

## Public Health Response to a Paralytic Shellfish Poisoning (PSP) Outbreak in Port Dickson, Negeri Sembilan

Fadzilah Abdullah<sup>1</sup>, Esther Rishma Sundram<sup>2</sup>, Guganesan Krishnanmoorthy<sup>3\*</sup> , Muhammad Nor Hasif Ismail<sup>4</sup>, Nik Zulkifli Amin Hashim<sup>5</sup>, Murugan Sinniah<sup>6</sup>

<sup>1</sup>District Health Office Port Dickson, KM11 Jalan Pantai, 71050 Port Dickson, Negeri Sembilan, Malaysia  
Email: fadzilah.a@moh.gov.my

<sup>2</sup>District Health Office Port Dickson, KM11 Jalan Pantai, 71050 Port Dickson, Negeri Sembilan, Malaysia  
Email: estherishma@gmail.com

<sup>3</sup>District Health Office Seremban, Jalan Lee Sam, 70590 Seremban, Negeri Sembilan, Malaysia  
Email: kguganesan@yahoo.com

<sup>4</sup>District Health Office Port Dickson, KM11 Jalan Pantai, 71050 Port Dickson, Negeri Sembilan, Malaysia  
Email: dr.hasif@moh.gov.my

<sup>5</sup>District Health Office Port Dickson, KM11 Jalan Pantai, 71050 Port Dickson, Negeri Sembilan, Malaysia  
Email: nikzul6566@gmail.com

<sup>6</sup>District Health Office Port Dickson, KM11 Jalan Pantai, 71050 Port Dickson, Negeri Sembilan, Malaysia  
Email: murugan58020@gmail.com

### ABSTRACT

#### CORRESPONDING

#### AUTHOR (\*):

Guganesan Krishnanmoorthy  
(kguganesan@yahoo.com)

#### KEYWORDS:

Paralytic Shellfish Poison (PSP)  
Outbreak  
Port Dickson  
Public Health  
Control

#### CITATION:

Fadzilah, A., Esther Rishma, S., Guganesan, K., Muhammad Nor, H. I., Nik Zulkifli, A. H., & Murugan, S. (2026). Public Health Response to a Paralytic Shellfish Poisoning (PSP) Outbreak in Port Dickson, Negeri Sembilan. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 11(6), e004056  
<https://doi.org/10.47405/mjssh.v11i6.4056>

Saxitoxin Paralytic Shellfish Poisoning (PSP) outbreaks are linked to the algal bloom of harmful dinoflagellates. This biotoxin can paralyse muscles and damage the nervous system, thus affecting human health. Excessive toxin concentrations can result in severe disease and fatalities. A retrospective descriptive outbreak investigation was conducted to describe the epidemiology and public health response to the PSP outbreak in Port Dickson. A suspected case was defined as any individual with neurological or gastrointestinal symptoms consistent with PSP following consumption of bivalve molluscs harvested from Port Dickson after 31 March 2024. The Negeri Sembilan State Health Department and State Fisheries Department initiated a joint emergency response after PSP cases were detected among individuals treated at a local hospital. The public health response complied with the Standard Operating Procedure for Potential Infectious Diseases. Data were obtained from official health and fisheries authorities and analysed using standard methods. The majority of patients experienced neurological and gastrointestinal symptoms. The contaminated shellfish and plankton samples were confirmed to contain biotoxins and pathogens. The State Health Department and State Fisheries Department undertook the necessary biosecurity measures in response to the outbreak. Among the strategies implemented were contingency planning and emergency preparedness, risk communication and public awareness, cooperation and interagency collaboration, and securing commitment and support from stakeholders. The prompt public health actions successfully prevented further PSP exposure among

the public and banned the sale and release of contaminated bivalve molluscs products.

---

**Contribution/Originality:** This study documents the epidemiological, environmental and food safety investigation of Malaysia's reported paralytic shellfish poisoning outbreak linked to mussel consumption. It highlights the importance of an integrated One Health approach in strengthening multisectoral outbreak response, fisheries surveillance, public health preparedness and risk communication.

## 1. Introduction

Paralytic Shellfish Poisoning (PSP) is an illness caused by consuming shellfish contaminated with toxic dinoflagellates. These organisms carry Saxitoxin (STX) in their tissue, which is the agent responsible for causing PSP in humans (Wiese et al., 2020). STX PSP outbreaks are typically associated with the algal blooms of toxic dinoflagellates such as *Pyrodinium bahamense*, *Gymnodinium catenatum*, and *Alexandrium* spp., which represent a significant public health hazard. In the context of mortality and severe illness, *Pyrodinium bahamense* var. *compressum* is a dangerous saxitoxin-producing dinoflagellate that can lead to paralytic shellfish poisoning, a potentially lethal condition in humans. Saxitoxin was isolated and named after the Alaskan butter clam (*Saxidomus gigantes*) in 1957 (Schantz et al., 1957). The production of toxins by these dinoflagellates is influenced by various factors, including bacterial-algal interactions, environmental conditions, and prey-predator dynamics (Flores-Moya et al., 2012; Uribe & Espejo, 2003; Yang et al., 2011).

Hallegraeff (1993) reported a global increase in the distribution of PSP. Before 1970, blooms of PSP-producing dinoflagellates, such as *Alexandrium catenella* and *Alexandrium tamarenis*, were only observed in the temperate waters of Japan, Europe, and North America. However, by 1990, PSP had become well-documented across the Southern Hemisphere, including regions like Thailand, South Africa, India, Australia, Sabah (Malaysia), Brunei Darussalam, Papua New Guinea, and the Philippines (Hallegraeff, 1993).

In Malaysia, the first reported case of PSP occurred in Kota Kinabalu, Sabah, which was caused by *Pyrodinium bahamense* var. *compressum* (Roy, 1977). The second PSP case was associated with the consumption of *Alexandrium tamiyavanichii* in Sebatu, Melaka (Lim et al., 2012; Usup et al., 2002). It triggered a ban on mussel consumption, resulting in significant losses for mussel farmers. Meanwhile, the third case was reported in Tumpat, Kelantan, which recorded one death while six others were hospitalised after consuming contaminated shellfish (Lim et al., 2004, 2006). *Alexandrium minutum* was identified as the responsible organism for this particular PSP outbreak. Finally, a PSP outbreak that occurred at Kota Kinabalu, Sabah circa 2013 resulted in 64 individuals being hospitalised and four fatalities (Jipanin et al., 2019; Suleiman et al., 2017). It was attributed to the consumption of contaminated shellfish from the nearby ocean, including oysters (*Crassostrea belcheri*), mussels (*Atrina fragilis*), and green mussels (*Perna viridis*; Suleiman et al., 2017).

PSP symptoms usually manifest within 30 minutes of consuming contaminated seafood, indicating the fast-acting nature of PSP toxins (STX). Asphyxia can kill a person three to four hours after consumption (Vilariño et al., 2018). Over 2,000 PSP cases involving

humans are recorded annually, with a 15% death rate worldwide (Cusick & Sayler, 2013). The primary symptoms of PSP include numbness in the extremities, tingling in the lips, mouth, and tongue, weakness, paraesthesia, nausea, ataxia, a dissociative or floating sensation, shortness of breath, dizziness, dysarthria, vomiting, dysphagia, and headache (Sinno-Tellier et al., 2023). Nearly all individuals exhibit hypertension in both the diastolic and systolic forms. Fluid therapy can aid in toxin elimination; however, respiratory support is the primary focus of medical treatment. Patients who survive for 24 hours, with or without breathing support, have a favourable prognosis (Wiese et al., 2020).

The occurrence of PSP incidents has prompted a comprehensive and urgent public health response to prevent its severe outcomes, which can lead to both morbidity and mortality. The limited reporting of PSP outbreaks in Peninsular Malaysia reveals a significant gap in the documentation of public health response mechanisms and interagency coordination. It justifies the need for this report to provide systematic insights into outbreak management practices, strengthen preparedness frameworks, and inform evidence-based policy development. In total, ten cases of PSP in Port Dickson, Negeri Sembilan were identified from the consumption of toxic mussels. These contaminated mussels were supplied from two breeding areas in Pasir Panjang, namely Kampung Sungai Sekawang and Kampung Telok (see Figure 1).

Figure 1: Map of mussel breeding areas in Pasir Panjang, Port Dickson, covering approximately 2 hectares



Note: "hektar" is the Malay term for hectare (ha)

## 2. Materials and Methods

This paper reports the public health response to the outbreak of Paralytic Shellfish Poisoning (PSP) in Port Dickson. It details the workflow from case verification to the implementation of strategies to prevent and control the epidemic.

A retrospective descriptive outbreak investigation was conducted to describe the epidemiology of the outbreak and the implementation of public health responses among the public in Port Dickson, Negeri Sembilan. The public health activities and procedures were conducted based on the Infectious Diseases Outbreak Rapid Response Manual (Disease Control Division, 2003). All procedures in studies involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its subsequent amendments, or with comparable ethical standards. Ethical registration was obtained from the National Medical Research Register [Reference no: NMRR ID-24-02513-7C1].

During the abovementioned outbreak, a suspected PSP case was defined as any individual who demonstrated one or more of the following symptoms: numbness in the extremities; tingling of the lips, mouth, and tongue; weakness; paraesthesia; ataxia; nausea; a floating or dissociative sensation; shortness of breath; vomiting; dizziness; difficulty swallowing (dysphagia); and difficulty speaking (dysarthria), with a history of bivalve mollusc consumption (such as oysters, clams, cockles, or mussels) harvested from a shellfish farm located in Port Dickson after 31 March 2024.

Four key strategies were implemented to control the public's exposure to the source of PSP toxin: (i) Emergency Preparedness and Contingency Planning, (ii) Public Awareness and Risk Communication, (iii) Interagency Collaboration and Cooperation, and (iv) Stakeholder Commitment and Support.

### **2.1. Emergency Preparedness and Contingency Plan**

Emergency preparedness in Negeri Sembilan involves ongoing efforts by all health facilities, including the Negeri Sembilan State Department, hospitals, district health offices, and health clinics. Preparedness is assessed annually through simulation exercises to ensure a rapid response and effective coordination during any health-related events or emergencies. On 2 April 2024, the Negeri Sembilan Health Department was immediately alerted when the Port Dickson District Health Office was notified by the Port Dickson Hospital about five patients admitted with PSP symptoms, including two in the Intensive Care Unit (ICU). Subsequently, the State and District Operation Rooms were activated to centralise command and coordinate response efforts, including intra and inter-agency activities.

The State Fisheries Department of Negeri Sembilan was informed about this incident and investigations were conducted immediately. A prompt press release was issued to the public advising them to avoid consuming mussels. As a strategic measure, the State Fisheries Department restricted the movement of shellfish and their products from the affected waters. This was done in accordance with Council Directive 91/492/EEC, which outlines health conditions for the production and marketing of live bivalve molluscs. The directive mandates safety measures during all stages of handling, harvesting, transport, storage, and distribution to protect public health. Council Directive 91/492/EEC was used as an international reference benchmark amid the absence of a specific local regulatory framework for shellfish sanitation.

Additionally, active case finding was conducted as part of the prevention efforts both in the community and across healthcare facilities. However, no additional cases were identified beyond those already detected through routine passive surveillance. Health education was promoted through multiple channels, including face-to-face interactions, mass media, and social media. Posters were placed at market entrances to warn the public about the dangers of toxic shellfish. Health clinics and hospitals were alerted to notify the presence of patients with PSP symptoms to the District Health Office.

To identify the causative agent, clinical samples were sent to the National Public Health Laboratory in Sungai Buloh, Selangor. Samples included stool cultures for *Salmonella* spp and *V. cholera*, rectal swabs for *Vibrio vulnificus/cholera/salmonella*, blood culture, and Hepatitis A. Unfortunately, clinical samples were not sent for biotoxins due to the lack of an available lab that could perform the test.

For food samples, both agencies sent mussel samples to two different labs. Samples of cooked mussels taken by the Food Safety and Quality Division of Port Dickson Health Office were sent to the National Public Health Laboratory in Sungai Buloh, Selangor for biological tests to detect *Vibrio*, primarily *Parahaemolyticus*. Meanwhile, fresh and cooked mussel samples taken by the State Fisheries Department were sent to the Biosecurity Lab.

## **2.2. Public Awareness and Risk Communication**

To raise public awareness, risk communication about Paralytic Shellfish Poisoning (PSP) was crucial to help people make informed decisions that could safeguard their health. This communication was directed towards the community, fisheries staff, and healthcare workers to share and exchange information in real time. The key messages included the risks of exposure, symptoms of PSP, the need for product restrictions, and addressing any questions or concerns. Additionally, risk communicators worked to prevent public panic and correct any rumours or misinformation. Press statements from the State Fisheries Department and State Health Department were distributed to the public. Public awareness efforts included the use of mass and social media as well as conducting health education sessions in public places like markets. Social media platforms such as Facebook and WhatsApp were vital for providing real-time information, which was complemented by posters displaying infographics on the subject matter. The primary goal was to inform everyone in the area about Paralytic Shellfish Poisoning (PSP) and how to avoid consuming shellfish from Port Dickson's waters.

## **2.3. Interagency Cooperation and Collaboration**

Collaboration was established among the State Health Department, Local Town Council, and State Fisheries Department. The partnership aimed to assign critical tasks based on each agency's expertise, share essential information, and provide updates on the PSP outbreak situation.

The State Fisheries Department provided weekly reports to the Operation Room regarding the results of water surveillance and laboratory investigations. Contact details and locations were exchanged to expedite investigations and early implementation of public health measures. The media played a crucial role in ensuring that accurate and relevant information was disseminated promptly nationwide.

## **2.4. Stakeholder Support and Commitment**

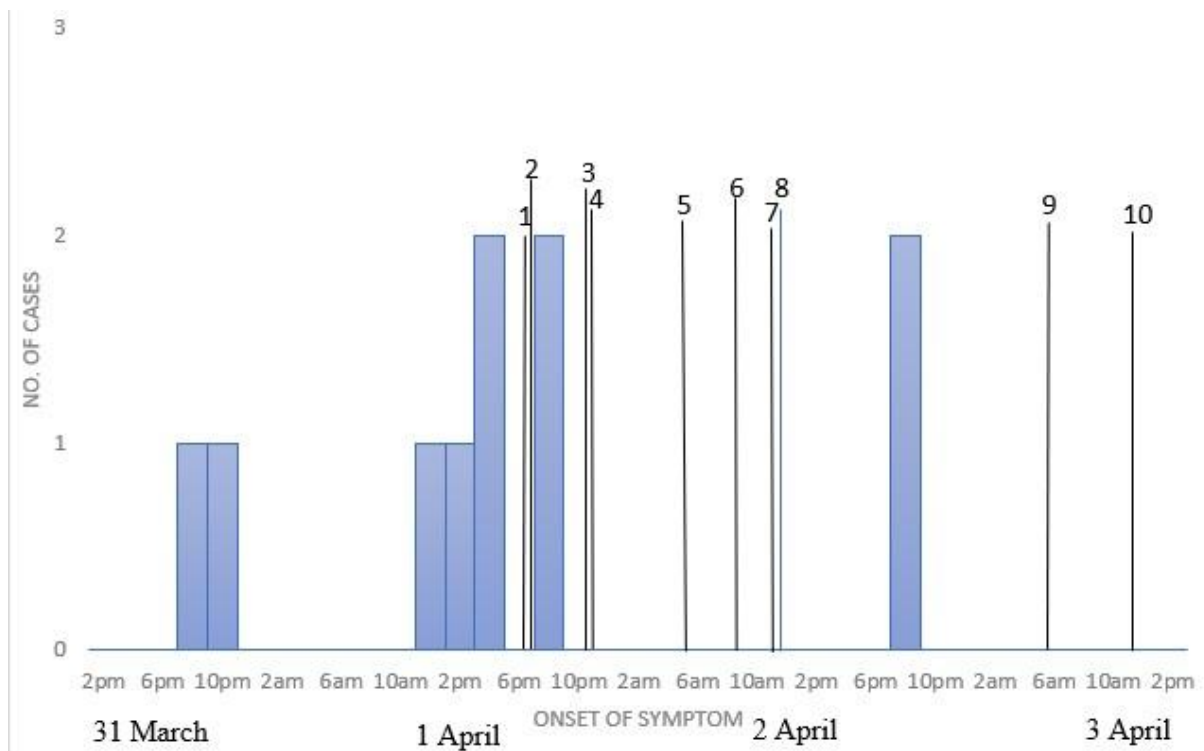
Stakeholders' support and commitment were demonstrated via a technical committee comprising of clinicians, public health personnel, representatives from the State Fisheries Department, and officials from the State Government. This committee served as a platform for critical decision-making and coordination of activities among the agencies and departments involved. The media also played a crucial role by ensuring the timely dissemination of information to the public with press statements issued by both the State Fisheries Department and the State Health Department.

### 3. Results

Several investigations were conducted during the management of this outbreak, including (i) epidemiological analysis, (ii) traceability analysis, (iii) environmental investigation, and (iv) laboratory investigation.

According to the epidemiological investigation, 10 cases of PSP infection were found during the outbreak period. The Assistant Environmental Health Officer (AEHO) conducted interviews in all cases to gather information regarding the onset of symptoms, case movements within the first 24 hours, the symptoms experienced, risk factors, shellfish exposure, and other relevant details. All cases were detected through Passive Case Detection (PCD) and involved an equal distribution of five males and five females. Most onset cases happened between 1 and 2 April 2024, with the earliest onset occurring on 31 March 2024. The minimum incubation period was 25 minutes after consumption, with a median incubation period of 2 hours and a maximum of 5 hours. Figure 2 shows the epidemic curve of the PSP outbreak.

Figure 2: Epidemic curve representing the onset of the PSP outbreak



Notification case

Note: Blue bar: number of cases by time of symptom onset, Fine line: individual notification/reporting times for each case

Some cases occurred after the issuance of prohibition order on harvesting and selling cockles because a patient stored cockles purchased on 30 March 2024 and cooked them on the day of the incident. The most recently reported onset case was on 2 April 2024 (2 days from the last onset case). The outbreak was declared over on 3 April 2024 (2 days from the previous onset case). Overall, the outbreak began with exposure to contaminated shellfish between 30 and 31 March 2024. The first case developed symptoms on 31 March

2024. On 2 April 2024, the outbreak was notified to the District Health Office, leading to immediate activation of the Crisis Preparedness and Response Centre (CPRC) and issuance of a prohibition order on shellfish harvesting and sale. The last reported case onset also occurred on 2 April 2024. Following the absence of new cases, the outbreak was officially declared over on 3 April 2024.

All individuals in the reported cases were stable and discharged after recovery. Two cases were admitted to the Intensive Care Unit (ICU), six cases were admitted to the general ward, and two cases were treated as outpatients. In both ICU cases, the patients had muscle weakness and were admitted to the unit with kidney problems. The majority of patients experienced numbness (100%), muscle weakness (90%), headache (70%), and vomiting (40%). Some patients were reported to experience paralysis (20%) and fainting (10%). The investigation revealed no dose-response effect as higher consumption was not associated with earlier onset or increased severity of symptoms. Underlying comorbidities play a significant role in determining the severity of disease, thereby influencing clinical outcomes. The field investigation denoted that food poisoning incidents occurred among individuals with a history of consuming mussels purchased from the Port Dickson Town Market and Kampung Teluk Fishermen Market in Pasir Panjang.

Traceability analysis was conducted to identify the source of toxin in the mussels. Two locations were involved in the sale of mussels in this poisoning case, namely the Port Dickson Town Market and the Kampung Telok Fishermen's Market in Pasir Panjang. The suppliers and breeders from Kampung Telok and Kampung Sungai Sekawang only supplied mussels to a group of sellers at these two locations. The Head of the Fishermen Association informed that there was no supply of mussels to customers outside of Port Dickson, Negeri Sembilan due to limited livestock production. However, it was discovered that suppliers were selling shellfish online through social media platforms.

Furthermore, three mussel farming areas in Pasir Panjang were identified for environmental investigations: Breeding Area Kampung Telok (using the tied with rope technique), (ii) Breeding Area Kampung Telok (using the staked wood technique), and (iii) Breeding Area Kampung Sungai Sekawang (using the staked wood technique). Mussel farming areas are typically located in river estuaries with calm, relatively shallow water. Harvesting mussels is only done during a specified maturity period of approximately 6 months. The environmental investigations revealed no visible signs of red tides and pollution sources around the mussel farming sites. Meanwhile, mussel-selling activities mainly occurred at the Port Dickson Market and Kampung Telok Fishermen Market. Only one stall at the Port Dickson Market sold fresh mussels. Daily monitoring after the incident revealed no mussel sales at either market.

The laboratory studies were divided into two categories: (i) samples collected by the Port Dickson District Health Office and (ii) samples collected by the Negeri Sembilan State Fisheries Department. The clinical and mussel samples were retrieved by the Port Dickson District Health Office and the Food Safety and Quality Unit, respectively.

The Port Dickson District Health Office obtained two types of samples: (i) clinical samples and (ii) food samples (mussels). The clinical samples involved examining stool cultures for *Salmonella* spp. and *V. cholera*, conducting rectal swabs for *Vibrio vulnificus*, cholera, and *Salmonella*, and administering blood cultures and Hepatitis A tests. *Salmonella* spp. was detected in the stool culture of one of the patients. Conversely, the rectal swabs

revealed negative results for *Vibrio vulnificus*, cholera, and salmonella. Similarly, no *V. cholera* was detected from the stool cultures, while the blood culture and Hepatitis A tests were negative. The Port Dickson Hospital collected all the clinical samples. No clinical samples were sent for biotoxin testing due to the lack of availability.

On the other hand, the food samples involved sending shellfish samples to the National Public Health Laboratory in Sungai Buloh, Selangor to analyse for *V. parahaemolyticus*. The Food Safety and Quality Department of the Port Dickson Health Office Unit gathered samples from four different places, of which three were detected to contain *V. parahaemolyticus*.

The State Fisheries Department also sent mussel samples to the Biosecurity Lab in Petaling Jaya to test for *Vibrio Parahaemolyticus*, *Vibrio Cholerae*, *Vibrio vulnificus*, and *Salmonella spp.* The results showed that most samples were positive for *Vibrio parahaemolyticus*, Faecal coliforms, and *E. coli* (see Table 1).

Table 1: Results of bacteriological testing for mussel samples sent by the Department of Fisheries Malaysia (DOF) on 3 April 2024

Sampling Location	<i>Vibrio parahaemolyticus</i> (Nil in 50 g)	<i>Vibrio cholerae</i> (Nil in 50 g)	<i>Vibrio vulnificus</i> (Nil in 50 g)	<i>Salmonella spp</i> (Nil in 50 g)	Faecal coliform MPN/100g (<300 MPN/100 g)	<i>E. coli</i> MPN/100 g (<230 MPN/100 g - EU) (<300 MPN/100 g - in house)
Breeding Area PNK Teluk Kemang (Coordinate: 2.4136, 101.93988)	Not detected	Not detected	Not detected	Not detected	1100+	300+
Breeding Area Sg Sekawang (Coordinate: 2.41026, 101.92546)	Detected	Not detected	Not detected	Not detected	1100+	<300
Port Dickson Market Nelayan Village	Detected	Not detected	Not detected	Detected	2300	1100+
Kampung Teluk Market	Not detected	Not detected	Not detected	Not detected	2300	300+
Mussels Sample from	Detected	Not detected	Not detected	Not detected	2300	2000+

Hospital  
Port  
Dickson

---

Further testing of the mussel samples by the Fisheries Department of Malaysia also revealed the presence of saxitoxin that exceeded the safe consumption limit of 800 ppb set by the Standard PSP Conc. (see Table 2). The initial sample recorded saxitoxin levels between 4,960 to 179,000 ppb, which later decreased in the third sample. This stands as objective evidence regarding the presence of saxitoxin in Port Dickson's mussels even though the red tide phenomenon was not visible during the incident.

Table 2: Results of Saxitoxin PSP testing for Sample 1 (2 April 2024), Sample 2 (5 April 2024), and Sample 3 (16 April 2024)

No.	Sampling Location	Results (ppb) first sample	Results (ppb) second sample	Results (ppb) third sample
1	Breeding Area PNK Teluk Kemang (Coordinates: 2.4136, 101.93988)	10 046.10	4851.92	1011.75
2	Breeding Area Sg Sekawang (Coordinates: 2.41026, 101.92546)	4 960.21	2751.46	641.55
3	Port Dickson Market Nelayan Village	7 352.54		
4	Kampung Teluk Market	179 408.59		
5	Mussels Sample from Hospital Port Dickson	76 141.07		

\*Standard PSP Conc. (ppb): 800

Table 3 shows that the seawater sent for plankton species came back positive for *Alexandrium* sp. and *Pseudo-nitzschia* sp. The level of *Alexandrium* spp. was alerting, with greater than zero cells per litre. *Alexandrium* spp. contains saxitoxin, which can cause paralytic symptoms.

Subsequently, risk communication was deemed vital for control measures. Effective communication among health staff, higher authorities within the Ministry of Health, and multiple agencies was crucial for managing the outbreak. The response began with the activation of the Operation Room at the Port Dickson District Health Office and the CPRC operation room at the Negeri Sembilan State Health Department on 2 April 2024. On the same day, public announcements and press statements were issued by the State Health Department, the State Fisheries Department, and the Port Dickson Fishermen's Association. It was followed by a series of discussions, including meetings with the Negeri Sembilan State Fisheries Department on 2 April 2024, consultations with Epidemic Intelligence Programme (EIP) experts from the Ministry of Health Malaysia on 4 April 2024, and a joint meeting with the State Fisheries Department on 5 April 2024. The nearby Crisis Preparedness and Response Centre (CPRC) in Melaka was also notified on 2 April 2024.

Table 3: Results of seawater analysis to identify plankton species

<b>Results (Toxin Dinoflagellate)</b>						
<b>Pyrodinium sp. (Cell/L)</b>	<b>Alexandrium sp. (Cell/L)</b>	<b>Dinophysis sp. (Cell/L)</b>	<b>Prorocentrum sp. (Cell/L)</b>	<b>Gymnodinium sp. (Cell/L)</b>	<b>Gonyaulax sp. (Cell/L)</b>	<b>Pseudo-nitzschia sp. (Cell/L)</b>
Not detected	300	Not detected	Not detected	Not detected	Not detected	400
Not detected	3400	Not detected	200	Not detected	Not detected	2600

The dissemination of epidemic information and alerts through the Port Dickson District Disaster Committee (2 April 2024) was also conducted amongst nearby facilities, including health clinics and private health facilities, for the purpose of case detection and notification to the Port Dickson District Health Office, if necessary. The prohibition order of selling/harvesting mussels by the State Fisheries Department was also enforced on the same day until subsequent monitoring confirmed that there was no excessive level of STX.

Daily market monitoring was conducted over several months to ensure compliance with the prohibition order issued by the State Fisheries Department. Health promotion activities, including talks, poster displays, and pamphlet distribution, were key components of risk communication and public awareness efforts. The posters were distributed via social media or face-to-face meetings to emphasise health education on the signs and symptoms of PSP and the complications resulting from consuming contaminated mussels. Other risk communication efforts were community announcements through relevant departments and non-governmental organisations (NGOs) such as Communication for Behavioural Impact (COMBI), *Kawasan Rukun Tetangga* (KRT), and places of worship (e.g., mosques, surau, churches, temples) within the district. Surveillance and monitoring were done by the Port Dickson District Health Office, while periodic seawater sampling for saxitoxins was performed by the State Fisheries Department.

#### 4. Discussion

The PSP outbreak in Port Dickson comprised ten cases, with two patients admitted into the ICU. The State Fisheries Department responded swiftly through immediate investigations and by controlling the movement of mussels around the market to eliminate the source of the outbreak. The prompt public health response effectively prevented both illness and death. Such a success is similar to the one reported by Grattan et al. (2016), who managed to avert illnesses related to harmful algal blooms in various regions of the United States of America (USA), including the Gulf, Pacific and Atlantic Coasts, Alaska, Hawaii and the Caribbean (Grattan et al., 2016). Young et al. highlighted that the critical factors contributing to effective management of harmful algae include emergency preparedness and contingency planning, risk communication and public awareness, interagency cooperation and collaboration, and stakeholder support and commitment (Young et al., 2020). Although the incidence of PSP in Malaysia is rare, it has deadly consequences, and immediate actions must be taken to prevent the source of the toxin from spreading further. On a global scale, over 2,000 cases of PSP are reported annually, with mortality rates ranging from 8.5% to 23.2% (Hallegraeff, 2004; Morse, 1977).

The primary issue identified during this outbreak was the fact that Port Dickson was not under the National Shellfish Sanitation Programme (NSSP) coverage. Hence, no periodic surveillance or early hazard identification was implemented in Port Dickson. There were also no tools for saxitoxin detection or appropriate facilities to conduct testing for humans in Malaysia. Therefore, the investigation was not done locally due to the lack of facilities and expertise.

Subsequently, strategies to include Port Dickson's water as part of surveillance under the NSSP were implemented. The programme was first implemented by the Fisheries Biosecurity Division in 2013 to ensure that cultured shellfish are in suitable waters to produce safe shellfish for consumption. According to the United States Food and Drug Administration, NSSP promotes public health by preventing contaminated shellfish from penetrating the market, thus reducing risks such as paralytic shellfish poisoning and typhoid fever due to shellfish consumption (US Food and Drug Administration [USFDA], 2025). The programme aims (i) to reduce the risk of food poisoning from shellfish, (ii) to provide quality assurance for landed shellfish, (iii) to demonstrate compliance with international HACCP control systems, (iv) to collect information for zoning purposes, and (v) to meet current industry requirements.

An effective sentinel monitoring system for harmful algal blooms and contaminated shellfish can serve as an early warning system for PSP toxin levels. Such a system requires close coordination between the Fisheries Department, Health Department, industry players, local health offices, volunteers, and fishermen. A weekly or biweekly sampling of seawater, shellfish, and filter-feeding fish should be conducted when harmful algal blooms are anticipated or detected. Similarly, during the Sabah case poisoning, lessons were learned from the regular monitoring of red tide occurrences and periodic sampling of shellfish to determine the STX levels, which improved early identification and enabled corrective measures to be taken (Suleiman et al., 2017).

Currently, the Negeri Sembilan State Fisheries Department conducts monthly seawater sampling from designated points and analyses the samples for dinoflagellate density. The results are then communicated to the State Health Department. If the levels exceed normal thresholds, the State Health Department will issue an alert or a press statement, particularly if multiple locations are affected. This will also prompt immediate health promotion efforts.

Laboratories also play a vital role in confirming diseases, identifying their causes, and guiding the appropriate responses to outbreaks. They are essential for detecting dangerous zoonotic threats, monitoring antimicrobial resistance, and discovering new pathogens that could pose risks to human health. A study by the United Nations Food and Agriculture Organisation highlights that veterinary laboratories in Africa were enhanced by offering practical guidance on molecular and serological assays, which led to the strengthening of sustainable quality management systems for accurate and reliable diagnostics, signifying the vital role of laboratories in combating the expansion of zoonotic diseases in the country (Food and Agriculture Organisation of the United Nations [FAO], 2023). Enhancing the capacity to test for pathogens within the country, reducing the time needed to accurately confirm outbreaks and initiate a response, and optimising resource and capacity management for years to come are key objectives of capacity-building efforts.

Effective risk communication and the reliability of disseminated information were also instrumental in alleviating public anxiety. Collaboration with the Fisheries Department of Malaysia was crucial in controlling the PSP outbreak. Weekly samples were taken from Port Dickson's water to measure the existence of toxins with restrictions on the movement of shellfish and related products outside the state. The affected area was placed under national surveillance, with weekly water samples taken to monitor toxin levels.

To effectively prevent further exposure, collaboration between the animal and health sectors is essential to minimise human exposure to the consequences of PSP. A zoonotic disease guide by the World Health Organisation (WHO) posits that collaboration between the animal and health sectors enables early warning, prompts the exchange of outbreak data and risk assessments, and expedites shared decision-making (World Health Organisation [WHO], 2008). This can be achieved through effective surveillance systems, effective risk communication and dissemination of information, and restricting people from consuming contaminated products. Interagency collaboration will also maximise resources and efforts.

## **5. Conclusion**

A Paralytic Shellfish Poisoning (PSP) outbreak occurred in Port Dickson, Negeri Sembilan in April 2024. Nevertheless, swift responses by the public health agencies were successful in minimising the deadly consequences. Among the efforts were continuous surveillance of the community who were potentially exposed to toxic mussels. The outbreak concluded on 3 April 2024, two days after the last reported case on 1 April 2024. The State Health Department deactivated its Operation Room on 3 April 2024. The State Fisheries Department continued weekly seawater surveillance for saxitoxin levels until they reached an acceptable threshold. Although PSP can be fatal, timely, comprehensive, and effective public health measures are essential to minimise the risks.

## **Ethics Approval and Consent to Participate**

All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its subsequent amendments, or with comparable ethical standards. Ethical registration was obtained from the National Medical Research Register [Reference no: NMRR ID-24-02513-7C1].

## **Acknowledgement**

We express our gratitude to the Ministry of Health Malaysia, the Negeri Sembilan State Health Department, the Negeri Sembilan Fisheries Department, the local authorities and the mass media for their assistance, input and support in the control and prevention of the PSP outbreak in Port Dickson, Negeri Sembilan. We would also like to thank the Director General of Health Malaysia for his permission to publish this article.

## **Funding**

This study received no funding.

## Conflict of Interest

The authors declare no conflicts of interest related to this study. An abstract based on this study was presented as a poster at the Global Health Scientific Conference (GHSC) 2026. The present manuscript represents the full study and has not been published elsewhere.

## References

- Cusick, K. D., & Sayler, G. S. (2013). An overview on the marine neurotoxin, saxitoxin: Genetics, molecular targets, methods of detection and ecological functions. *Marine Drugs*, 11(4), 991–1018. <https://doi.org/10.3390/md11040991>
- Disease Control Division, Ministry of Health Malaysia (MOH). (2003). *Infectious diseases outbreak rapid response manual* (1st ed.). Ministry of Health Malaysia (MOH).
- Flores-Moya, A., Rouco, M., García-Sánchez, M. J., García-Balboa, C., González, R., Costas, E., & López-Rodas, V. (2012). Effects of adaptation, chance, and history on the evolution of the toxic dinoflagellate *Alexandrium minutum* under selection of increased temperature and acidification. *Ecology and Evolution*, 2(6), 1251–1259. <https://doi.org/10.1002/ece3.198>
- Food and Agriculture Organisation of the United Nations (FAO). (2023). *Veterinary laboratory testing protocols for priority zoonotic diseases in Africa*. FAO Animal Production and Health Guidelines No. 34. Food and Agriculture Organisation of the United Nations (FAO). <https://doi.org/10.4060/cc3956en>
- Grattan, L. M., Holobaugh, S., & Morris, J. G., Jr (2016). Harmful algal blooms and public health. *Harmful Algae*, 57(B), 2–8. <https://doi.org/10.1016/j.hal.2016.05.003>
- Hallegraeff, G. M. (1993). A review of harmful algal blooms and their apparent global increase. *Phycologia*, 32(2), 79–99. <https://doi.org/10.2216/i0031-8884-32-2-79.1>
- Hallegraeff, G. M. (2004). Harmful algal blooms: A global overview. In G. M. Hallegraeff, D. M. Anderson & A. D. Cembella (Eds.), *Manual on harmful marine microalgae* (pp. 25–50). UNESCO. <https://www.intesal.cl/assets/uploads/2021/04/Manual-on-harmful-microalgae-2004.pdf>
- Jipanin, S. J., Shaleh, S. M., Lim, P. T., Leaw, C. P., & Mustapha, S. (2019). The monitoring of harmful algae blooms in Sabah, Malaysia. *Journal of Physics: Conference Series*, 1358, 012014. DOI:10.1088/1742-6596/1358/1/012014
- Lim, P. T., Leaw, C. P., & Usup, G. (2004). First incidence of paralytic shellfish poisoning of the east coast of Peninsula Malaysia. In S. M. Phang, V. C. Chong, S. S. Ho, N. Mokhtar, & J. L. S Ooi (eds), *Marine science into the new millennium: New perspectives and challenges* (pp. 661–667). Maritime Research Center, University of Malaya.
- Lim, P. T., Leaw, C. P., Usup, G., Kobiyama, A., Koike, K., & Ogata, T. (2006), Effects of light and temperature on growth, nitrate uptake, and toxin production of two tropical dinoflagellates: *Alexandrium tamiyavanichii* and *Alexandrium minutum* (Dinophyceae). *Journal of Phycology*, 42(4), 786–799. <https://doi.org/10.1111/j.1529-8817.2006.00249.x>
- Lim, P. T., Usup, G., & Leaw, C. P. (2012). Harmful algal blooms in Malaysian waters. *Sains Malaysiana*, 41(12), 1509–1515. <https://journalarticle.ukm.my/5667/1/03%2520Lim.pdf>
- Morse, E. V. (1977). Paralytic shellfish poisoning: A review. *Journal of the American Veterinary Medical Association*, 171(11), 1178–1180. DOI:10.2460/javma.1977.171.11.1178
- Roy R. N. (1977). Red tide and outbreak of paralytic shellfish poisoning in Sabah. *The Medical Journal of Malaysia*, 31(3), 247–251.

- Schantz, E. J., Mold, J. D., Stanger, D. W., Shavel, J., Riel, F. J., Bowden, J. P., Lynch, J. M., Wyler, R. S., Riegel, B., & Sommer, H. (1957). Paralytic shellfish poison. VI. A procedure for the isolation and purification of the poison from toxic clam and mussel tissues. *Journal of the American Chemical Society*, 79(19), 5230–5235. <https://doi.org/10.1021/ja01576a044>
- Sinno-Tellier, S., Abadie, E., Guillotin, S., Bossée, A., Nicolas, M., & Delcourt, N. (2023). Human shellfish poisoning: Implementation of a national surveillance program in France. *Frontiers in Marine Science*, 9, 1089585. DOI: 10.3389/fmars.2022.1089585
- Suleiman, M., Jelip, J., Rundi, C., & Chua, T. H. (2017). Case report: Paralytic shellfish poisoning in Sabah, Malaysia. *The American Journal of Tropical Medicine and Hygiene*, 97(6), 1731–1736. <https://doi.org/10.4269/ajtmh.17-0589>
- Uribe, P., & Espejo, R. T. (2003). Effect of associated bacteria on the growth and toxicity of *Alexandrium catenella*. *Applied and Environmental Microbiology*, 69(1), 659–662. <https://doi.org/10.1128/AEM.69.1.659-662.2003>
- US Food and Drug Administration (USFDA). (2025, Mar 25). *National shellfish sanitation program*. US Food and Drug Administration (USFDA). <https://www.fda.gov/food/federal-state-local-tribal-and-territorial-cooperative-human-food-programs/national-shellfish-sanitation-program-nssp-centennial>
- Usup, G., Leaw, C. P., Ahmad, A., & Lim, P. T. (2002). *Alexandrium* (Dinophyceae) species in Malaysian waters. *Harmful Algae*, 1(3), 265–275. DOI:10.1016/S1568-9883(02)00044-6
- Vilariño, N., Louzao, M. C., Abal, P., Cagide, E., Carrera, C., Vieytes, M. R., & Botana, L. M. (2018). Human poisoning from marine toxins: Unknowns for optimal consumer protection. *Toxins*, 10(8), 324. <https://doi.org/10.3390/toxins10080324>
- Wiese, M., D'Agostino, P. M., Mihali, T. K., Moffitt, M. C., & Neilan, B. A. (2010). Neurotoxic alkaloids: Saxitoxin and its analogs. *Marine Drugs*, 8(7), 2185–2211. <https://doi.org/10.3390/md8072185>
- World Health Organisation (WHO). (2008). *Zoonotic diseases: A guide to establishing collaboration between animal and human health sectors at the country level* [Internet]. World Health Organisation (WHO). [https://iris.who.int/bitstream/handle/10665/207731/9789290613992\\_eng.pdf](https://iris.who.int/bitstream/handle/10665/207731/9789290613992_eng.pdf)
- Yang, I., Selander, E., Pavia, H., & John, U. (2011). Grazer-induced toxin formation in dinoflagellates: A transcriptomic model study. *European Journal of Phycology*, 46(1), 66–73. <https://doi.org/10.1080/09670262.2011.552194>
- Young, N., Sharpe, R. A., Barciela, R., Nichols, G., Davidson, K., Berdalet, E., Fleming, L. E. (2020). Marine harmful algal blooms and human health: A systematic scoping review. *Harmful Algae*, 98, 101901. doi: 10.1016/j.hal.2020.101901