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A CASE STUDY OF MALAYSIA PIPELINE GAS EXPLOSION: RETHINK DISASTER RESPONSE AFTER PUTRA HEIGHTS INCIDENT

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List of Abbreviations

ARCH Project	: ASEAN Regional Capacity on Disaster Health Management Project
ASEAN	: Association of Southeast Asian Nations
CPRC	: Crisis Preparedness and Response Center
DOC	: Disaster Operations Commander
EDOC	: Emergency Department Operations Center
EMTS	: Emergency Medicine and Trauma Services
ETD	: Emergency and Trauma Department
ICS	: Incident command system
MCI	: Mass Casualty Incident
MECC	: Medical Emergency Coordination Center
MOH	: Ministry of Health
NADMA	: National Disaster Management Agency
PGU	: Peninsular Gas Utilization

ABSTRACT

Introduction: On 1 April 2025, a high-pressure natural gas transmission pipeline ruptured and exploded in Putra Heights, Selangor, generating extreme thermal energy, structural damage, and a technological mass casualty incident (MCI). **Objective:** To analyze the emergency medical response and identify transferable lessons for cross-jurisdictional disaster response in Malaysia and the region**. Methods:** A retrospective qualitative operational

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evaluation triangulated an operational leadership account with logs, communication records, and archived Emergency Department Operations Center (EDOC) data. **Results:** Overlapping jurisdictions created ambiguity regarding the coordinating authority, delaying MCI declaration by approximately 30 minutes. The Medical Emergency Coordinating Center (MECC) Putrajaya was designated lead coordinator, with an EDOC established at Putrajaya Hospital. A flexible cross-jurisdictional command structure emerged, prioritizing functional task allocation over territorial boundaries. Two field medical bases at Sri Maha Kaliamman Temple (84 casualties) and Nurul Iman Mosque (26 casualties) regulated patient flow across eight receiving hospitals. However, parallel casualty processing without an integrated tracking platform resulted in discrepancies. **Conclusions:** Flexible cross-jurisdictional command can support effective rescue and clinical distribution during an MCI. However, tactical agility should be supported by interoperable digital casualty-tracking infrastructure to enable real-time synchronization, patient accountability, and system-wide coordination.

Keywords: Mass Casualty Incident; Cross-Border Command; Data Integration

INTRODUCTION

Malaysia's rapid urbanization and expanding industrial infrastructure have increased vulnerability to technological disasters (1, 2). The Putra Heights gas pipeline explosion represents one of the most significant recent technological mass casualty incidents in Malaysia, underscoring the critical need for robust disaster preparedness and response mechanisms in such complex environments (3).

On 1st April 2025, at approximately 8:07am, a high-pressure natural-gas transmission pipeline ruptured and ignited in Putra Heights, Subang Jaya, Selangor (4, 5). The pipeline forms part of the Peninsular Gas Utilization (PGU) network operated by the National Petroleum Company, a transmission system that conveys gas at high pressure to industrial and power-generation off-takers across Peninsular Malaysia (6, 7). Its rupture therefore combined extreme thermal output—witnesses and responders reported flames reaching 40 meters in height and ground temperatures of the order of 1,000 °C—with disruption to downstream gas supply in areas such as Petaling Jaya, Shah Alam and Klang (4, 5). The resulting fire spread through the adjacent residential neighborhood of Taman Putra Harmoni and surrounding areas of Putra Heights, prompting evacuation within an approximately 500-metres radius of the rupture and damaging a large number of homes (4–6).

Underground gas pipeline failures, unlike natural hazards, present a unique array of challenges due to their high thermal intensity, potential for secondary fire propagation,

structural collapse risks, and the pervasive public panic they engender, often impacting multiple jurisdictions simultaneously (8). These incidents, characterized by their rapid onset and minimal lead time for coordinated activation, critically test existing emergency management frameworks and operational realities (9). This case study thus offers valuable insights into the complexities of managing sudden-onset, technologically induced mass casualty events, which often present significant challenges in identifying the situation, balancing contingency plans with reality, establishing functional crisis organizations, and adapting medical responses (10). The incident at Putra Heights further illuminates the intricate difficulties in ensuring a resilient response amidst the dynamic and unpredictable nature of such events (10). This manuscript aims to analyze the Putra Heights gas pipeline explosion, identifying critical areas for improvement in emergency management and highlighting the imperative for enhanced planning and information management approaches within Malaysia's disaster response framework (11).

This study adopts a qualitative operational evaluation framework to examine two central research questions: (A) How do cross-jurisdictional command structures dynamically adapt during sudden-onset technological disasters? and (B) What structural data vulnerabilities emerge during the conduct of parallel, multi-site field operations? This analysis will scrutinize the pre-hospital notification processes, casualty triage protocols, medical management strategies, and the command-and-control structures employed during the incident, drawing parallels with identified challenges in managing similar sudden-onset, man-made disaster scenarios (12). This comprehensive review is crucial for developing refined strategies to mitigate the impact of future technological incidents and to bolster the adaptive capacity of emergency services in rapidly urbanizing regions.

The general objective of this case study is to analyze the emergency medical response to the Putra Heights pipeline gas explosion and to derive transferable lessons for cross-jurisdictional disaster response in Malaysia and the wider region. The specific objectives are: (A) to describe the command-and-control and coordination arrangements that emerged across jurisdictional boundaries; (B) to describe the establishment and operation of the two field medical bases and the resulting distribution of casualties; (C) to evaluate the casualty-tracking and data-reconciliation processes and to characterize the sources of the observed discrepancy; and (D) to propose system-level recommendations for strengthening future disaster response.

METHODS

This study utilized a retrospective, qualitative case study methodology based on a lead

operational leadership account. To evaluate the systemic gaps in multi-agency interoperability, primary operational logs were triangulated against technical communication records and archival data from the Emergency Department Operations Center (EDOC). The analytical focus was directed at two core operational phases: (A) the transition from localized response to an adaptive, cross-border command structure, and (B) the synchronization of casualty tracking data across parallel field medical sites. Data streams were analyzed using thematic reconciliation to identify where administrative discrepancies occurred between field-base numbers and final hospital admission.

RESULTS

The Incident

On 1st April 2025 at approximately 8:07am, a high-pressure natural-gas transmission pipeline ruptured and ignited at Putra Heights, Subang Jaya, Selangor, affecting the adjacent residential area of Taman Putra Harmoni and prompting mass evacuation within an approximately 500 m radius. Most of the victims assembled in either the Sri Maha Kaliamman Temple or the Nurul Iman Mosque. The medical responders went to these two locations to set-up an emergency treatment area known as field medical base (Figure 1). The emergency medical responders managed a total of 110 casualties across the two field medical bases established during the incident.



Figure 1. Aerial View of the Incident Site with Location of the Two Medical Bases and Their Distances from the Incident Site.
Source: Pamela et al., 2026

Command-and-Control and Coordination Arrangements

The scale and cross-boundary nature of the incident initially created significant ambiguity regarding the primary coordinating authority. The explosion's impact spanned administrative lines, leading to early confusion as to which Medical Emergency Coordination Center should assume overall command. This was complicated by dual jurisdictional responsibilities, the simultaneous activation of parallel response units, and independent communication streams (11). However, rather than adhering to the rigid single-chain hierarchy typically outlined in traditional emergency management models, a functional and flexible cross-border command structure emerged organically. This adaptive approach prioritized operational effectiveness and situational capability over territorial designations (13–14). Other than that, functional task allocation was based on resource proximity and capability. Mutual recognition of leadership authority across jurisdictional boundaries is also another element, which allowed for a more resilient command and control environment (14).

Field Medical Bases and Casualty Distribution

In order to mitigate the risk of surge collapse at the nearest receiving hospitals, two separate medical bases were strategically established. The two medical bases were located at Sri Maha Kaliaman Temple and Nurul Iman Mosque which were respectively situated approximately 500 meters and 1 kilometer away from the incident site. The primary objectives were to facilitate rapid triage, provide immediate life-saving interventions, and control patient distribution to prevent overcrowding. In this incident, a total of 8 hospitals within a 35-km radius participated, namely Hospital Sultan Idris Shah Serdang, Hospital Putrajaya, Hospital Kajang, Hospital Banting, Hospital Shah Alam, Hospital Ampang, Hospital Tengku Ampuan Rahimah Klang and Hospital Cyberjaya.

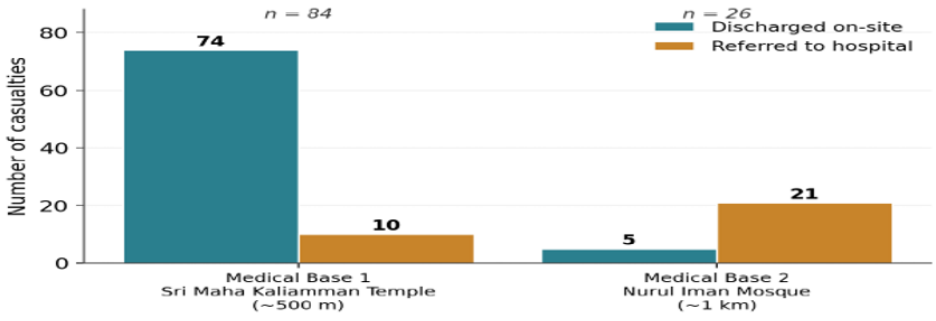


Figure 2. Distribution of Casualties by Field Medical Base and Disposition (Referred to Hospital Versus Discharged On-Site).

Source: Pamela et al., 2026

Casualty Tracking and Data Reconciliation

Despite the operational success of the field medical bases, the use of parallel casualty processing introduced significant administrative complications. The establishment of independent triage sites led to inconsistent triage documentation as each base utilized separate casualty numbering systems and independent documentation protocols. Based on this incident, a total of 110 casualties were managed across the two medical bases. Delayed data consolidation was also noticed in this incident: real-time victim counts were difficult to reconcile, leading to discrepancies when the Emergency Department Operations Center attempted to generate unified reports.

As shown in Figure 3, reconciliation of the two referral streams revealed a four-casualty discrepancy between the expected and the recorded emergency-department totals. This discrepancy is attributable to casualties who entered the hospital system outside the medical-base referral pathway, for example by self-transport or inter-facility transfer.

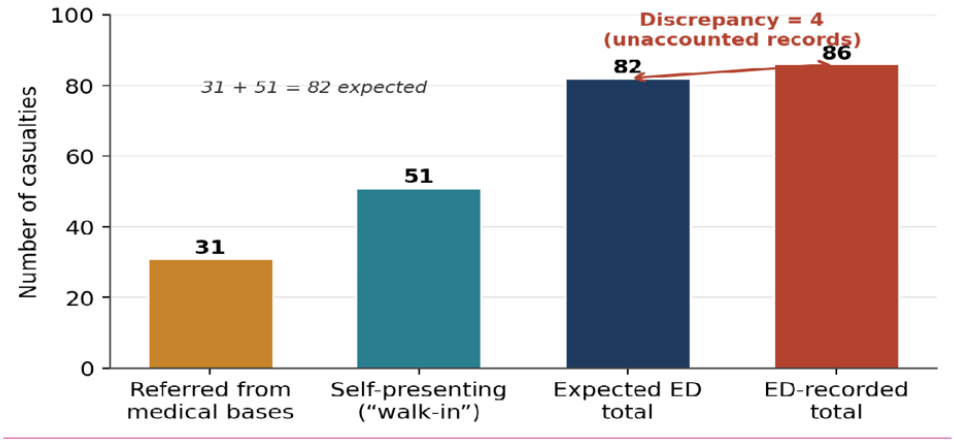


Figure 3. Casualty Reconciliation Across Referral Streams.

Source: Pamela et al., 2026

DISCUSSION

The Incident Command System (ICS) is a standardized emergency management framework designed to provide a clear command structure and facilitate the coordination of personnel, resources, and operational activities during incidents of varying scale and complexity. By establishing defined roles, responsibilities, and reporting relationships, ICS enhances organizational effectiveness and inter-agency collaboration (15). Since its development, ICS has been widely adopted internationally, with many countries adapting the framework to align with their respective disaster management systems and operational contexts.

Malaysia's disaster response operates under the National Disaster Management Agency (NADMA) Directive No.1 (previously known as National Security Council Directive No.20), which establishes an integrated, multi-agency command structure across three administrative tiers—district, state and federal—coordinated nationally by NADMA (16). Based on this directive, Police is automatically appointed as the Disaster Operations Commander and all other government or non-government agencies were divided into Responding, Technical, Supporting or Aid & Recovery sections based on their area of expertise. Within this framework, and as stipulated in the directive for a health crisis, the Ministry of Health provides the technical lead, operating through its Crisis Preparedness and Response Center (CPRC) and the MECC network. Rather than constituting a separate model, the health sector's disaster response has progressively adopted Incident Command System principles—unified command, defined roles and standard coordination—within the Directive No.1 mechanism (Figure 4). The cross-jurisdictional coordination observed at Putra Heights therefore reflects this ICS-aligned national framework operating under the demands of a boundary-spanning technological disaster.



Figure 4. Disaster Health Incident Command System (ICS) in Malaysia based on National Disaster Guidelines for Crisis Preparedness & Response Crisis response (CPRC) Published 2016.

Source: Pamela et al., 2026

In Malaysia, the Medical Emergency Coordination Center (MECC) is the primary strategic unit for pre-hospital services under the Ministry of Health Malaysia. Its inception in 2008 coincided with the unification of national emergency services. Per the Emergency Medicine and Trauma Services (EMTS) Policy 2012, MECC facilitates the continuum of care through five key pillars: clinical triage, multi-agency resource dispatching, pre-arrival instruction, online medical direction, and disaster-scale victim distribution. Nationwide

operations are managed by 21 MECCs co-located within major Emergency and Trauma Departments (ETD). Within the Klang Valley, the distribution of seven centers (five in Selangor and one each in Kuala Lumpur and Putrajaya) allows for specialized management of high-density populations. Through rigorous ambulance mapping and defined regional boundaries, these centers ensure efficient daily operations and minimize cross-jurisdictional issues.

In a Mass Casualty Incident (MCI) or disaster, resource mobilization may need to extend beyond the typical jurisdictional boundaries to effectively manage victims at the scene. To prevent overlapping commands and confusion among ground personnel when coordinating resources from different areas, one ETD is usually designated as the primary coordination center (typically the nearest one). For an ETD with a heavy workload and an existing Medical Emergency Coordination Center (MECC), a separate, temporary coordination center called the Emergency Department Operations Center (EDOC) is often established. The EDOC then assumes the role of coordinating all incident-related activities, such as mobilizing resources to the incident site and determining the most appropriate healthcare facility for victim disposition. This allows the MECC to concentrate on its routine function of managing day-to-day ambulance responses for other medical emergencies (17).

The geographic location of the incident presented a unique coordination challenge: while the site was in Selangor, day-to-day coverage was provided by MECC Putrajaya, with MECC Serdang bordering the area. This overlap meant both centers were initially involved in the response. The transition to a Mass Casualty Incident (MCI) framework was delayed by about 30 minutes, due to limited intelligence suggesting a routine house fire. Once the situation was correctly identified as an MCI due to the nature of the incident and expected number of casualties by our Emergency medical response team who arrived at incident site, MECC Putrajaya was designated as the lead coordinator based on the locality of the MCI. This triggered the establishment of the EDOC at Putrajaya Hospital and a mandate for all Klang Valley MECCs to support the lead center with resources and data.

The effectiveness of the cross-border response was heavily facilitated by the use of standardized triage frameworks and familiar radio communication protocols. This alignment allowed for mutual recognition of clinical authority and clear role assignment, even as personnel from different jurisdictions integrated on-site. Such findings underscore that disaster resilience is not a product of the crisis itself but is built through rigorous peacetime training and regional cooperation (18). For instance, initiatives like the ASEAN ARCH Project have focused on harmonizing international emergency medical team coordination and regional

standard curricula to ensure responders speak a "common language" during mass casualty incidents (18, 19). By utilizing standardized triage categorizations similar to those employed in previous Malaysian MCIs, such as the Batang Kali, Selangor, Malaysia landslide response, teams can maintain a high operational tempo despite the chaotic nature of the field environment (20).

The establishment of the two field medical bases proved clinically effective, successfully distributing the casualty load and maintaining a steady operational tempo. By establishing these bases, the response teams were able to significantly reduce bottlenecks at the nearest hospital emergency departments by sending patients to several different hospitals within close distance, and this also improved overall patient flow through early stabilization and distribution. While these multi-site operations optimized clinical outcomes, they were consistent with challenges noted in international transboundary disasters, where the complexity of managing multiple medical sites often exceeds the capacity of standard localized resources (21, 22).

The most significant systemic weakness identified in this encounter was the failure of data integration between the two medical bases. In mass casualty scenarios, accurate victim counts are essential for resource allocation, family tracing, and maintaining public trust through transparent reporting (23, 24). The establishment of parallel medical bases, while clinically effective for distributing patient load, created administrative uncertainty due to independent numbering systems and delayed data consolidation. These inconsistencies highlighted a gap in the current disaster response framework; the absence of an integrated, interoperable real-time casualty tracking system (11). Such gaps often result in a temporary loss of situational clarity and administrative tension, as official reporting becomes uncertain.

Research indicates that medical information is frequently "lost" or duplicated during the transition from field care to hospital settings when interoperable digital systems are absent (23). This incident highlights a critical need for an integrated, real-time casualty tracking system in Malaysia that complies with national disaster management criteria while enabling synchronous digitalization across jurisdictions (25, 26). The transition from paper-based or independent analogue systems to integrated digital platforms can reduce missing or duplicated patient identifiers by nearly 50%, highlighting the need for a unified digital infrastructure in future Malaysian disaster encounters (22, 23). Without such a framework, even the most successful clinical interventions can be overshadowed by the administrative challenges of reconciling victim data (27).

The Putra Heights explosion provides critical lessons that are highly transferable within

the ASEAN region, particularly in areas where dense urban populations and industrial zones intersect across administrative boundaries (18). The incident underscores that cross-jurisdictional interoperability must be rehearsed during peacetime through joint exercises, as the "organic" command structures observed here are only effective when responders share a common operational language and trust (20, 21).

Furthermore, the case demonstrates that casualty tracking systems must be unified across all medical bases to prevent the administrative uncertainty that often arises in transboundary incidents (22, 23). MECC designation protocols must be predefined for boundary-spanning incidents to eliminate early confusion and dual-jurisdictional delays (11, 25). Finally, a **s**tructured patient distribution planning and the implementation of real-time digital dashboards are essential to manage surge capacity and prevent the discrepancies in casualty reconciliation that can undermine public trust during a crisis (24, 28). These lessons hold significant regional relevance as ASEAN continues to move towards a more integrated disaster health management framework under initiatives like the ARCH Project (18).

Based on the operational challenges and adaptive successes observed in this incident, several critical, evidence-based policy changes are recommended to strengthen future transboundary disaster responses within Malaysia and the broader ASEAN region.

1. Implementation of an Interoperable Digital Casualty Tracking Infrastructure**:** To mitigate the critical data discrepancies and "information loss" common in paper-based multi-site triage, the Ministry of Health should transition from decentralized, analog numbering systems to a standardized, real-time digital casualty tracking dashboard. This infrastructure must establish a unified patient identifier system synchronized seamlessly between field medical bases and receiving hospital emergency departments to maintain a comprehensive common operational picture.
2. Institutionalization of Cross-Border Disaster Simulation Exercises: The federal and state healthcare administrations should conduct regular, large-scale, cross-boundary disaster simulations. These exercises must explicitly test "flexible hierarchy" models and multi-agency integration, shifting the training paradigm from rigid administrative adherence to functional, scene-level interoperability across district and state borders.
3. Refinement of the MECC Lead Designation Algorithm: To eliminate early command ambiguity and dual-jurisdictional processing delays, national emergency management protocols should adopt a predefined, algorithm-driven framework for lead agency designation in boundary-spanning incidents. This algorithm must prioritize immediate operational capability and resource proximity over strict administrative territorial

boundaries.

4. Standardization of a National Disaster Documentation Bundle: A mandatory, standardized medical documentation package should be enforced across all states, districts, and participating auxiliary agencies (such as St. John Ambulance and the Malaysian Red Crescent). Standardizing clinical triage logs and victim identity records ensures complete data synchronicity, regardless of which agency or jurisdiction initially manages a specific field medical base.

LIMITATION

The reconciliation of victim data was hindered by limitations in obtaining consent from relevant government agencies.

CONCLUSION

The Putra Heights gas pipeline explosion served as a critical systems stress test for Malaysia's multi-agency emergency framework, providing a clear vantage point to answer the study's central research questions.

Regarding the first research question—how cross-jurisdictional command structures dynamically adapt—this study demonstrates that an organically emerged, flexible hierarchy can effectively bypass territorial friction to optimize immediate life-saving interventions and manage surge capacity through strategic field medical bases. However, this study's analysis of the second research question—the structural data vulnerabilities arising during parallel triage—reveals that such operational fluidity comes at a significant administrative cost. The observed discrepancy of 4 unaccounted patients highlights that when decentralized, independent numbering systems are utilized without a synchronized digital platform, the resulting "information loss" undermines total situational clarity.

Ultimately, this analysis concludes that disaster maturity in transboundary environments cannot rely on operational speed alone. While structural fluidity is essential for tactical success during the chaos of a sudden-onset technological disaster, it must be tethered to a unified, interoperable digital casualty tracking infrastructure to ensure accountability. True resilience requires a deliberate balance: the tactical agility to adapt to the unpredictable nature of the event, coupled with the administrative precision of real-time, integrated data management. Without the latter, the clinical successes of decentralized response are perpetually vulnerable to systemic reconciliation failures.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

ETHICAL APPROVAL

The study protocol was registered with the National Medical Research Register (NMRR). Because the analysis used only identified records collected during an official emergency disaster response, the committee waived the requirement for individual informed consent.

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