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A NOVEL HEALTH MANAGEMENT MODEL FOR SEARCH AND RESCUE (SAR) TEAMS DURING THE BATANG KALI LANDSLIDE, 2022: A CASE STUDY OF PUBLIC HEALTH RESPONSE

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List of Abbreviations

CVA	: Cerebrovascular Accident
CPRC	: Crisis Preparedness and Response Centre
DDMC	: District Disaster Management Committee
DHOOR	: District Health Office Operation Room
EMT	: Emergency Medical Team
FWBD	: food and water-borne diseases
HSDHO	: Hulu Selangor District Health Office
IMS	: Incident Management System
FRDM	: Fire and Rescue Department of Malaysia
MCDF	: Malaysia Civil Defence Force
MECC	: Medical Emergency Coordinating Centre
MERT	: Medical Emergency Response Team
MHPSS	: Mental Health and Psychosocial Support
MOH	: Ministry of Health
OSCP	: On-Scene Control Post
PFA	: Psychological First Aid
PPE	: Personal Protective Equipment

RAT : Rapid Assessment Team
RMP : Royal Malaysia Police
RRT : Rapid Response Team
SAR : Search and Rescue
SMART : Special Malaysian Disaster Assistance and Rescue Team

ABSTRACT

Introduction: A catastrophic landslide in Batang Kali, Hulu Selangor, Malaysia on December 16, 2022, displaced 16 million cu ft of soil, resulting in 61 rescues and 31 fatalities. Search and Rescue (SAR) team members face significant health risks and traumatic experiences during such operations. **Objectives:** This case study examines four key aspects of SAR operations, that is the efficacy of global health management for SAR teams, the physical and mental health implications on personnel during extended operations, the assessment of environmental health hazards in the disaster area and their mitigation measures, and the documentation of key lessons learned for future operational improvements. **Methods:** This is a case study on piloting innovative composite questionnaire on global assessment of health risks of SAR team members. The environmental health assessments were conducted using an adapted form from MOH Malaysia Guidelines for the Diagnosis, Management, Prevention and Control of Leptospirosis, 2011. The mental health using Whooley and GAD-2 questionnaires and the rest of the assessments including physical health using adapted MOH Malaysia Flood Preparedness Guidelines, 2008. Data was analysed using descriptive statistics. A one-stop health base was established for surveillance, coordination, and support. **Results:** Of 509 SAR team members, 56 (11%) participated. Physical health screening (n=18) revealed physical injuries (37.5%), hypertension (25%), mental health issues (25%), and one cardiovascular accident (12.5%). Mental health screening (n=29) identified three (10.3%) positive cases requiring counselling. Nine members attended Psychological First Aid sessions (44% psychoeducation, 33% relaxation, 23% sleep hygiene). No infectious diseases were reported during or one-month post-operation. **Discussion & Conclusion:** This novel model demonstrates effective comprehensive health monitoring during disaster response. The study supports pre- and post-deployment health screenings and improved interagency coordination, serving as a framework for future emergency responses.

Keywords: Disaster Health Management; Search and Rescue (SAR); Integrated Health Surveillance; First Responder Mental Health; Landslide Response

INTRODUCTION

Natural disasters represent significant global challenges to public health systems, with the World Health Organization reporting over 15,000 natural disasters affecting 1.5 billion people worldwide between 2000-2020. These events are defined by the United Nations as "serious disruptions of community functioning that exceed local capacity to respond using indigenous resources". United Nation and World Health Organisation defined a disaster as “a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources (1). Disasters can be categorized into natural disasters and man-made disasters. Among the common natural disasters are landslides, earthquakes, floods, tsunamis, hurricanes, tornadoes, volcanic eruptions, wildfires, and blizzards. Landslides are a common cause of natural disasters worldwide (2).

In Malaysia, the rain and hot weather lead to intensive and extensive weathering of features on the ground and these combined with other causative factors such as slope angle, drainage conditions, and geological boundaries have made landslides as one of Malaysia’s most common natural disasters (3). There were at least 21,000 landslide prone-areas identified in Malaysia, with 76% recorded in Peninsular Malaysia and the remaining 24% in East Malaysia (4). The most catastrophic was the 1993 Highland Tower collapse in Ulu Klang, Selangor (48 deaths), followed by the December 2022 Batang Kali landslide (31 deaths) along the Genting Highlands Road.

Genting Highlands represents one of Malaysia's premier entertainment and recreational destinations, characterized by its developed tourism infrastructure and natural attractions. Situated within accessible distance from the Klang Valley metropolitan area, this highland destination is distinguished by its temperate microclimate, which provides a stark contrast to Malaysia's typical tropical weather conditions. The primary access route, the Batang Kali - Genting Road, traverses through the Hulu Selangor District and features numerous designated camping areas along its course. This transportation infrastructure, however, is constrained by its predominantly single-lane configuration and mountainous terrain, presenting significant implications for accessibility and safety considerations (5).

The Batang Kali disaster occurred at approximately 2:00 AM on December 16, 2022, at a popular glamping site. The landslide, involving 16 million cubic feet of soil, resulted in 31 fatalities among 92 victims, with 61 survivors and 8 requiring hospitalization. The incident

prompted an immediate activation of Malaysia's disaster response system, involving multiple agencies and over 500 Search and Rescue (SAR) personnel.

While extensive research exists on disaster impacts on victims, limited attention has been paid to the health risks faced by SAR personnel, particularly in the context of concurrent challenges like the COVID-19 pandemic SAR operations expose team members to multiple health risks. SAR team members face multiple categories of health risks during disaster response operations. Physical health risks include traumatic injuries sustained during rescue operations in hazardous environments, as well as prolonged exposure to harsh environmental conditions including extreme heat, heavy rainfall, and unstable terrain. The extended duration of operations frequently leads to physical exhaustion, while close contact during rescue efforts increases the risk of communicable disease transmission among team members.

The mental health impact on SAR personnel is equally significant. Team members frequently experience acute stress reactions from exposure to traumatic scenes, particularly during body recovery operations. The psychological burden is compounded by intense operational pressures and strict time constraints, as every hour is critical in rescue efforts. Additionally, many SARS personnel face cumulative stress from deployment to multiple disaster operations over time, potentially leading to long-term psychological effects.

The COVID-19 pandemic has introduced additional layers of complexity to SAR operations. Personnel must contend with enhanced personal protective equipment requirements, which can significantly impact operational efficiency, especially in physically demanding conditions (6). The implementation of more stringent infection control protocols has added to operational complexity, while the overall pandemic situation has increased the psychological burden on emergency responders.

In Malaysia, the formal disaster response mechanism is initiated when a District Officer, who heads the District Disaster Management Committee (DDMC), officially declares a disaster. The DDMC serves as the primary coordinator for disaster response and preparedness initiatives at the district level, with the District Health Officer playing a crucial role in addressing health-related contingencies, including disease outbreaks, medical services, and public health concerns. The operational framework includes establishing an On-Scene Control Post (OSCP), where the Royal Malaysia Police (RMP) assumes the role of Incident Commander, facilitating interagency collaboration for search and rescue (SAR) operations. This dual-structure approach, comprising both DDMC and OSCP, ensures effective command, control, communication, and coordination during disaster responses.

In response to these multifaceted challenges, the Hulu Selangor District Health Office

(HSDHO) implemented a novel comprehensive health management approach during the Batang Kali response. This integrated approach began with the activation of the District Health Office Operation Room (DHOOR) as the central coordination point. The response structure included the mobilization of specialized Emergency Medical Teams (EMT), comprising four key components: the Rapid Assessment Team (RAT) for initial situation evaluation, the Medical Emergency Response Team (MERT) for urgent medical interventions, the Rapid Response Team (RRT) for ongoing medical support, and the Mental Health and Psychosocial Support Team (MHPSS) for psychological care. The DHOOR implemented the Incident Management System (IMS), establishing a comprehensive response framework. Operating continuously throughout the incident, the DHOOR coordinated data collection, verification, and transmission to State and National Crisis Preparedness and Response Centres (CPRC), while managing human resources and logistics.

This case study aims to evaluate this novel approach to managing SAR team health during disaster response operations. Particular attention is paid to addressing the unique challenges posed by the concurrent COVID-19 pandemic and the local disease burden, including endemic cases of malaria, leptospirosis, and melioidosis in the operational area. The study pursues four primary objectives. First, it seeks to evaluate the effectiveness of the comprehensive health management model implemented for SAR teams during the disaster response. Second, it aims to assess both the physical and mental health impacts experienced by SAR personnel throughout the extended operation. Third, it analyses the environmental health risks present in the disaster zone and evaluates the effectiveness of preventive measures implemented. Finally, it documents critical lessons learned to inform and improve future disaster response operations.

This research makes a significant contribution to the limited body of literature on SAR team health management during complex disaster responses. Its findings are particularly relevant given the contemporary context of managing emergency operations during concurrent public health emergencies, offering valuable insights for future disaster response planning and implementation.

METHODS

This is a case study on piloting an innovative composite questionnaire on global assessment of health risks of SAR team members, evaluates the public health response and health management model during the Batang Kali landslide disaster from December 16-25, 2022. The study setting was the disaster site in Batang Kali, Hulu Selangor, Malaysia, where a

dedicated Health Base was established in the designated green zone of the operation area. The study population comprised 509 SAR team members from various agencies involved in the rescue operation. Participation in health screenings was voluntary. Participants were actively involved in the Batang Kali landslide SAR operation, provide voluntary consent for health screening, and be registered members of official SAR agencies such as FRDM, MCDF, or SMART.

The study employed a descriptive statistic on relevant data in the form of counts and proportions. This includes the physical health assessment consisting of standardized physical examinations, vital signs measurements, medical history documentation, health issue classification, and referral documentation. Mental health assessment utilized standardized tools including the Whooley Questionnaire, which was considered positive if any of its two items received an affirmative response, and the GAD-2 Questionnaire, with a cut-off score of ≥ 3 indicating positive findings. All referrals and interventions were systematically documented.

Environmental health assessments were conducted using an adapted form based on the MOH Malaysia Guidelines for The Diagnosis, Management, Prevention and Control Of Leptospirosis In Malaysia (7). These assessments included daily site inspections, comprehensive food safety evaluations, water supply assessments, and regular monitoring of sanitation facilities. The study utilized three primary instruments for data collection. The Physical Health Screening Form captured demographic information, medical history, current symptoms, physical examination findings, vital signs, and details of treatment or referrals. Mental health assessment employed validated Malay versions of both the Whooley and GAD-2 questionnaires, along with a structured PFA session documentation form. A newly developed Natural Disaster Environmental Assessment (NDEA) Form adopted from *Garis Panduan Pengurusan Banjir* (*Kesihatan*) (8), evaluated multiple components including safety and health measures, sanitation facilities, sewage disposal systems, environmental conditions, PPE usage, food and water safety, and vector control measures.

The intervention strategy centered around five key components. The Health Base Services functioned as a one-stop crisis center, providing health services, inter-agency health coordination, health surveillance, and mental health support. Physical Health Services delivered medical examinations, first aid, treatment of minor ailments, and referrals for specialized care when needed. Mental Health Support services included both individual and group PFA sessions, mental health screening, counseling services, and distribution of PFA kits. Environmental Health Interventions consisted of daily environmental assessments, food safety inspections, water quality monitoring, sanitation monitoring, and vector control activities.

Health Education and Promotion activities were delivered through individual counseling, group health talks, educational material distribution, PPE usage demonstrations, and agency-level briefings.

Data analysis was performed using Microsoft Excel 2019, employing descriptive statistical analysis, frequency distributions, and percentage calculations. There were also data that underwent thematic analysis of environmental assessments, with systematic documentation of intervention outcomes and compilation of daily inspection reports. Quality control was maintained through multiple mechanisms including the use of standardized assessment forms, deployment of trained healthcare professionals, daily data verification processes, regular team briefings, and systematic documentation procedures.

The study adhered to strict ethical guidelines, ensuring voluntary participation, maintaining confidentiality of health information, obtaining informed consent for all screenings and following professional standards throughout the period. The study timeline began with the initial response on December 16, 2022, followed by the establishment of the Health Base on December 19, 2022. The study concluded on December 25, 2022, with post-disaster surveillance continuing for one month after the operation's completion.

RESULTS

From the total SAR operation workforce of 509 personnel, 56 (11.0%) participated in various health screening activities. The distribution of participation across different health services is presented in Table 1.

Table 1. Overview of SAR Team Member Participation in Health Services

Service Type	Number of Participants (n)	Percentage of Total SAR Force (%)
Physical Health Screening	18	3.5
Mental Health Screening	29	5.7
PFA Sessions	8	1.8
Total Unique Participants	56	11.0

Source: Sidek et al., 2025

Physical Health Screening Results

A total of 18 SAR team members underwent physical health screening between December 19-25, 2022. The demographic characteristics and health findings are presented in Table 2 and Table 3.

Table 2. Demographic Characteristics of Physical Health Screening Participants

Characteristic	Category	Number (n=18)	Percentage (%)
Gender	Male	18	100
	Female	0	0
Agency	FRDM	12	66.7
	MCDF	6	33.3

Source: Sidek et al., 2025

Table 3. Health Issues Identified During Physical Screening

Health Condition	Number Affected (n=8)	Percentage (%)	Action Taken
Physical Injuries	3	37.5	First aid and follow-up
Hypertension	2	25.0	Medication and monitoring
Mental Health Issues	2	25.0	Referred to MHPSS
CVA	1	12.5	Hospital Referral
Total	8	100	-

Source: Sidek et al., 2025

Mental Health Screening and PFA Services

The MHPSS team from HSDHO conducted psychological first aid (PFA) interventions and mental health assessments for SAR personnel. The assessment utilized two standardized screening tools: the Whooley questionnaire for depression and the Generalized Anxiety Disorder-2 (GAD-2) scale. Additionally, PFA kits were distributed to support the psychological wellbeing of SAR team members. The screening outcomes and intervention results are presented in Table 4 and Table 5.

Table 4. Mental Health Screening Results

Variable	Category	Number (n=29)	Percentage (%)
Gender	Male	29	100
Agency	FRDM	27	93.1
	MCDF	2	6.9
Screening Results	Whooley Positive	3	10.3
	GAD-2 Positive	0	0
Referrals |	Counselor	3	10.3
	Family Medicine Specialist	0	0
	Psychiatrist	0	0

Source: Sidek et al., 2025

Table 5. PFA Session Characteristics

Variable	Category	Number (n=9)	Percentage (%)
Session Type	Individual	5	55.6
	Group	4	44.4
Agency	FRDM	9	100
PFA Activities	Relaxation	3	33.3
	Psychoeducation	4	44.4
	Sleep Hygiene	2	22.2

Source: Sidek et al., 2025

Environmental Health Assessment Results

Daily environmental health assessments conducted from December 18-24, 2022, yielded comprehensive findings regarding food safety and sanitation measures. In terms of food safety management, the operation was supported by one appointed food caterer and eleven food donors. All food handlers received typhoid vaccination as a preventive measure, and their premises underwent regular inspections, consistently achieving satisfactory ratings. A strict four-hour consumption time limit was implemented for all prepared food. Throughout the operation, no food-borne illness cases were reported, demonstrating the effectiveness of these preventive measures.

Water supply and sanitation management proved equally successful. *Air Selangor* (water services provider for Selangor state) provided clean water supplies on a regular basis throughout the operation period. The site was equipped with an adequate number of mobile toilets, which underwent daily maintenance and sanitation procedures. Local authorities efficiently managed waste disposal, ensuring proper sanitation standards were maintained throughout the operation period.

Health Education and Promotion Activities

Table 6: Summary of Health Education and Promotion Activities

Activity Type	Number Conducted	Reach
Individual advice sessions	22	22 personnel
Practical demonstrations	2	45 personnel
Resource Distribution:		
- PFA Kits	6	Agency heads
- Repellent	150	All personnel

Activity Type	Number Conducted	Reach
- Hand Sanitizer	20	Key positions
- Disease Information Pamphlets	6	All agencies
Group discussions	3	75 personnel
Public announcements	1	All personnel
Committee briefings	2	Agency leaders

Source: Sidek et al., 2025

Comprehensive health protection measures were implemented through targeted health education interventions (9). These included guidance on appropriate protective clothing and the application of mosquito repellents for vector-borne disease prevention (10). PPE protocols were emphasized, particularly the requirement for protective boots to mitigate melioidosis and leptospirosis exposure risk. Health promotion activities were conducted to enhance awareness of potential infectious disease risks among all SAR team members during the operation.

Health Base Operations

The Health Base, established as a comprehensive one-stop center, effectively coordinated multiple health services including screening programs, mental health support, and environmental monitoring. This centralized approach facilitated efficient inter-agency communication and systematic data collection throughout the operation. The implemented surveillance system, extending one-month post-operation, proved highly effective in disease prevention. No cases of endemic diseases (leptospirosis, malaria, melioidosis), food/water-borne illnesses, or respiratory infections (COVID-19, influenza) were reported among personnel. This success can be attributed to systematic preventive protocols and integrated health monitoring through the Health Base's daily verification procedures. Our findings demonstrate that a centralized health management approach can effectively support complex disaster response operations while maintaining comprehensive health surveillance and prevention measures.

DISCUSSION

The Batang Kali landslide response operation enabled evaluation of a novel health management model centred on the Health Base concept. This approach facilitated integrated health services and real-time surveillance through centralized coordination. Physical injuries, showing a 37.5% injury rate is consistent with global SAR statistics (30-40%). Cerebrovascular accidents may be attributed to the stressful work demand of rescue operations, however, in our

study it accounted for only one case (12.5%). Mental health support participation rates (5.7%) suggest effective early intervention strategies despite the stigma of mental health among general population (11).

Operational adaptations for COVID-19 prevention, including modified PPE protocols and enhanced ventilation, successfully prevented infectious disease transmission (12). Environmental health measures demonstrated effectiveness through zero reported vector-borne and foodborne illnesses. Despite limitations in participation rates and documentation on the earlier phase of the incident, this model shows potential for replication across different disaster scenarios. Future implementations should consider mandatory pre-deployment screening and enhanced documentation systems. Additional research is needed to evaluate long-term health impacts and cost-effectiveness.

LIMITATIONS

This study had several notable limitations. The voluntary participation yielding an 11% response rate introduces potential selection bias, limiting result generalizability. The lack of pre-deployment health data hindered our ability to differentiate between pre-existing conditions and operation-related health impacts. Data collection was affected by operational constraints during the initial 72-hour response period and physical site limitations. The validated mental health screening tools may not have fully captured psychological impacts, particularly given cultural factors and stigma surrounding mental health. Additionally, the one-month follow-up period may be insufficient to detect longer-term health outcomes, including delayed onset of infectious diseases and emerging mental health issues.

CONCLUSION

The Batang Kali landslide response operation demonstrated the effectiveness of a novel global health management model through the Health Base concept. Physical health screening revealed significant musculoskeletal injuries (37.5%) and cardiovascular issues (37.5%) among participants. Mental health services, despite low participation (5.7%), showed positive outcomes with only 10.3% requiring intervention, attributable to early psychological first aid and structured support systems (13,14,15).

The model's environmental health component proved successful, with zero reported cases of foodborne illness and effective water and sanitation management. Our integrated approach to health service delivery and inter-agency coordination presents a promising template for

future disaster responses. This model shows potential for adaptation across various disaster scenarios, though further research should address long-term health impacts, cost-effectiveness, and enhanced environmental monitoring protocols (16).

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

APPENDIX A

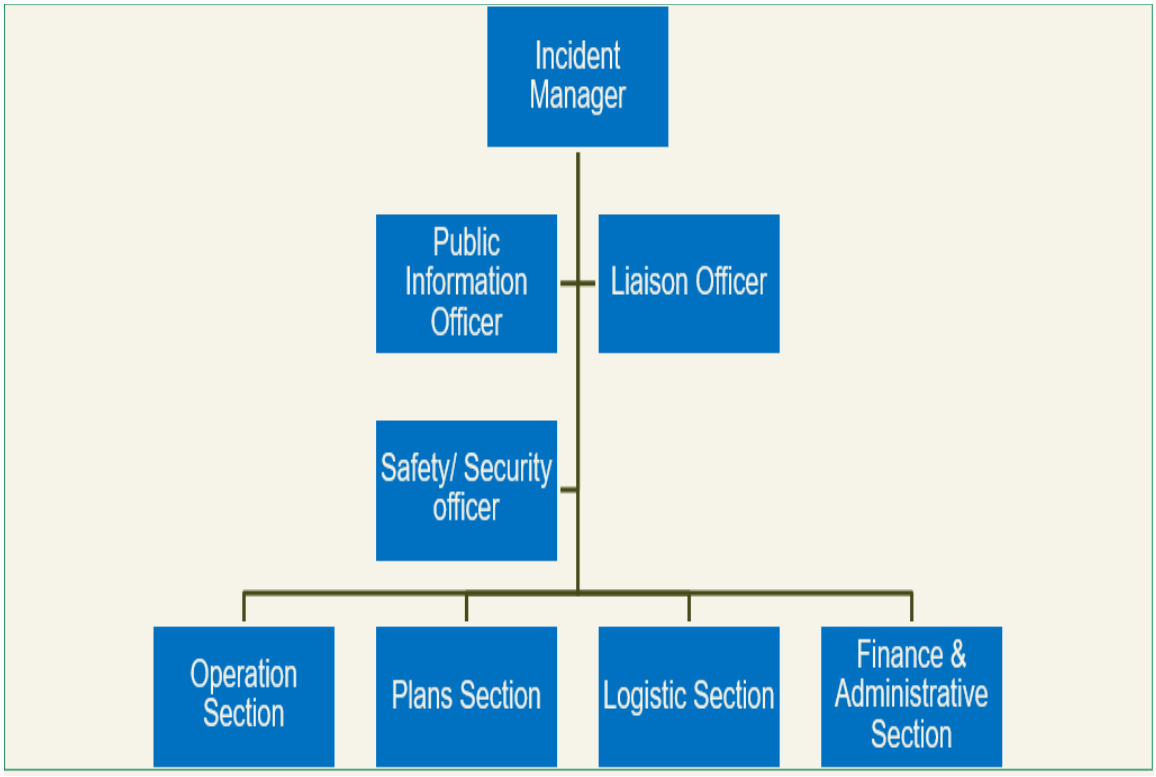

Figure 1. District Health Office Incident Management System

Source: Ministry of Health Malaysia, 2023

APPENDIX B

Figure 2. Public Health and Mental Health Activities at the Health Base

Source: Ministry of Health Malaysia, 2023

APPENDIX C

ENVIRONMENTAL HEALTH ASSESSMENT FORM

Hulu Selangor District Health Office

Year ____

Date and Time of Assessment : _____

Type of Disaster : _____

Location :_____

Scope	Yes	No	Notes
	(Compliant)	(Non-Compliant)	
A. Prevention Of Leptospirosis Infection Source			
1. Rodent Control (Food & Water Storage)			
a. Food storage store:			
Food storage store is clean, neat and tidy			
Cleaning Schedule and Good inventory of goods present			
a. Rodents Control Activities			
b. No rodent/rodents' remains at sight			
c. A good management of food remains			

d. Food remains not thrown everywhere			
e. Food remains thrown neatly in the waste bag			
f. Safe drinking water (treated water)			

2. Prevention Of Rodents Infestation At Disaster Site			
Clean Surrounding			

3. Sanitation Facilities			
Toilet (mobile) present			
No Rodent at sight			
Clean toilet			
Clean sewage management present			
Frequent and good cleaning schedule			
Regular sanitation of toilet			
No sewage seepage			

4. Food Waste And Garbage Management			
a. No of rubbish bin			
Adequate			
In good condition			
With cover			
Rubbish bag present			
No trash littering			
Regular garbage collection schedule			
b. Garbage Collection Site;			
Clean			
Neat & tidy			
No garbage pile at the floor			
Regular cleaning and collection of garbage			

5. Surrounding Situation at Disaster Site			
a. Treated water source			
b. A good drainage system at disaster site			
No stagnant water			
Drainage in good condition			
Doesn’t trap garbage			

6. PPE Usage by Sar Personnel			
Wear Boots			

Wear long sleeve shirt			
Wear face mask			
Repellent usage			
Frequent hand washing			

Comments:

Corrective action/s to be carried out:

Reported by:	Checked by
Assessor signature	Signature
Name and stamp	Name and stamp
Date	Date

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