboratories in halal assurance, a qualitative

approach is particularly appropriate for exploring the experiences, practices, and challenges of VLS personnel and industry stakeholders. This approach enables a deeper understanding of how laboratory services contribute to halal assurance and public health protection within the Brunei context.

Therefore, this study aims to examine the role of Veterinary Laboratory Services (VLS) in safeguarding public health and supporting the development of the halal industry in Brunei Darussalam. Specifically, this study explores (1) how VLS contributes to public health protection, (2) how laboratory testing indirectly supports halal integrity, and (3) the conditions required for VLS further to support Brunei's aspiration as a global halal hub.

2. Materials and methods

2.1 Research design

This study adopted a qualitative research design (Islam & Aldaihani, 2022) to explore the roles, contributions, and challenges of VLS in safeguarding public health and supporting halal assurance in Brunei Darussalam. A qualitative approach was selected because the study aimed to understand participants' professional experiences, institutional practices, and perceptions, which cannot be adequately captured through quantitative measurement. Through semi-structured open-ended interviews, the study obtained detailed insights into VLS operations, inter-agency collaboration, and challenges affecting its contribution to halal assurance.

2.2 Research sample

The study targeted VLS laboratory personnel directly involved in public health and halal assurance-related testing, as well as one industry representative with experience submitting samples to VLS. These participants were selected because their professional experiences and insights provided a first-hand understanding of how VLS contributes to food safety, public health, and halal assurance in Brunei Darussalam.

Purposive sampling was used in this study, with participants selected based on their professional roles, experience, and direct involvement in VLS operations. The inclusion criteria required participants to be currently employed at VLS or directly involved with VLS services, actively involved in laboratory testing, supervision, or decision-making related to animal health, food safety, or halal compliance, and willing to participate voluntarily in the study. A total of six participants were involved in this study, comprising five VLS personnel and one industry representative.

The selected participants represented major functional subunits and decision-making levels within the laboratory, enabling the study to gather informed, relevant perspectives aligned with the research objectives. The sample size was considered appropriate because this study was exploratory in nature and focused on an in-depth investigation of a single national veterinary laboratory in Brunei Darussalam rather than statistical generalisation. As VLS is a specialised government institution with a limited number of personnel directly involved in relevant laboratory functions, the selected participants provided sufficient depth and contextual coverage to address the research objectives meaningfully.

Data saturation was considered achieved when subsequent interviews no longer generated new information, codes, or themes relevant to the research objectives. Following the completion and review of the six interviews, no substantially new themes emerged, indicating that sufficient depth had been achieved to address the study's aims. This approach is consistent with the concept of data saturation, in which data collection may cease when additional interviews no longer yield new insights (Guest *et al.*, 2006, as cited in Islam & Aldaihani, 2022).

2.3 Data collection procedure

Data were collected through open-ended, semi-structured interviews, which allowed predetermined questions to guide the discussion while providing flexibility to explore additional insights from participants. Interviews with VLS were conducted in person and lasted approximately 30-45 minutes per session, while the industry representative participated via a separate interview.

The primary research instrument was an interview guide. It began by gathering background information on the participants' experiences and roles at VLS, followed by questions on laboratory testing activities, contributions towards public health and halal assurance, operational challenges, and future directions for VLS. All interview questions were open-ended, allowing participants to share their experiences, perspectives, and opinions in detail.

To ensure ethical research practices, participants were informed of the study's purpose, confidentiality procedures, and voluntary participation before the interviews were

conducted. Written informed consent was obtained prior to the interviews, and participants were informed that they could withdraw from the study at any stage without consequences. With participants' permission, interviews were audio-recorded to ensure transcription accuracy. All recordings and transcripts were stored securely and used strictly for academic purposes.

Secondary data were also used to support the study's findings. These included official VLS publications, government policy documents, halal regulatory frameworks, and related literature relevant to veterinary laboratory services, food safety, and halal assurance. Data triangulation was also applied by comparing interview findings with documentary evidence from these secondary sources, thereby enhancing the credibility and trustworthiness of the study (Donkoh & Mensah, 2023).

2.4 Data analysis

The collected data were analysed using thematic analysis following the six-step framework proposed by Braun and Clarke (2006, as cited in Ahmed *et al.*, 2025). This method enabled the systematic identification, examination, and reporting of recurring themes within the interview data. Interview transcripts and participant responses were manually reviewed and coded to identify recurring ideas and patterns related to VLS roles in public health protection, halal integrity, and halal industry development. The coded data were subsequently grouped into broader themes that represented the study's major findings. This approach allowed participants' experiences and perspectives to be systematically interpreted while preserving the data's overall meaning.

To enhance the trustworthiness of the analysis, coding was performed iteratively, with initial codes reviewed and refined multiple times to ensure consistency and accuracy in theme development. The interview findings were also cross-checked against secondary sources, including official VLS publications, government policy documents, and halal regulatory frameworks, to strengthen their credibility through data triangulation.

The analysis followed a systematic progression from familiarisation with the data, to the generation of initial codes, to searching for themes, to reviewing themes, to defining and naming themes, and to producing the final report in accordance with Braun and Clarke's (2006, as cited in Ahmed *et al.*, 2025) thematic analysis framework.

3. Results and discussion

3.1 Overview of qualitative findings

The findings were derived from semi-structured interviews with six participants, including five VLS officers and one representative from the food industry. The participants were selected based on their direct experience in food safety, veterinary testing, and halal assurance, providing valuable insights into VLS's role and operations in Brunei Darussalam.

To maintain confidentiality, the identities of all participants were anonymised and assigned specific codes (R1-R6) for reporting and analysis purposes, as presented in Table 1. The selected participants represented different roles and functional areas related to VLS operations, including laboratory testing, management, and industry engagement.

Table 1: Respondent profile

Respondent	Code	Organisation/Sub-unit	Years of Experience
Respondent 1	R1	Animal Diagnostic & Veterinary Public Health	26 years
Respondent 2	R2	Animal Diagnostic, Feed & Biotechnology, Salmonella Reference Lab	15 years
Respondent 3	R3	Animal Diagnostic & Veterinary Public Health	12 years
Respondent 4	R4	Animal Diagnostic & Salmonella Reference Lab	15 years
Respondent 5	R5	Overall Laboratory Management	23 years
Respondent 6	R6	Food Industry Representative	28 years

The data were analysed using thematic analysis to identify key themes and recurring patterns across the interviews. The findings are presented based on the main themes that emerged from the analysis and are discussed in relation to the role of VLS in public health protection, halal assurance, operational challenges, and future development.

3.2 VLS as a safeguard for public health

Respondents perceived that VLS plays an important role in safeguarding public health in Brunei Darussalam through comprehensive diagnostic, analytical, and monitoring activities that ensure food safety, animal health, and disease control. Rather than operating in isolation, the work of VLS was reported by respondents to support national animal health programmes, food safety regulation, and public health protection by preventing biological, chemical, and nutritional hazards from reaching consumers.

The findings indicate that VLS contributes to public health through several laboratory functions, including microbiological testing, disease surveillance, residue testing, nutritional analysis, and molecular testing. These activities help ensure that animal-based products are safe, clean, and suitable for consumption. R1 highlighted the importance of microbiological testing in preventing harmful contaminants from reaching consumers:

"For MCL, livestock products are analysed to ensure they are clean, safe for sale and consumption by the public. We ensure that the products are free from bacteria such as Salmonella, Listeria monocytogenes, Campylobacter, E. coli, coliform, and Staphylococcus aureus. This monitoring is important so that harmful bacteria do not reach consumers."

These findings are consistent with broader functions of veterinary laboratories, which extend beyond disease diagnostics to include food safety testing, disease surveillance, and other analytical services that support both animal and public health (Marrana *et al.*, 2022). In the context of Brunei Darussalam, these functions are reflected in the services provided by VLS, where microbiological testing contributes to monitoring potential foodborne hazards and supports preventive measures within the national food safety system (VLS Testing Booklet, 2021).

Similarly, R2 explained that VLS contributes to public health protection through disease monitoring, antimicrobial

guidance, and nutritional analysis:

"At VML, we conduct Salmonella testing to monitor livestock farms in Brunei. The aim is to ensure that the farms are free of Salmonella or have controlled levels of it. At SAL/AML, we determine the appropriate antibiotics to use for Salmonella infection, including the appropriate dosage. This helps control the disease and avoid the misuse of antibiotics."

Beyond laboratory diagnostics, respondents indicated that VLS outputs also support regulatory processes within national food safety and animal health systems. R5 highlighted that VLS functions as part of national efforts to maintain food safety and public health:

"This laboratory is under the DoAA, and VLS supports the department's mission to maintain public safety and health through the control of infectious diseases. This effort is in line with Brunei's 2035 Vision, as public health and food safety contribute to the economic stability and well-being of the country."

The presence of systematic disease surveillance and laboratory monitoring supports decision-making by relevant authorities in managing food safety risks and implementing appropriate control measures. Overall, VLS was perceived as a preventive mechanism within Brunei's food system. Its role is not only to conduct laboratory analysis, but also to support early detection, risk reduction, and consumer safety.

3.3 Laboratory testing as support for halal standards

Findings from the interviews showed that veterinary laboratory testing plays a role in supporting halal standards in Brunei, particularly through halal authenticity and safety assurance. Although VLS does not conduct halal certification, respondents perceived that laboratory testing contributed to halal assurance by providing scientific evidence to verify product authenticity, detect contamination, and strengthen confidence in halal products.

One of the key contributions highlighted by the respondents was the use of molecular-based testing, particularly meat speciation analysis, to identify animal species in food products. R1 explained:

"For MBL, one of the tests that really supports halal is meat speciation. Usually, the samples that we received, we need to

ensure the absence of pork DNA or other prohibited species indicators, besides ensuring that it is free from any disease..."

Similarly, R4 emphasised that meat speciation testing supports halal assurance by verifying the authenticity of animal-based products:

"For VLS, most of the halal-related tests are at MBL. They do meat speciation, which can identify species in a product. If the meat is not pure, this test will show it in its result. Therefore, it really helps support the halal industry in Brunei."

Respondents further suggested that halal-related laboratory testing could be expanded beyond meat speciation to strengthen halal assurance in Brunei. R5 emphasised the need to reinforce halal-related testing by stating:

"...We strongly support halal not only from a health perspective, but also from the perspective of Qur'an and Hadith. To improve, we need to strengthen the halal laws further and ensure that more halal-related tests are carried out and strengthened."

However, before adding more tests to improve the halal testing, R3 emphasised the need for more studies and research: "... To improve halal testing further, new tests need to be added. But before adding tests, we need more studies and research."

Overall, the findings indicate that VLS supports halal assurance through scientific verification rather than direct halal certification. By providing reliable laboratory evidence on food safety and product authenticity, VLS strengthens halal integrity and contributes to greater confidence in halal products.

3.4 Challenges faced by VLS personnel

The findings identified several operational and institutional challenges faced by VLS personnel. These include resource and material constraints, workload pressure, limited specialised personnel, technical limitations, equipment dependency, accreditation requirements, and financial constraints.

Respondents reported that shortages of laboratory materials, testing kits, and consumables may affect the ability to consistently perform certain tests. R1 highlighted that the limited availability of testing kits could interrupt laboratory activities, stating that: "Our main challenge is the shortage of kits. When we run out of stock, we must inform clients that the test cannot be performed. Sometimes we borrow from other labs if they have a surplus."

In addition to resource limitations, respondents also highlighted workload pressure due to the responsibility of managing multiple laboratory functions simultaneously. R1 and R2 explained that operating several laboratories with limited human resources creates time constraints, particularly when samples are received concurrently.

"...In addition, because we operate three labs at a time, we must run here and there to complete all the work. The workforce is the same, but the workload is high..." (R1)

"We also face the challenge of managing three laboratories. When samples come in simultaneously for all three laboratories, we must fight for time to complete each test." (R2)

The issue of workforce limitations is particularly significant in specialised laboratory settings, where testing activities often require technical expertise and competency in specific areas. Previous organisational studies suggest that insufficient staffing may increase workload demands and reduce operational efficiency within organisations (Engetou, 2017). In the context of VLS, this shortage may cause delays in processing the sample, reduced laboratory efficiency, and an overload of current staff, which may affect the validity and consistency of test results.

Technical and capacity-related limitations were also identified as important challenges. Respondents highlighted that advanced laboratory equipment requires specialised knowledge, continuous training, and proper maintenance. R3 specifically noted challenges associated with operating LC-MS/MS equipment, including its complexity and the need for additional technical competency.

"The main challenge is how to handle the machine since it is very complex and not 'straightforward'. Not only it is difficult to operate, but the maintenance is also numerous and complicated." (R3)

Furthermore, a shortage of specialised personnel and dependency on limited equipment were identified as factors affecting laboratory sustainability. R5 highlighted the need for more specialised expertise and modern equipment to ensure continuity of testing services.

"From a human resources perspective, we lack chemists and toxicologists. Currently, we only have two specialists..." (R5)

Accreditation and financial sustainability were also identified as important challenges. Maintaining ISO/IEC 17025 accreditation requires continuous investment in equipment maintenance, calibration, consumables, quality assurance activities, and staff competency development. R4 explained that maintaining accredited tests becomes challenging when resources are limited, while R5 highlighted the financial burden of maintaining accreditation.

"Our main challenge is to ensure that all the tests we have remain accredited. To do that, consumables and supplies must always be available, and all equipment must be well maintained." (R4)

"...The fourth challenge is the cost of maintaining ISO accreditation. In a year, the maintenance cost can exceed half a million." (R5)

Overall, the findings indicate that VLS's ability to support public health and halal assurance is closely connected with its operational capacity. Adequate human resources, sufficient resources, reliable equipment, continuous training, and sustainable funding are important conditions for strengthening VLS's role. These findings are comparable with earlier observations by Khalaf (1980), who identified financial limitations, inadequate laboratory infrastructure, shortage of skilled personnel, and insufficient institutional support as major constraints affecting veterinary diagnostic laboratories. Although veterinary laboratory systems have advanced through technological and management improvements, resource availability, technical expertise, and organisational support remain fundamental factors influencing the sustainability and effectiveness of laboratory services.

3.5 Future directions and strategies for VLS

Interview findings indicate that respondents generally viewed the role of VLS as likely to expand in the future, particularly in strengthening food safety, halal assurance, and export facilitation. Several strategies were suggested to improve the effectiveness and sustainability of VLS operations, including strengthening human resources, expanding laboratory testing capacity, improving technical competency, and enhancing industry support.

One of the key strategies identified was strengthening human resources. Respondents highlighted that additional skilled personnel and specialised experts would help improve laboratory efficiency, reduce workload, and allow staff to focus more effectively on specific laboratory functions. R1 noted that the large number of laboratories within VLS requires sufficient staffing to maintain effective operations.

"In terms of improvement, VLS does need more staff. The laboratory is large and has many small laboratories, as the number of existing staff is still not enough." (R1)

Similarly, R4 emphasised that additional qualified experts would enable staff to specialise in specific laboratory areas, thereby improving work quality and supporting the expansion of testing services.

"If a laboratory technician only focuses on one laboratory, the quality of work can be improved. Currently, operating multiple laboratories with one staff is quite challenging..." (R4)

Another important future direction identified was the expansion of laboratory testing capacity, particularly accredited tests. Respondents suggested that expanding testing could strengthen halal assurance and food safety beyond existing services. R1 highlighted the potential to expand halal-related testing beyond meat speciation, while R2 suggested extending testing coverage to processed animal-based products.

"...halal testing can also be improved, not just meat speciation, but by adding other types of halal testing." (R1)

"...In terms of improvement, halal testing and the role of VLS can be expanded not only to raw meat, but also to processed products such as sausages and canned food." (R2)

Participants also emphasised that expansion of testing services requires adequate financial support, specialised expertise, and continuous competency development. R3 noted that although additional tests could strengthen VLS's contribution, further studies and cost considerations are necessary before implementation.

"...However, the addition of tests requires a larger budget. Before making these tests mandatory, further studies should be conducted to ensure that the tests are cost-effective." (R3)

The need for continuous capacity development identified by respondents is consistent with international approaches for strengthening veterinary services. According to VLS (2023), adopting the Performance of Veterinary Services (PVS) Gap Analysis framework developed by the World Organisation for Animal Health (WOAH) represents a strategic approach for strengthening veterinary services. The PVS Gap Analysis

provides a systematic evaluation of veterinary service performance against international standards and forms part of the broader PVS Pathway, which guides veterinary services through structured stages of orientation, evaluation, planning, and targeted support for capacity improvement (OIE PVS Pathway Secretary, 2018).

In the context of VLS, this framework may serve as a useful reference for identifying operational gaps and prioritising areas for improvement, particularly in workforce capacity, technical competency, laboratory infrastructure, and service sustainability. Such an assessment-based approach may support the continuous strengthening of VLS and enhance its ability to contribute to animal health, food safety, and halal assurance in Brunei Darussalam.

From the industry perspective, R6 highlighted that VLS testing provides important support in maintaining food safety, hygiene, and halal integrity within food processing operations. However, further improvements could include clearer communication, technical guidance, faster turnaround times, and stronger engagement between VLS and industry stakeholders.

"VLS already provides valuable support, but there are several areas where their assistance could be further strengthened to help companies maintain halal integrity and food safety.... enhanced guidance, clearer communication, and more structured support from VLS would help companies strengthen their halal assurance systems and maintain high food safety standards more effectively." (R6)

Overall, the findings suggest that the future development of VLS depends on continuous investment in human resources, laboratory capacity, accreditation, technological advancement, and stronger collaboration with industry stakeholders. These improvements may further strengthen VLS's contribution to public health and halal assurance in Brunei Darussalam.

3.6 VLS as a technical pillar in Brunei's halal industry development

Respondents highlighted VLS as an enabling institution that supports Brunei's halal assurance ecosystem by providing scientific evidence for product safety, authenticity, and compliance. The findings indicated that laboratory testing, particularly meat speciation and other food-safety-related analyses, helps strengthen consumer trust and maintain the integrity of animal-based products.

Although VLS does not directly issue halal certification, its laboratory services provide technical support that complements the halal certification process. Through scientific verification, VLS helps detect potential risks, such as species adulteration, contamination, and food safety hazards, thereby supporting transparency and trust within the halal supply chain.

The findings further suggest that VLS's contribution to the development of the halal industry depends on its operational capacity and institutional support. Participants identified several factors that influence VLS's ability to expand its role, including sufficient human resources, specialised expertise, laboratory resources, equipment capacity, accreditation scope, inter-agency collaboration, and sustainable financial support. These conditions are important to ensure that VLS can

continue providing reliable scientific evidence to support halal assurance and public health protection.

Strengthening laboratory capacity and expanding testing services may further enhance Brunei's halal ecosystem by providing stronger scientific assurance for both domestic and export markets. The availability of reliable, accredited testing facilities may foster greater confidence among industry stakeholders and consumers in the authenticity and safety of halal products.

Furthermore, respondents noted that strengthening regional collaboration and alignment with international halal standards could further enhance the credibility and competitiveness of Brunei's halal ecosystem.

Overall, VLS can be understood as a technical pillar within Brunei's wider halal governance ecosystem. Its contribution extends beyond laboratory testing alone, as it provides scientific support that strengthens halal assurance, public confidence, and the credibility of Brunei's halal industry. However, the full potential of VLS depends on continuous investment, organisational support, and stronger coordination among relevant stakeholders.

4. Conclusion

This study explored the role of Veterinary Laboratory Services (VLS) in supporting public health protection and halal assurance in Brunei Darussalam. The findings demonstrate that VLS serves as an important technical institution within the broader halal governance ecosystem by providing scientific evidence to support food safety, product authenticity, and regulatory decision-making. While VLS does not perform halal certification, its laboratory activities complement halal assurance systems by strengthening verification processes through scientific testing.

From a theoretical perspective, this study contributes to understanding halal governance by highlighting that halal assurance extends beyond certification mechanisms and requires integration among religious, regulatory, and scientific institutions. The findings reinforce the concept of *halalan toyyiban* by demonstrating that laboratory-based verification contributes not only to halal authenticity but also to the safety, quality, and wholesomeness aspects of food products.

From a policy perspective, the findings suggest that strengthening veterinary laboratory capacity should be considered an important component of national food safety and halal strategies. Policymakers may consider supporting VLS through sustainable funding, workplace development, equipment improvement, and stronger coordination between relevant agencies involved in food safety and halal governance. Enhancing laboratory capacity may improve national preparedness to manage food safety risks, zoonotic diseases, and the growing demand for halal assurance.

For halal regulatory and accreditation agencies, the findings highlight the importance of recognising scientific laboratories as supporting partners within halal assurance frameworks. Greater collaboration among laboratories, halal certification bodies, and industry stakeholders may strengthen the reliability, transparency, and credibility of halal verification systems, particularly for animal-based products.

However, this study has several limitations. The findings were based on a small number of participants from a single veterinary laboratory. They primarily reflected the experiences and perceptions of VLS personnel, with limited representation from industry and other regulatory stakeholders. Therefore, the findings should be interpreted within the institutional context of VLS and are not intended for statistical generalisation. Future studies may involve a broader range of stakeholders, including halal certification authorities, government agencies, industry representatives, and consumers. Comparative studies involving veterinary laboratories across ASEAN or other halal-producing countries may also provide further insights into best practices and the role of scientific institutions in strengthening halal assurance systems.

Overall, this study acknowledges Brunei's aspiration to position itself as a leading halal hub; however, the evidence is qualitative and perception-based, derived primarily from VLS personnel and a single industry representative. Therefore, the findings do not represent a national-level determination of halal hub readiness. Instead, this study identifies the perceived enabling roles of VLS in providing scientific assurance, supporting risk detection, and strengthening compliance within the halal governance ecosystem.

Although VLS alone cannot determine the readiness or competitiveness of Brunei's halal industry, its contribution as a technical pillar remains significant. The effectiveness and scalability of its role depend on several factors, including interagency integration, industry adoption, regulatory support, and sustained investment in laboratory capacity. Addressing constraints related to resource availability, equipment dependency, accreditation requirements, and technical expertise may further strengthen VLS's ability to support halal assurance and public health protection.

Overall, VLS provides essential scientific support that strengthens halal standards, safeguards public health, and contributes to the development of a credible and sustainable halal assurance system in Brunei Darussalam.

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6. Conflict of interest

The authors declare no competing interests.

7. AI declaration

Artificial Intelligence (AI) tools, including ChatGPT (OpenAI, San Francisco, CA), were used to assist with language editing, improve sentence structure, and clarify grammar during manuscript preparation. The authors reviewed, verified, and take full responsibility for the accuracy and integrity of the content. No AI tools were used for data analysis, result interpretation, or scientific conclusions.

8. Open access

The article will be published under the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0), allowing others to share and adapt the work for non-commercial purposes, with appropriate credit.

9. Author contribution

Author 1: project administration, conceptualisation, methodology, formal analysis, investigation, data curation, writing original draft preparation, writing, reviewing, and editing.

Author 2: supervision, critical review, editing, and guidance in refining the manuscript, including providing feedback on structure, clarity, and academic content.

References

- Ahmed, S., Mohammed, R.A., Nashwan, A.J., Ibrahim, R.H., Abdalla, A.Q., M. Ameen, B.M., & Khedhir, R.M. (2025). Using thematic analysis in qualitative research. *Journal of Medicine, Surgery, and Public Health* Volume 6. <https://doi.org/10.1016/j.glmedi.2025.100198>
- Al-Teinaz, Y., Spear, S., & Abd El-Rahim, I. (2020). The halal food handbook. <https://doi.org/10.1002/9781118823026>
- Brunei Darussalam Food Authority. (2022). About. <https://bdfa.gov.bn/about/>
- Department of Agriculture and Agrifood, Brunei Darussalam. (2021). Veterinary Laboratory Services (VLS) testing booklet. Ministry of Primary Resources and Tourism.
- Donkoh, S., & Mensah, J. (2023). Application of triangulation in qualitative research. *Journal of Applied Biotechnology and Bioengineering*, 10(1), 6–9.
- Engetou, M.E. (2017). Impact of insufficient personnel on organizational performance (Bachelor's thesis, Centria University of Applied Sciences).
- Islam, M. A., & Aldaihani, F. M. F. (2022). Justification for adopting qualitative research method, research approaches, sampling strategy, sample size, interview method, saturation, and data analysis. *Journal of International Business and Management*.
- Khalaf, A. M. (1980). Problems associated with veterinary laboratory diagnosis in developing countries. Proceedings of the 2nd International Symposium of Veterinary Laboratory Diagnosticians. Lucerne, Switzerland.
- Kifli, S. N. (2023). Halal certification in Brunei Darussalam: Bureaucratisation in everyday life. In *Representing Brunei Darussalam: A sociology of the everyday*.
- Marrana, M., Appiah, E., Jeannin, M., Gilbert, W., Nilsson, A., Hamilton, K. & Rushton, J. (2022). Reporting on 16 years of laboratory capacity building while exploring the future of WOA's Laboratory Twinning Programme. *Front. Vet. Sci.* doi: 10.3389/fvets.2022.1058335
- Maulana, A. (2020). The term "*toyib*" in correlation with foods (Undergraduate thesis, UIN Walisongo Semarang).
- Musfirah, S., Man, S., & Ramli, M. A. (2015). Food safety from the perspective of Islamic law. *Jurnal Fiqh*, 1, 1–28.
- Nugraha, A. (2025). The rise of the global halal industry: Trends and key sectors for future direction. *Islamic Business Review*.
- OIE PVS Pathway Secretary. (2018, February). A paper presented during PVS Pathway Orientation Workshop for South Asia and Mongolia. https://rr-asia.woah.org/app/uploads/2020/05/2_overview-of-the-pvs-pathway.pdf
- Sekretariat Tetap Wawasan Brunei (2035). Jabatan Perdana Menteri. (2020). Wawasan Brunei 2035.
- Veterinary Laboratory Services. (2023). A paper presented during the SEACFMD Laboratory Network Meeting. <https://rr-asia.woah.org/app/uploads/2023/11/1-13-brunei.pdf>
- World Health Organization. (2023). One Health. <https://www.who.int/news-room/fact-sheets/detail/one-health>
- World Organisation for Animal Health. (2008). The role of veterinary services in food safety. <https://www.woah.org/app/uploads/2008/09/en-role-des-services-veterinaires-securite-sanitaire-des-aliments>