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Waterborne diseases in flood compromised WASH conditions in Malaysia: a planetary health perspective

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Floods are one of the major climate events that disrupt vital built systems such as water drainage and sanitation facilities. These conditions make it extremely difficult to obtain clean water and sanitation. The lack of safe and clean water, sanitation, and hygiene (WASH) has detrimental effects on the community, for example, the spread of a wide range of infectious illnesses, particularly waterborne illnesses. This review examines the major disease spread and difficulties encountered in a compromised WASH situation in Malaysia during flood catastrophes. We reviewed the literature on the Web of Science, ScELO Citation Index, PubMed, and Scopus databases for articles published between 1972 and 2024. Among the 41 identified articles, 10 were eligible for inclusion based on writing in English, removing duplicate literature, and observing that the study was conducted in Malaysia. This study discusses these issues and the WASH framework in Malaysia. Food poisoning, cholera, hepatitis A, diarrhea, and typhoid fever are among the most common ailments that flood victims are diagnosed with. Enhancing the WASH practices and infrastructure in Malaysia is crucial for reducing the risk of these illnesses. This requires a multifaceted strategy that includes sustainable technology, community involvement, and governmental action.

KEYWORDS

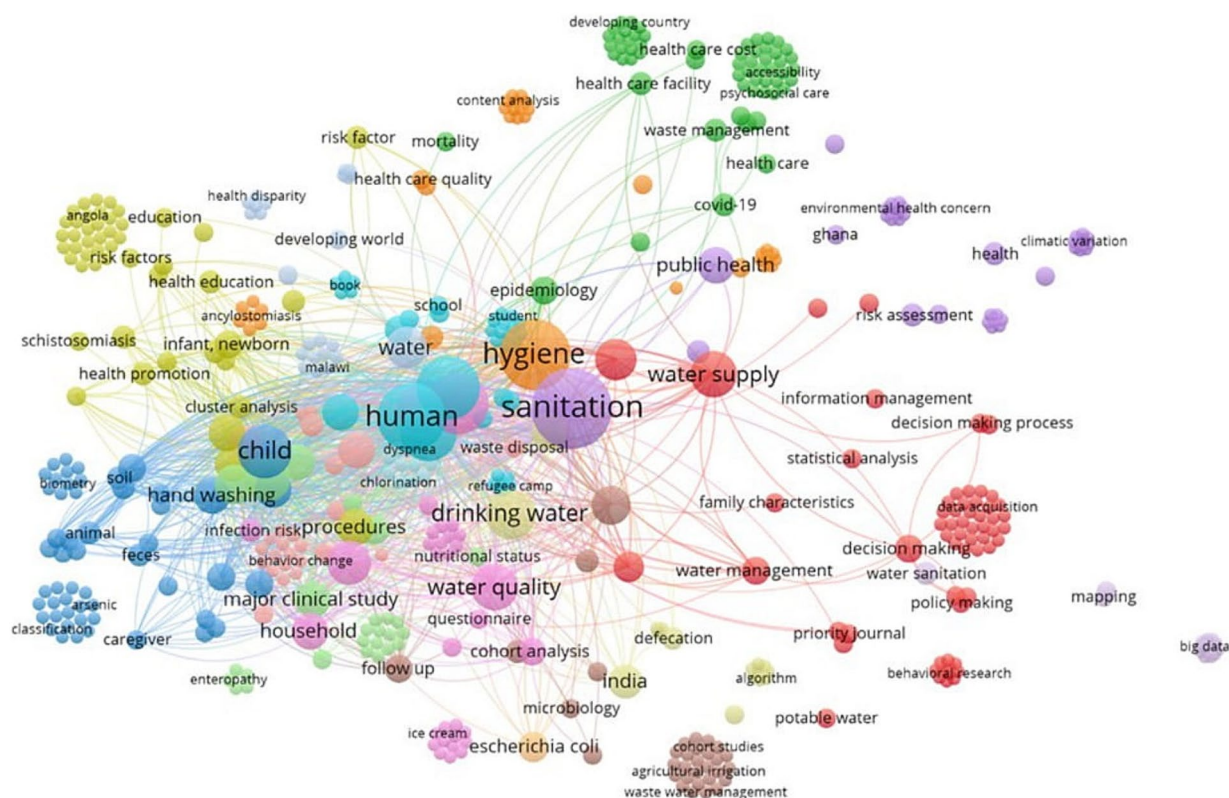
planetary health, WASH, waterborne diseases, flood disaster, SDG 6, Malaysia

1 Introduction

A region's unique atmospheric conditions, which are measured and can change over extended periods, such as seasons, years, or decades, are referred to as the climate. Precipitation and temperature are two such factors that influence climate and both have extreme fluctuations worldwide (Botkin and Keller, 2005). Climate change refers to any sustained and noteworthy alteration in the "average weather" a particular area encounters (NASA, 2014). Average weather refers to typical wind patterns, precipitation amounts, and temperatures. It deals with variations in average or variable atmospheric conditions over many decades to millions of years (Rahman, 2009). More specifically, throughout the past million years, Earth's annual temperature has varied by several degrees Celsius. This phenomenon is a major contributor to climate change. Temperature records from the past 30–50 years show warming trends in most nations, including Malaysia. Drought, flooding, and rising sea levels are only a few occurrences caused by climate change (Rosmadi et al., 2023; Rosmadi et al., 2024). Among

Raya Kampung Perpat in Johor, 69 flood victims from 17 families were given access to sanitary facilities, with priority given to those who were most in need. For contagious illnesses such as cholera spread by feces, poor sanitation management may undoubtedly have a detrimental effect on the local population. The subsequent issue is that, in certain areas, it may not be as convenient to access clean water for daily use, which could potentially affect the health of the population due to the scarcity of clean water. Water, sanitation, and hygiene issues are frequently associated with cholera and diarrhea. The World Health Organization has reported that 88 % of diarrhea cases worldwide are attributable to unsafe water, inadequate sanitation, or insufficient hygiene (Zin et al., 2015). Clean water and safe sanitation are goal no. 6 of the global Sustainable Development Goals (SDGs), and this SDG6 is highly affected by flooding events. Malaysia is ranked 78th in 2023 in the worldwide SDGs ranking of nations in terms of attaining sustainable development. Before its inception, Malaysia was ranked 72nd in 2022, 65th in 2021, 60th in 2020, 68th in 2019, 55th in 2018, and 54th in 2017. Globally, many researchers have focused on identifying sustainable drinking water and sanitation plans (Figure 1). To propose improved policies for the Malaysian government in the age of rapid climate change, this assessment set out to investigate the existing state of water, sanitation, and hygiene, particularly during floods.

To address the important challenges of safe drinking water and sanitation and to enhance the quality of life of millions of people, particularly those residing in developing or low-income areas, a variety of organizations, governments, non-governmental



organizations, and international agencies implement Water, Sanitation, and Hygiene (WASH) initiatives. A lack of adequate WASH facilities can have serious repercussions, especially during humanitarian crises and emergencies, when access to sanitary facilities and clean water is even more vital to halt the spread of illness and increase the chances that affected communities will survive. WASH is an umbrella term for several issues including access to clean water, sanitary facilities, and hygiene-promoting behaviors. These three components are interconnected and are essential for public health, sustainable development, and the overall wellbeing of individuals and communities. There are many agencies in Malaysia for water governance, such as the Suruhanjaya Perkhidmatan Air Negara (SPAN) and the National Water Services Commission. SPAN is also a national regulatory agency in the water sector. SPAN draws its authority from Article 11(b) of the Federal Constitution. Water services are now shared between the States and the Federal Government under the Concurrent list, 9D of Article 95 B (1) (b), under the purview of water supplies and services (Ahmed et al., 2018). Public health and disease prevention are very important because access to clean water and proper sanitation are crucial for preventing the spread of waterborne diseases, such as cholera, typhoid, and diarrhoea (Saimy and Yusof, 2013). Maintaining good hygiene lowers the risk of illness, particularly in places with high population density. Decreased mortality is also significant because, especially in underdeveloped countries, where children are most susceptible to illnesses associated with water, better WASH infrastructure directly

lowers child mortality rates (Sharma Waddington and Cairncross, 2021). Thus, enhancing the WASH score may result in a decrease in waterborne diseases (Figure 2).

In Malaysia, research on WASH is essential for preventing waterborne illnesses and enhancing public health and wellbeing. Given Malaysia's ongoing urbanization, knowledge of WASH issues contributes to the development of infrastructure in rapidly expanding cities, and guarantees that rural and indigenous populations have access to sanitary facilities and clean water. The influence of climate change is also discussed in this study, because droughts and floods in Malaysia have an impact on the availability and quality of water. By examining WASH concerns, Malaysia can increase disaster preparedness, strengthen the sustainability of WASH infrastructure nationwide, and better match the United Nations (UN) SDG 6 on clean water and sanitation. Ensuring sustainable and equitable development in both urban and rural areas depend on the study. The four stages of flood disaster management in Malaysia were readiness, response, recovery, prevention, and mitigation (Ahmed et al., 2020). The best course of action is to focus on readiness, disaster prevention, and mitigation, as these two stages will lessen the strain in the subsequent stages. Major flood control agencies in Malaysia were recognized in this analysis, including the Department of Irrigation and Drainage and the Malaysian National Disaster Management Agency (NADMA). It also emphasized the critical role that local communities play in reaction and preparation. In addition to providing invaluable local information, communities are essential for

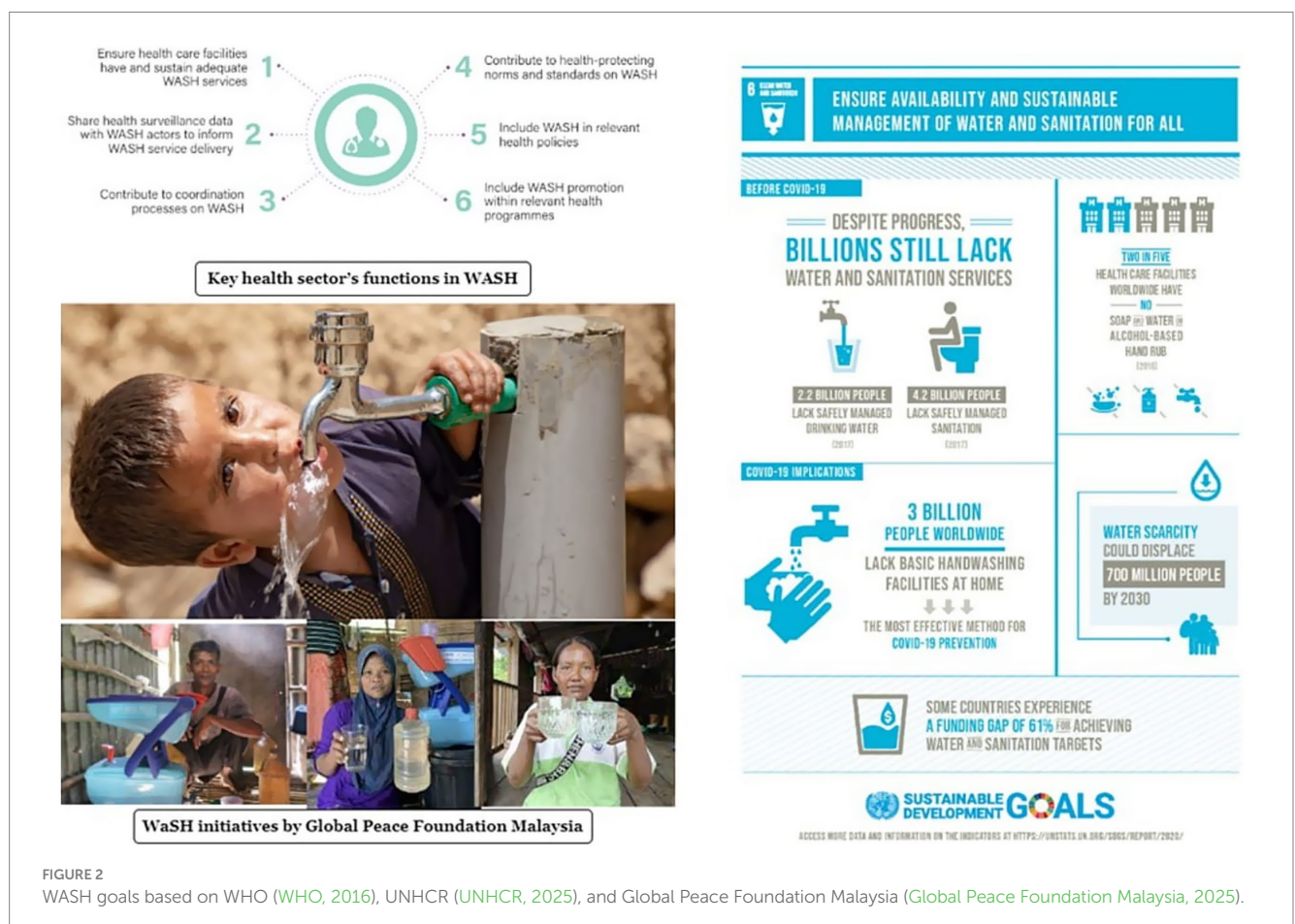


FIGURE 2

WASH goals based on WHO (WHO, 2016), UNHCR (UNHCR, 2025), and Global Peace Foundation Malaysia (Global Peace Foundation Malaysia, 2025).

lessening the effects of disasters. Health risks associated with flooding were evaluated using the Water, Sanitation, and Hygiene (WASH) framework, with a focus on the spread of waterborne illnesses, including cholera and diarrhea. There are still several unanswered questions in Malaysia's WASH research, particularly regarding the effects of flooding on public health. WASH data integration with real-time flood risk and health surveillance systems is not very well performed. Community-based flood resilience strategies have not been well studied in rural and indigenous contexts. Long-term policy alignment and consistency are also lacking in the interagency collaboration for disaster response and WASH infrastructure planning. Few studies have discussed how climate change aggravates problems with water quality and sanitation, such as protracted droughts and severe flooding. Furthermore, it is difficult to assess how well present public awareness and education campaigns regarding flood preparedness are working. The implementation of a fully integrated one-health concept is hampered by these constraints.

This study aimed to use the Water, Sanitation, and Hygiene (WASH) paradigm to investigate the connection between flood management and public health in Malaysia. The main goals include finding policy and infrastructure deficiencies, assessing WASH-related practices during flood events, and suggesting integrated methods to lower health risks. A thorough review of WASH-related research conducted in Malaysia from 2013 to 2024 was conducted to support these goals. To effectively manage flood consequences, the review's findings emphasize the vital need for integrated methods that include institutional collaboration, community participation, and an enhanced WASH infrastructure. Reducing the hazards of waterborne diseases requires public education regarding flood preparedness and response. The One Health concept, which advocates for cross-sectoral cooperation between health, environmental, and disaster management organizations, is also emphasized in this paper as being relevant. By tackling the difficulties in improving WASH results after flooding, this study provides evidence-based policy suggestions to create more resilient and health-secure communities throughout Malaysia.

2 Methods

A review of the literature served as the basis for this study. The Web of Science, PubMed, SciELO Citation Index, and Scopus databases were searched for relevant articles published from 1972 to 2024. The keywords used to search the articles broadly included health, morbidity, illness, disease, infection, water-borne, diarrhea, WASH, flood, inundation, and Malaysia. The detailed search strategy, with the keyword search for WASH-related articles based in Malaysia, is presented in [Figure 3](#).

Using records from both databases ($n = 5$) and registers ($n = 41$), studies were found in five databases and a variety of registers, including Web of Science ($n = 371$), SCOPUS ($n = 162$), SciELO Citation Index ($n = 197$), and PubMed ($n = 273$). Twenty-two records were eliminated before screening, including 10 eliminated for other reasons, five records that were flagged as ineligible by automation technologies, and seven duplicate records. Three records were eliminated from the 19 records that were checked following the initial filtering. Two reports could not be retrieved from the 16 studies that were searched. Four papers were excluded for various reasons (such as relevance or quality difficulties) after the remaining 14 publications

were evaluated for eligibility. The final review included 10 studies. Two steps were included in the search strategy. Keywords including "flood," "hydrological event," "deluge," "torrent," "high water," "high tide," "stormwater," "waterlogging," "water logging," "storm surge," and "inundation" were used in the first step to refer to floods and hydrological occurrences. Second, the search was broadened to include location-specific keywords and health-related terms. The terms "flood," "hydrological event," "deluge," "torrent," "high water," "high tide," "stormwater," "waterlogging," "waterlogging," "storm surge," and "inundation" were among the combinations it contained, as were "health," "disease," "infection," "water-related," "water-borne," "waterborne," "diarrhea," "diarrhoea," or "cholera," and "Malaysia." Therefore, all articles were scanned and identified as suitable WASH-related studies in Malaysia. After careful scanning and analysis, 10 WASH-related articles were finalized for analysis in the context of Malaysia. Ten articles focusing on flood-related WASH and waterborne diseases in Malaysia were included in this study. Articles that were not related to Malaysia and were not written in English were excluded. We searched the article titles, key phrases, and abstracts of the online databases. Subsequently, content analysis of the selected articles was conducted using the WASH criteria.

The performance of WASH systems during flood disasters, related health consequences, and policy deficiencies could all be systematically assessed using this methodology. Recurring issues such as poor sanitation after displacement, restricted access to potable water in rural regions vulnerable to flooding, and the absence of community-based preventive measures were all identified with assistance. This assessment reinforces Malaysia's commitment to SDG 6 (Clean Water and Sanitation) and SDG 13 (Climate Action) by adopting a methodical and open approach, supporting evidence-based recommendations for integrated flood and WASH management strategies nationwide.

2.1 Conceptual framework for improving WASH situations

The outcome was predicated on three requirements, each linked to an output of the WASH program, as per the conceptual framework ([Figure 4](#)): (1) enhanced access to fundamental drinking water services, (2) enhanced access to basic sanitation and hygiene services, and (3) a reinforced environment that supports WASH. In both rural and urban settings as well as in development and humanitarian contexts, the WASH program would assist in making these circumstances a reality at the home, community, and institutional levels. A comprehensive understanding of how numerous interrelated factors affect WASH conditions and the consequences of waterborne diseases, particularly in the context of Malaysia, is provided by the conceptual framework in [Figure 4](#). The primary causes, which include harsh weather and climate change, as well as socioeconomic factors, including poverty, low levels of education, and migration, put strain on the home, community, and individual contexts. Contaminated water sources are caused by unplanned urbanization, poor sanitation, and poor water supply management in public places. Poor waste management, hazardous sanitation procedures, and inappropriate water storage contribute to the spread of infections in homes. Individuals are immediately at risk of health problems owing to inadequate personal cleanliness and the use of contaminated drinking water. Cholera and diarrhea are among

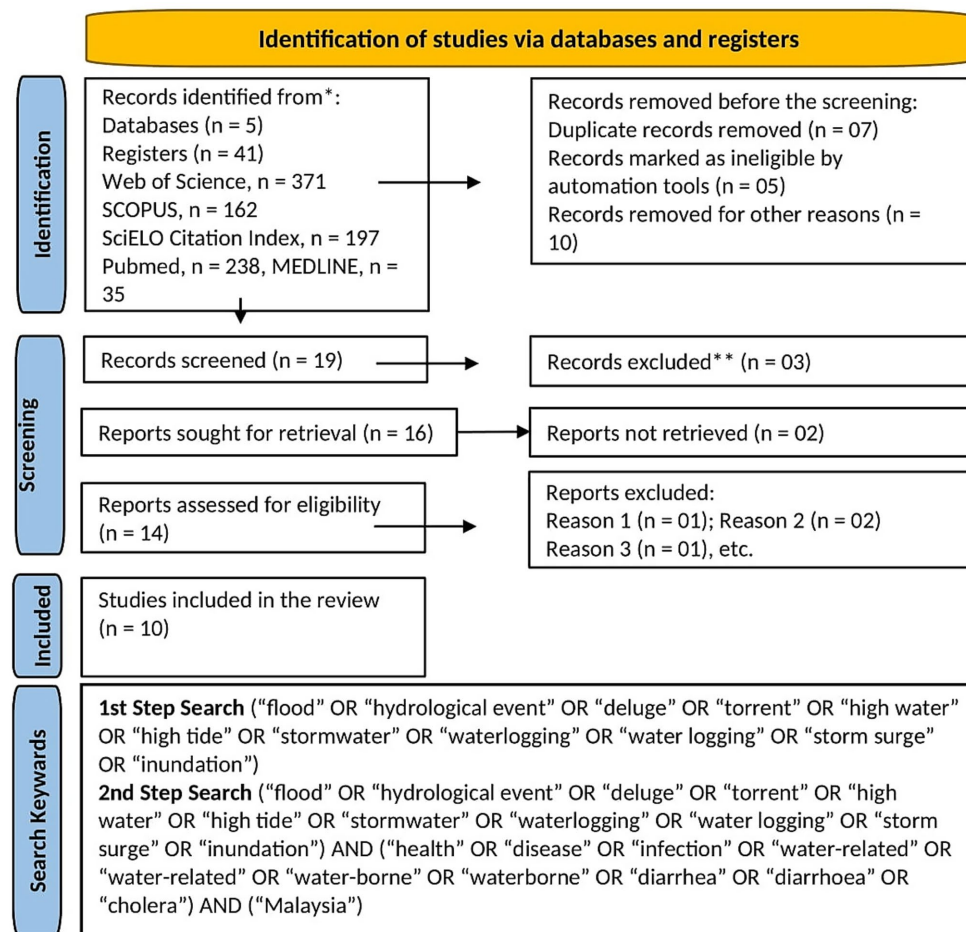


FIGURE 3

Flowchart for the systematic literature review of WASH applications in Malaysia (Page et al., 2021) (the automation tool is not used for this systematic review, because limited studies are conducted, and those studies are easily identified).

the illnesses caused by waterborne bacteria that spread as a result of this exposure. The severity of these illnesses emphasizes the pressing need for concerted efforts in risk management, health promotion, policy reform, and treatment plans. The framework emphasizes the importance of addressing WASH through multi-level, integrated interventions that incorporate both behavioral and structural changes, in line with more general objectives, such as SDG 6 and the One Health approach. The National Environmental Health Action Plan (NEHAP, 2020) was used as a guide to create this conceptual framework for improving WASH situations in Malaysia, especially during flood disasters, in line with the United Nations Children's Fund (UNICEF's) WASH program. Communities would also benefit from the WASH Program's assistance in becoming more resilient to shocks, especially those brought on by catastrophes and climate change. In humanitarian settings, where gender-based violence is frequently widespread, the program would continue to offer gender guidance, with a focus on the most vulnerable boys and girls.

3 Results

Malaysia is one of the emerging countries moving from poverty to prosperity and wealth. Malaysia needs to modify its way of life in a

manner similar to many other emerging countries. Enhanced access to sanitary restrooms and clean water is one such adjustment. Malaysia is becoming a role model for developing countries trying to guarantee secure and healthy livelihoods through advancements in water and sanitation. Malaysia's efforts to provide access to clean water and pipe systems can be observed in the collected data. Furthermore, data collected in 2015 by the World Health Organization (WHO) and UNICEF Joint Monitoring Program indicated that approximately 92% of Malaysians had access to safe water sources, and 82% had sanitation facilities. Therefore, these figures are better than anticipated when compared to other emerging countries (Supplementary Table 1). Floods in Malaysia usually lead to an upsurge in waterborne illnesses, such as cholera, typhoid, and diarrhea, particularly in areas such as Johor, Sabah, and Kelantan. Poor sanitation and tainted water supplies in flood-affected communities are associated with epidemics. To reduce these health hazards, it is essential to improve disease surveillance and the WASH infrastructure.

Using the Flood Risk Index (FRI) for hydrological modelling, a study conducted in 2013 found that more than 70% of data points were at moderate risk and 29.23% of data points were at high risk. Additionally, the study discovered that the viability of live bacterial cells increased during monsoon seasons, highlighting a heightened risk of waterborne illness transmission associated with seasonal

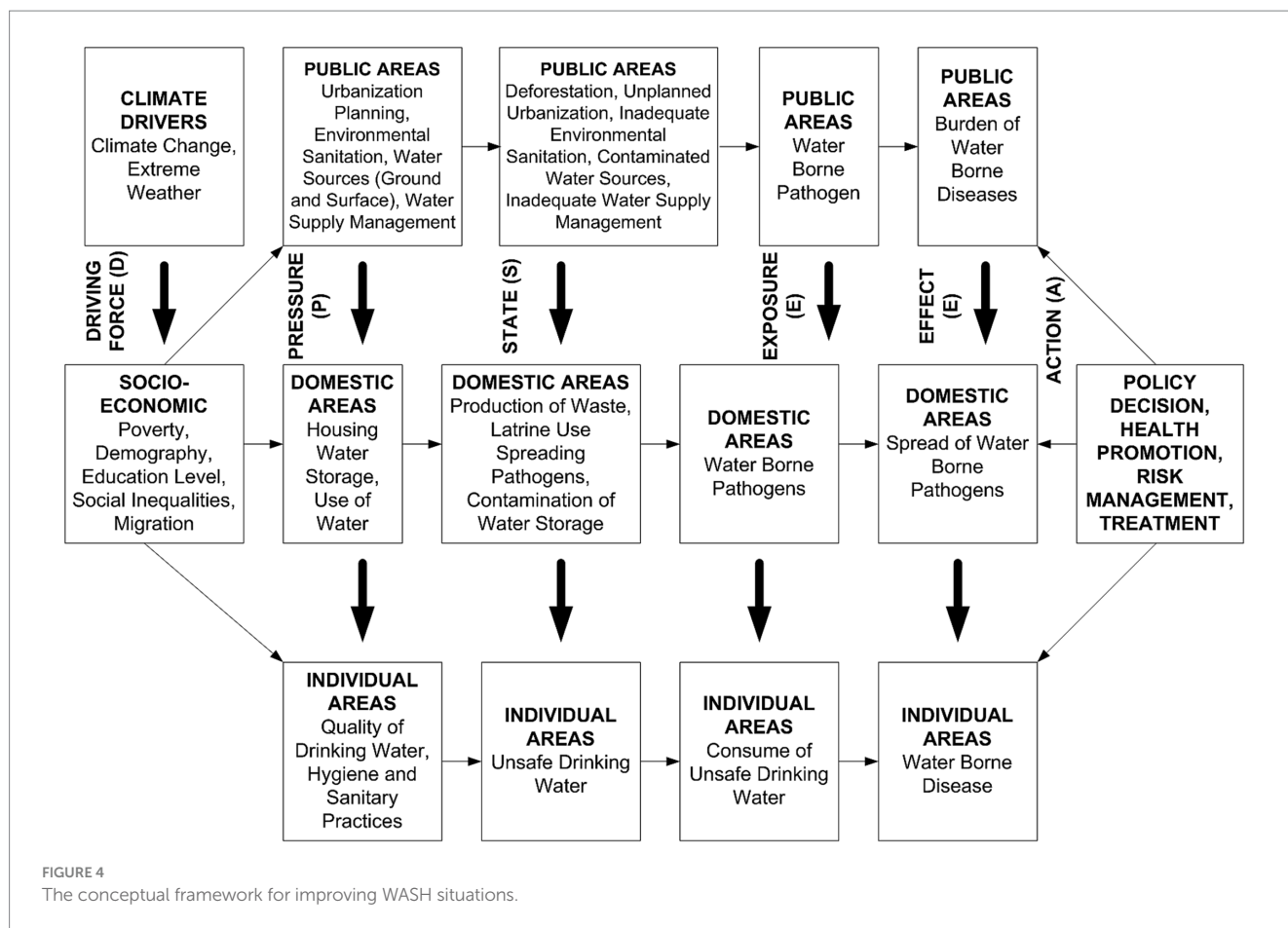


FIGURE 4
The conceptual framework for improving WASH situations.

flooding. In particular, the link between inadequate WASH practices during floods and Irritable Bowel Syndrome (IBS) was underlined in a 2017 article. It also highlights how displaced communities' greater demand for medical care and increased susceptibility to disease are caused by poor sanitation during flood disasters. Using a Knowledge, Attitude, Belief, Practice (KABP) questionnaire for leptospirosis, this study sought to evaluate public knowledge and behavior in 2018. The two measures lacked discriminatory power, indicating inconsistent understanding during floods, although many items were statistically acceptable. The instrument also identified gaps in public knowledge. According to a 2020 study, Kota Kinabalu had the highest rate of flood-related waterborne diseases (FWBDs), accounting for 68.5% of all cases. This illustrates how color-coded alerts and real-time flood predictions might help residents communicate risks and prepare for emergencies (Figure 5).

A cross-sectional study of 165 persons conducted in 2022 found that people's knowledge (40%) and attitudes (76%), as well as their awareness (59%) of WASH and waterborne diseases, were moderate. It revealed differences in WASH-related health literacy by finding statistically significant relationships between knowledge levels and variables including gender and family income. The 2023 paper examined the role of climate change in the spread of waterborne illnesses, citing local instances, such as Cyclone Nargis (2008) and Typhoon Haiyan (2013). The study linked increased storm frequency and intensity to rising public health risks, underscoring the need for climate-adaptive WASH systems in Southeast Asia, particularly Malaysia. The 2024 study investigated how people perceive the risk of

flooding and their awareness of WASH. In rural areas, 63.3% said they knew very little about flood dangers, whereas 88% of the respondents from urban areas said they were somewhat to very informed. This has brought to light a recurring disparity in WASH readiness and awareness between the urban and rural areas. Collectively, these 10 publications demonstrate a wide spectrum of WASH issues in Malaysia, such as public perception, health effects, risk modeling, and climate effects. The results demonstrate that integrated WASH policies that incorporate scientific data, public education, and community engagement are necessary to reduce flood-related health hazards and meet national resilience targets.

Our current review displays publications on waterborne illnesses during floods in Malaysia, based on [Supplementary Table 1](#). Due to variations in monsoon winds, Malaysia is one of the countries that experiences floods, so several studies have been conducted. Furthermore, because of climate change, the frequency and intensity of flood events have increased with the uncertainty of their occurrence. The spread of infectious diseases and deaths are only two of the numerous negative effects of floods. Consequently, when taken as a whole, every article connects waterborne illnesses with floods. Flood victims frequently develop illnesses including cholera, hepatitis A, dysentery, typhoid fever, and food poisoning. The illness manifests as fever, vomiting, diarrhea, headache, and stomach pain. Bacteria are consumed in contaminated food or water, leading to the development of ailments. This disease is extremely serious and infectious.

Malaysia has made great progress in enhancing sanitation and water services, particularly in cities. Over the years, the nation has

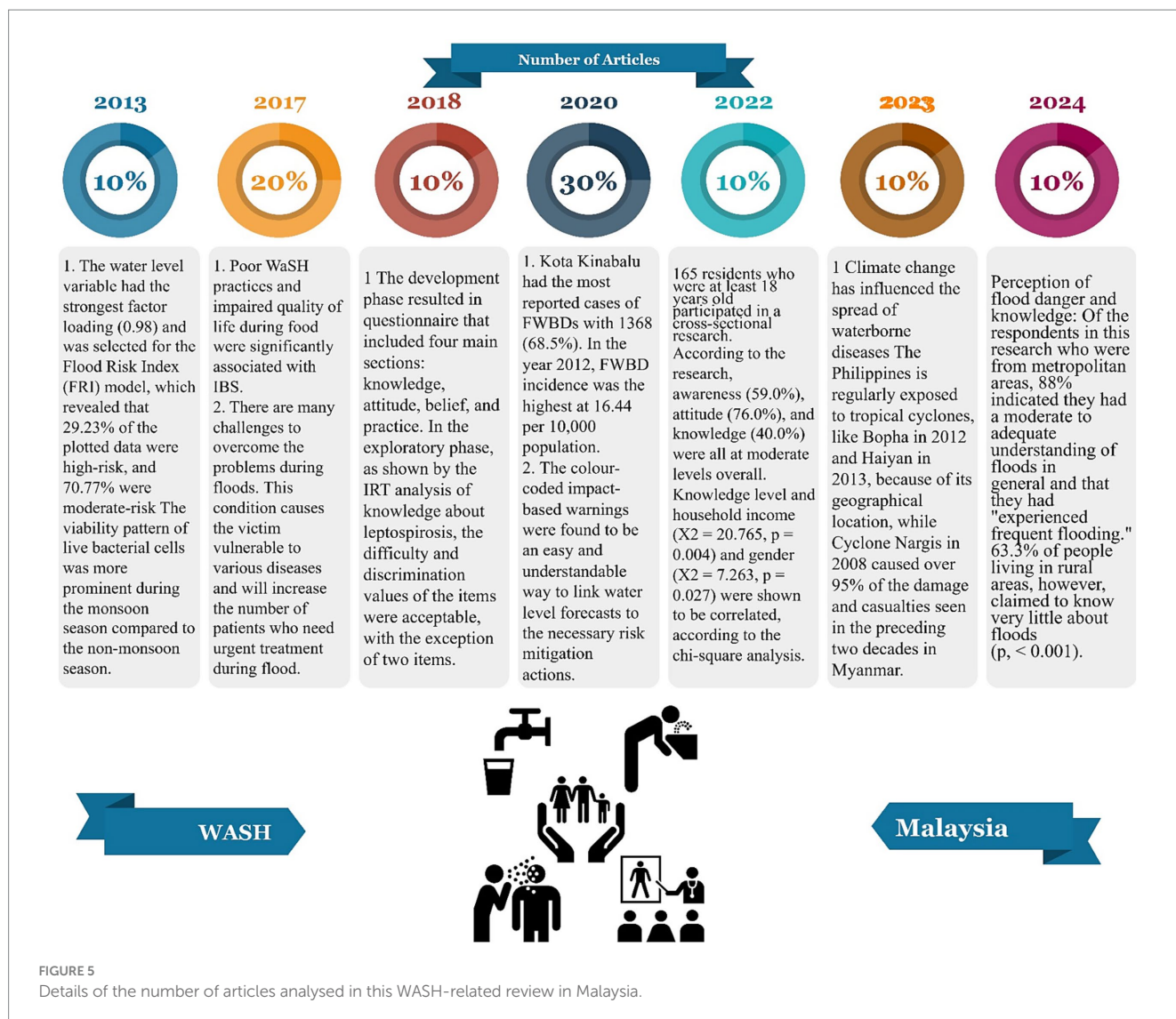


FIGURE 5
Details of the number of articles analysed in this WASH-related review in Malaysia.

undertaken several projects and regulations to improve sanitary infrastructure and provide access to clean water. These efforts have been demonstrated by the growth of water treatment facilities, enhancements to wastewater treatment systems, and extensive sanitation programs, which have helped many areas witness a decrease in the prevalence of waterborne illnesses. Nevertheless, flood-related waterborne infections continue to pose a serious public health concern in Malaysia, despite these advancements. Owing to its geographic location, the nation is prone to regular flooding, particularly during the monsoon season. Water quality is being threatened by floods that occur more frequently and with greater intensity, due in part to climate change. Flooding frequently introduces bacteria into water sources, resulting in outbreaks of waterborne illnesses, such as cholera, dysentery, and typhoid. Rural communities are disproportionately affected by these diseases because they have less access to sanitary facilities and clean drinking water.

Malaysia's development in WASH has been inconsistent, especially when considering flooding issues. Although water and sanitation infrastructure has improved in urban areas, there are still significant gaps in rural and flood-prone areas. Floods have the potential to overrun the current infrastructure, contaminate water supplies, and

cause public health emergencies. More focused interventions are still required, especially in flood-prone areas, despite the government's attempts to strengthen the resistance of water and sanitation systems to flooding. By examining sustainable strategies to prevent waterborne diseases during and after floods as well as how flood occurrences impact the effectiveness of water and sanitation systems, WASH research in Malaysia should close these gaps. Protecting public health and strengthening the robustness of Malaysia's WASH systems depend heavily on this research.

WHO and UNICEF (2015) claimed that Malaysia has achieved notable progress in providing access to water and sanitation, with nearly universal coverage in urban areas. However, floods still pose a threat to these accomplishments, especially during the monsoon season. Floods frequently overwhelm water and sanitation systems, causing contamination and spreading waterborne illnesses, such as cholera and typhoid, despite infrastructure improvements. Rural and flood-prone communities are particularly at risk because of their weak infrastructure. Despite the overall improvements in water and sanitation, the risk of catching waterborne illnesses during floods highlights the need for flood-resilient WASH systems. Future initiatives should concentrate on enhancing the ability of the water

and sanitation infrastructure to endure floods and safeguard susceptible groups. Adaptive solutions for flood-prone areas should be investigated to reduce threats to public health and guarantee sustainable water and sanitation services during emergencies.

4 Discussion

Extreme weather events have profound impact on public health, particularly in flood prone countries such as Malaysia. This study demonstrates the association between floods, public health, and WaSH in Malaysia. Planetary health events, such as heat waves, deluges of rain, and floods, interfered with the ability of homeless people to obtain WASH supplies and restricted the amount of extra assistance provided by service providers. In particular, meeting the requirements of homeless persons placed a two-fold load on health services and the WASH. Concerns such as waste management are given less attention in this setting, although issues such as access to safe drinking water are comparatively better understood. Flooding has less established effects on the health and WASH circumstances of homeless people than extreme weather events, such as heatwaves. However, data gaps, lack of knowledge about the unique health needs of homeless populations, and inadequate access to crucial WASH services frequently impede efforts to improve their situations. Consequently, they are even less represented in planning and response activities.

4.1 Water situation in Malaysia

According to the Dublin Principles on Water (ICWE, 1992), freshwater can be defined as a finite and vulnerable resource essential for sustaining life, development, and the environment (Principle 1). This resource should be recognized for its social, economic, and environmental value (Principle 4). Water management and development should be based on a participatory approach involving users, planners, and policymakers at all levels (principle 2). (3) Women play a central role in the provision, management, and safeguarding of water (Principle 3), in which they are central to household water use and hygiene, especially during floods and shortages. However, they remain underrepresented in water management decisions. Empowering women enhances WASH outcomes and supports more resilient and inclusive water governance. Malaysia has an abundance of water resources. Rivers and streams with no reservoirs account for 98 percent of the total water used in Malaysia (Rahman, 2021).

Children's access to clean and safe drinking water is crucial for their general development, health, and wellbeing, making it a major global problem. Access to safe and clean drinking water is a worldwide problem for many children (Alam et al., 2021). Malnutrition, waterborne infections, and mortality may have resulted from this lack of access (Brown et al., 2013). Furthermore, tainted water supplies can give rise to waterborne illnesses including dysentery, cholera, and diarrhea, which are the leading causes of illness and mortality among children, particularly in poor countries. Malaysian citizens, even adults, are widely recognized as having access to clean and safe drinking water (Mazed, 2023). The country has invested in infrastructure and water management

to ensure a consistent supply of clean water. Malaysia has made significant progress in guaranteeing that its citizens can access potable water. Most rural and urban areas have access to treated drinking water. A comprehensive water management system is used in Malaysia to distribute and control water resources. Ensuring a consistent and sustainable supply of water is the aim of this system (Afroz et al., 2014).

4.2 Sanitation situation in Malaysia

Malaysia is unique to Southeast Asia because it has recently achieved notable advancements in wastewater management and cleanliness. Since the early 2000s, remarkable advancements have been made in sanitation research. With the support of the commercial sector and a robust regulatory framework, a comprehensive strategy was adopted to manage centralized, community, and on-site sanitation systems. Integrity considerations play a major role in the mix of variables that has made Malaysia a successful model for other countries (Narayana, 2020).

Malaysia is often seen as having made considerable strides in enhancing access to clean water and sanitation for its people, especially children. The government has launched several projects and programs to improve sanitary conditions and personal hygiene nationwide. Urban regions, such as flush toilets and appropriate waste disposal systems, tend to have more advanced sanitation amenities than rural regions do. Maintaining hygiene is essential, particularly for young people, and it requires access to sanitary facilities. Additionally, several campaigns and educational initiatives have been implemented to encourage young people and the general public to practice appropriate hygiene. Educating children on the value of handwashing and practising personal hygiene is one such initiative (Rah et al., 2015). Next, the state of sanitation in Malaysia, which encompasses both men and women's access to clean water and adequate sanitation facilities, is discussed. Access to adequate sanitary facilities is essential for women's health and safety in urban and rural areas. To protect women's dignity and wellbeing, there must be sufficient private bathrooms and public restrooms in homes and businesses (Joshi, 2017). Access to menstrual hygiene supplies and facilities is crucial for women's health and comfort. Efforts have been made to ensure that sanitary goods and facilities are accessible in public areas, businesses, and schools.

4.3 Hygiene situation in Malaysia

In contrast to the surrounding countries, Malaysia has excellent sanitation facilities. Although tap water is safe, bottled water tastes better and safer. According to the Asian standards, a country's medical supply is good. If there are any issues, access to quality medical treatment will not be far away. A vital component of a child's health is hygiene, and Malaysia has worked to encourage youth to practice basic hygiene (Patel et al., 2020). One of the most important aspects of hygiene is teaching children how to wash their hands properly. The need to wash hands with soap and water, especially before eating and after using the restroom, is often taught to children through educational campaigns and

programmes. Schools must maintain hygienic conditions for children's health. In Malaysia, many schools have implemented hygiene programs that provide students with access to handwashing facilities and sanitary restrooms (Mathew et al., 2009). To maintain proper hygiene, children must have access to clean, safe drinking water. Clean water is often easy to obtain in metropolitan areas; however, it can still be difficult to obtain in certain isolated and rural areas. In Malaysia, adult hygiene is an important component of public health and wellbeing. Access to facilities and menstrual hygiene products is crucial for adult women (Pednekar et al., 2022; Patel et al., 2022). Attempts have been made to make sanitary items accessible and menstrual hygiene education available. Adults must ensure that their workplace is clean. Facilities for employees to use toilets and personal hygiene products are recommended, as are safe and hygienic working conditions.

4.4 Better implementation of WASH in Malaysia

Enhancing WASH practices and infrastructure in Malaysia necessitates a multifaceted strategy that includes sustainable technology, community involvement, and government action (Putri et al., 2021). Malaysia has several superior WASH initiatives including planning and assessment. The present WASH infrastructure is examined in detail, noting any shortcomings and areas that require development. Provide a thorough national WASH plan with objectives, targets, and execution schedules. To obtain feedback and guarantee inclusion in planning, they interact with key stakeholders, NGOs, and local communities (WHO, 2019; Mokhtar et al., 2017). One better way may be to promote cleanliness. Organize initiatives to raise awareness and educate people about cleanliness issues in communities, schools, and healthcare institutions (Jakariya et al., 2016; Ahmed, 2023). Good handwashing habits should be encouraged to prevent the transmission of the illness. Encouraging the construction of hygienic sanitation facilities, including toilets and handwashing stations.

Several serious WASH issues affect Malaysia, particularly during floods. Water supplies are frequently contaminated by seasonal monsoon flooding, which increases the risk of waterborne illnesses such as cholera, leptospirosis, and diarrhea. Bacterial cell viability was shown to be considerably higher during monsoon seasons in 2013, underscoring the increased health concerns related to flooding (Rahman, 2021). One of the biggest concerns is inadequate sanitation and hygiene. Many temporary evacuation centers (PPS) and homes do not have adequate restrooms, potable water for hand washing, or waste management systems during floods. For vulnerable groups, such as women, children, the elderly, and those with impairments, this is particularly risky. WASH-related behavioral patterns and public awareness vary (Brown et al., 2013). According to studies conducted in 2024, more than 60% of rural communities lack basic flood preparedness and understanding of safe hygiene practices, despite the fact that urban dwellers frequently have moderate to good awareness of flood dangers and WASH-related diseases (Patel et al., 2022). Further increasing vulnerability during catastrophes is a knowledge gap regarding disease transmission, latrine use, and water storage.

There are clear differences between urban and rural areas in terms of risk communication, health education, and infrastructure availability. Disease outbreaks are more likely to occur in rural

areas because many depend on untreated surface water and have inadequate sanitary facilities. Floods are becoming more frequent and severe owing to climate change, which worsens these vulnerabilities (Patel et al., 2022). Due to poor coordination and little community involvement, WASH responses are frequently dispersed, even in the presence of local authorities and national disaster agencies such as NADMA. In general, integrated community-based approaches that prioritize rural areas, increase disaster preparedness, raise public awareness, and fortify institutional cooperation are needed to address Malaysia's WASH issues (Putri et al., 2021). In light of the growing climate hazards, these actions are crucial for achieving SDG 6 and maintaining health security.

The study would gain from a more thorough examination of the WASH marketing tactics specific to Malaysia. Public health campaigns, school-level awareness initiatives, and community-based hygiene education were included, particularly in areas that are vulnerable to flooding. Enhanced outreach can be achieved through cooperation with regional disaster agencies, NGOs, and health authorities. Additionally, communication about behavioral change and culturally relevant messaging should be prioritized. Improving WASH habits and reducing the spread of disease require comprehensive promotion efforts.

4.5 Strength, limitations of the study and future research directions

- 1 This study demonstrates how Malaysia has made significant strides in expanding access to sanitary facilities and clean water, particularly in urban areas, backed by both national development objectives and international standards, such as those set by UNICEF and WHO.
- 2 It has also identified a significant loophole in the infrastructure's ability to withstand floods. Regular and severe floods jeopardize sanitary infrastructure and water quality, particularly in low-lying and rural areas. According to the study, flood exposure is directly linked to a higher risk of waterborne illnesses, such as cholera, typhoid, and diarrhoea. This highlights the pressing need for flood-resilient adaptive WASH systems to protect public health in the face of climate change.
- 3 Focusing on the relationship between public health and climate-related hazards, it provides insights into how environmental stressors affect WASH services in Malaysia. Contextual depth is further increased by utilizing regional data and policy references.
- 4 However, the absence of primary field data or case-specific analysis, which would provide empirical support for the conclusions, is a limitation.
- 5 Furthermore, more general trends have been examined, less is known about localized variations in infrastructure quality and community-level reactions. Field surveys and stakeholder interviews should be conducted in future studies to confirm and build on these results.

Regarding future studies, evaluation of the performance of the current WASH infrastructure both during and after flood disasters should be the main goal. The local health effects and coping

strategies at the community level in flood-prone areas should be investigated in future studies. Remote sensing and GIS integration can be used to map infrastructure gaps in vulnerable areas. Additionally, policy implementation and disaster response coordination in WASH-related events must be evaluated. Finally, research should focus on affordable and sustainable solutions for robust water and sanitation systems.

5 Conclusion

WASH is crucial for Malaysia. Thus, individuals in good health may live in decent circumstances. Excellent health is ensured when hygiene is maintained, particularly during flooding. In addition, other strategies may be employed to combat issues such as cholera and diarrhea that arise during floods. To accomplish the SDGs, the nation must collaborate with several entities, including governmental and non-governmental organizations. The risk of waterborne illnesses can be decreased by practising good hygiene during floods. Bacteria and viruses in water can cause fatal waterborne diseases. Both rural and urban residents should be educated on flood risk, mitigation, and prevention, because future floods are expected to be more severe owing to climate change. Floods affect people of all ages, but different groups require different safety information and mitigation strategies. Moreover, these programs must incorporate means of informing non-Malay speakers of situations that might not have access to or an understanding of first-aid supplies and local flood education. Access to clean water is a basic human right for every nation. Consequently, if not all parties care about this subject, it will negatively affect the country. This is vital to the community, particularly during the flood season.

Author contributions

FJ: Data curation, Methodology, Investigation, Writing – original draft, Software, Formal analysis, Visualization. MiA: Funding acquisition, Validation, Conceptualization, Methodology, Supervision, Project administration, Writing – review & editing. BH: Writing – review & editing, Visualization, Validation. TK: Writing – review & editing, Visualization, Validation. MuA: Resources, Writing – review & editing, Validation, Methodology, Supervision.

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Conflict of interest

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Supplementary material

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