Review Article

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Basic theoretical frameworks of health education, research needs and practice implications in China

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Abstract: The health of the population is the foundation of social civilization and progress, and it is a common pursuit among the general populace. With robust policy support, China aims to shift the focus of healthcare from disease treatment to prevention. Health education is a key strategy in this shift. However, this approach faces numerous challenges, including the application of fundamental health education theories across diverse health issues, healthcare systems, cultural contexts, and varying resource availability. This paper aims to summarize and present several theories related to health education, and then to discuss their application and related suggestions in China. Firstly, behavior change stages, social cognitive theory, the health belief model, theories related to promoting and supporting behaviors, locus of control, self-determination, the ecological model, and expectancy-value theory are briefly interpreted. Secondly, research needs and challenges regarding health education in China are discussed. Finally, using dengue fever control as an example, the RE-AIM model – standing for Reach, Effectiveness, Adoption, Implementation, and Maintenance – and the formative research framework are employed to illustrate the methodology for developing a tailored health education intervention program.

Keywords: healthcare model; health education; theoretical framework; formative research; dengue fever; health literacy

Introduction

The health of the people is the foundation of social civilization and progress, an important symbol of national prosperity and strength, and a common pursuit of the general populace. To enhance the health level of the entire Chinese population, the Central Committee of the Communist Party of China and the State Council issued the *Healthy China 2030 Plan Outline* on 25 October 2016. The outline proposes strategic tasks in five areas: promoting healthy lifestyles, optimizing health services, improving health security, building a healthy environment, and developing the health industry [1]. On 15 July 2019, the State Council released the *Healthy China Action Plan (2019–2030),* in which health knowledge popularization is the first of 15 special campaigns [2]. On 29 May 2024, the *Three-Year Action Protocol for Improving National Health Literacy (2024–2027)* (hereinafter referred to as "Three-Year Action Protocol") along with *Health Literacy of Chinese Citizens – Basic Knowledge and Skills (2024 Edition)* were released. The protocol aims to comprehensively and systematically enhance the health literacy of the entire population [3, 4]. The Chinese term "Jiankang Suyang" corresponds to the English terms "health literacy" and "health cultivation." Health literacy is the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions. Health cultivation refers to a holistic approach to maintaining and improving health through various practices, including the knowledge, skills, attitudes, and practices that individuals possess, which enable them to understand and effectively use health information and skills [5, 6].

Health education is an interdisciplinary approach that integrates theories and methods from preventive medicine, communication studies, sociology, education, behavioral science, psychology, and social marketing. It supports individuals and communities in enhancing health knowledge, establishing appropriate health values, modifying unhealthy behaviors and adopting healthier ones by mitigating unhealthy risk factors and ultimately integrating them into daily habits or lifestyles. This is done with the purpose of preventing diseases, actively pursuing health,

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and improving overall health levels [7–10]. Transitioning healthcare from disease treatment to prevention highlights the importance of health cultivation over mere knowledge acquisition and disease management [7]. Health education is foundational for improving understanding, promoting healthy behaviors, facilitating interdisciplinary collaboration, engaging the public, and supporting policy development. The basic principles of health education are grounded in theories of behavioral psychology, such as the health belief model (HBM), social cognitive theory (SCT), and the ecological model. These behavioral psychology theories are widely used in developing health education interventions to promote behaviors [11, 12]. The percentage of studies utilizing these theories can vary, and the extent of their use depends on the specific health issue being addressed and the target population. However, there is a growing trend towards incorporating behavioral psychology theories into health education interventions to enhance their effectiveness. This trend is driven by the recognition that theory-based interventions are generally more effective in achieving desired health outcomes [13]. The application of these theories also varies globally, reflecting differences in healthcare systems, cultural contexts, and resource availability. In developed countries, these theories are widely integrated into chronic disease management and infectious disease control programs. Their application is often supported by health policies that encourage preventive care, robust healthcare infrastructure, and access to digital health technologies. For example, interventions aimed at increasing physical activity based on SCT among adults with multiple sclerosis (MS) have documented that self-efficacy, goal-setting, and social support significantly increased physical activity among individuals with MS who experience fatigue in the United States [14]. In developing countries, there is a growing recognition of the importance of behavioral psychology theories in managing chronic diseases and preventing infectious diseases. For example, a study on educational intervention based on HBM documents found that the HBM can improve behaviors related to the prevention of dengue fever in southern Iran [15]. In developing regions such as Africa, the application of these theories is less prevalent, primarily due to limited healthcare resources and infrastructure [13, 16]. In public health, dengue fever is one of the most challenging arboviral diseases to control globally due to the lack of effective antiviral therapies and a highly protective vaccine. Therefore, behavioral psychology theories are crucial in designing effective health education interventions for dengue fever control [17–21]. Based on the situation analysis, this study aims to summarize the theoretical framework of behavioral psychology and its application in explaining and predicting health-related problems and influencing factors. It also discusses the research needs for health education in China. Finally, dengue fever control is used as a case study to illustrate how to design and conduct formative research in developing and implementing a tailored health education intervention program.

Basic theoretical frameworks of health education

Theories related to the stages of behavior change

In planning health education programs, it is essential to thoroughly understand the stages of behavior change at both individual and population levels. The transtheoretical model and the precaution adoption process model describe the stages individuals progress through, from lack of knowledge and awareness to taking actions and maintaining health behaviors as a lifestyle [22]. The diffusion of innovations theory categorizes a population into five adopter groups: innovators, early adopters, early majority, late majority, and laggards, highlighting individual differences within a community. These theories propose that designers and educators of health education programs should comprehend the stages and adopter groups involved, from the introduction of an innovation to the decision-making process of the targeted population. Additionally, they should be aware of the necessary actions required in health promotion activities (Table 1) [21–25].

As emphasized by the World Health Organization, intensified environmental management for vector control and the early detection of individuals infected with the dengue virus are two key strategies for controlling dengue fever [26, 27]. The Dai people in Yunnan Province, Southwestern China, are among the populations most affected by dengue fever outbreaks in the country [28–31]. A health education program targeting dengue fever control among the Dai Ethnic Minority exemplifies the integration of behavioral psychology theories into health education interventions. This program is designed to reduce the breeding habitats of *Aedes* spp. mosquitoes by engaging community participation in environmental management. Additionally, it aims to promote treatment-seeking behaviors among individuals suspected of having dengue fever, thereby facilitating early detection and isolation of dengue virus cases. However, what is the current stage of behavioral innovation adoption among the target population? What are the current proportions of innovators, early adopters, early

Table 1: Comparison of theories related to the stages of behavior change.

Level	Transtheoretical model [20][a] Individual	Precaution adoption process model [23][a] Individual	Diffusion of innovations theory [21, 22][b] Population
Stage 1	Precontemplation: the individual is not yet considering change or is unaware of the need to change	Unaware of the issue: the individual has no knowledge of the health threat	Five adopter groups of new behaviors: (1) Innovators; (2) Early adopters; (3) Early majority; (4) Late majority; (5) Laggards
Stage 2	Contemplation: the individual recognizes the need for change and is considering it but has not yet committed to taking actions	Unengaged by the issue: the individual is aware of the health threat but is not personally engaged or concerned	
Stage 3	Preparation: the individual is planning to take action soon and may begin taking small steps toward behavior change	Deciding about acting: the individual is considering whether to take actions but has not yet made a decision	Five stages from innovation to decision: (1) Knowledge distribution; (2) Persuasion; (3) Decision-making; (4) Implementation; (5) Confirmation or consolidation
Stage 4	Action: the individual actively implements strategies to change their behavior	Deciding not to act: the individual has decided not to take actions	
Stage 5	Maintenance: the individual works to sustain the behavior change over time and prevent regression	Deciding to act: the individual has decided to take actions	Seven actions needed in health promotion activities: (1) Find sound innovations; (2) Find and support innovators; (3) Invest in early adopters; (4) Make early adopter activity observable; (5) Trust and enable reinvention; (6) Create slack for change; (7) Lead by example
Stage 6	Termination: the individual has fully integrated the new behavior into their lifestyle, and the risk of relapse is minimal	Acting: the individual is taking the necessary steps to address the health threat	
Stage 7		Maintenance: the individual is maintaining the behavior change over time	

[a]These two models interpret the stages of how individuals develop their own behaviors. [b]This theory explains how, why, and at what rate new ideas, technologies, and behaviors spread through cultures within a population. It categorizes adopters of new behaviors into five groups based on their readiness to adopt the innovation and proposes seven actions needed in health promotion activities.

majority, late majority, and laggards within this group? The literature provides limited data [28, 29], but highlights a significant challenge; for instance, only 36.8 % reported that they would seek treatment for dengue fever from public health facilities [20]. From the perspectives of the transtheoretical model and the precaution adoption process model, most of the target population possesses a certain level of knowledge and awareness about dengue fever. However, there is a lack of data indicating that they have recognized the need for behavior change and have actively engaged in it. According to the diffusion of innovations theory, insights from the public health sector suggest that current health education activities are primarily focused on disseminating knowledge.

SCT

The SCT, formerly known as social learning theory, posits that behavior is determined by expectancies and incentives. This theory explores how individuals learn new information and adapt their behavior based on this knowledge, including the acquisition and application of new information in various contexts. Cognitive development, as proposed by Piaget, includes four stages: sensorimotor, preoperational, concrete operational, and formal operational stages. The SCT incorporates cognitive processes such as attention, perception, memory, decision-making (motivation), and action [32]. Individuals must pay attention to a behavior, remember it, and possess the ability to reproduce it. In these processes, perception refers to how individuals interpret sensory information to make sense of the world, based on their past experiences, expectations, and cultural background [33, 34]. For heuristic purposes, the expectancies can be divided into the following three types. The first type of expectancy involves beliefs about environmental cues, specifically how events are interconnected, such as understanding what leads to what. In dengue fever, individuals should recognize the connection between their home and surrounding environment and the transmission of the virus. They should also understand the link between promptly seeking treatment for suspected dengue fever and improved patient prognosis, as well as

the relationship between early treatment and reduced further transmission of the virus. Behavior is regulated by its consequences, and individuals have the ability to interpret and understand the outcomes of their actions. The second type of expectancy, known as outcome expectations, refers to beliefs about how an individual's behavior is likely to influence outcomes. In dengue fever, individuals should believe that environmental management can reduce the transmission of the dengue virus and that promptly seeking treatment for suspected dengue fever can improve patient prognosis and reduce further transmission to others, including their relatives and friends. Here, the consequences, also referred to as incentives or reinforcements, are defined as the value of a particular object or outcome. These outcomes may include health status, physical appearance, approvals from others, economic gain, or other consequences. The third type of expectancy, known as efficacy expectations or self-efficacy, refers to an individual's belief in their competence to perform the behavior needed to influence outcomes. Self-efficacy involves an individual's confidence in their ability to overcome obstacles, such as costs in terms of money, time, and effort, to succeed in specific situations or accomplish a task. High self-efficacy can enhance motivation and performance by influencing choices, effort, persistence, and achievement. In dengue fever, the literature indicates that actual actions by communities were often lacking unless enforced by local government authorities. Environmental management requires time and energy, which can be significant barriers. Barriers to seeking treatment for dengue fever at public health facilities with laboratory testing include the perceived severity of the disease, lack of information about where laboratory tests for dengue fever are available, and insufficient recognition of the importance of prompt diagnosis and early treatment. Other barriers include the overuse of over-the-counter drugs, time costs such as travel and waiting, and the financial expenditure associated with diagnosis and treatment services for dengue fever [20].

Beyond the issue of dengue fever, the theory can be applied to broader areas such as chronic disease management, smoking cessation, and physical exercise. For example, an individual who values the perceived effects of lifestyle changes (incentives) will attempt to change if they believe that their current lifestyle, such as dietary habits, poses threats to their personally valued outcomes, such as health or appearance (Type 1, environmental cues). They must also believe that specific behavioral changes will mitigate these threats (Type 2, outcome expectations) and that they are personally capable of adopting new behaviors, such as changing dietary habits (Type 3, self-efficacy) [32].

HBM

The HBM is a prominent framework for guiding behavioral change interventions. It is a psychological model used to understand and predict individuals' health behaviors by focusing on their beliefs and attitudes [32]. The HBM posits that health-related actions are influenced by four core components of personal beliefs about health conditions: perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. First, perceived susceptibility refers to an individual's belief about the likelihood of acquiring a condition or disease. It involves the perception that one is at the risk of developing an unhealthy status. In the example, despite the government's classification of dengue fever as a major public health threat, only a small proportion of the target population perceives themselves to be at high risk. The low perceived susceptibility among the Dai people highlights a significant barrier to effective public health interventions and their engagement [29]. Second, perceived threat or severity refers to an individual's beliefs about the seriousness of a health condition and its potential consequences. This encompasses the perception of one's vulnerability to a significant health issue and the possible sequelae of an illness. In the example, respondents from the target population in the qualitative study were not familiar with dengue hemorrhagic fever, which is characterized by severe bleeding and circulatory system failures. They had not heard about dengue fever-related deaths in Yunnan Province, China, and only a limited number of respondents perceived the disease as serious. This lack of awareness might explain why some chose self-medication by purchasing drugs from drug stores if they suspected a dengue virus infection. Such behavior may lead to delayed detection of dengue virus infection, potentially causing further transmission and an epidemic. This highlights a critical gap between the awareness of the target population and the health education provided [20, 29]. Third, perceived benefits refer to beliefs about the effectiveness of taking actions to reduce risk or severity. This involves the belief that adhering to a specific health recommendation or practice would be advantageous in mitigating the perceived threat at a cost deemed acceptable by the individual. In dengue fever, the public health sector and scientific community consider that environmental management and early detection of dengue virus infection for rapid response can prevent further transmission and potential epidemics [20, 28, 29]. Therefore, the program recommends promoting community-based environmental management and encouraging early treatment-seeking behavior for suspected dengue fever patients. Emphasizing perceived benefits highlights the importance of communicating the

advantages of preventive measures to encourage public compliance and reduce the risk of dengue virus transmission. However, data on the target population's beliefs regarding the effectiveness of environmental management and early treatment-seeking are still lacking. Fourth, adopting a new behavior or modifying an existing one often incurs costs, which can be physical, emotional, or financial. Within the framework of health behavior theories, perceived barriers are the potential negative aspects or costs associated with taking actions. Addressing these perceived barriers is crucial for facilitating behavior change and ensuring adherence to health recommendations. To adhere to health recommendations, these perceived barriers must be identified and overcome [30]. In the example, some individuals within the target population are unable to overcome the barriers to effective environmental management. A qualitative study identified three barriers to early treatment for suspected dengue fever patients in public health facilities with laboratory testing: the high accessibility and convenience of over-the-counter drugs, the lengthy time required to seek treatment in public health facilities, and increased financial costs due to unnecessary laboratory tests or physical examinations [20]. Addressing these barriers is crucial for improving early treatment-seeking behavior and effective environmental management in dengue control efforts.

The traditional HBM focused on specific preventive actions, such as accepting immunizations and participating in screening programs. This focus may explain why the HBM initially overlooked the concept of self-efficacy. Actions that involve altering lifelong habits related to diet, smoking, maintaining a healthy environment, and using bed nets in hot weather are substantial and more complex than a one-time screening or immunization. These actions require confidence in one's ability to change. For successful behavioral change, individuals must have an incentive to act, feel threatened by their current behaviors, and believe that change will lead to a valued outcome at an acceptable cost. More importantly, individuals must also feel competent (self-efficacious) to make the change. The SCT initially emphasized self-efficacy, recognizing its critical role in initiating and maintaining complex behavioral changes. Increasingly, researchers acknowledge the importance of self-efficacy in health behavior change, and its incorporation into the HBM is now widely accepted [32, 34]. The inclusion is crucial for understanding and facilitating behavior change, especially for complex lifestyle modifications.

Theory of locus of control, self-determination and ecological model

The development of comprehensive health promotion strategies must address the complex interplay between individual personality and environmental factors. Theories such as locus of control, self-determination, and ecological model, are integral to understanding the factors that support behavior establishment.

Locus of control is a personality construct that describes the extent to which individuals believe their actions influence the outcomes in their lives. It is a key concept in understanding how people perceive and interact with their environment. It is divided into two types: internal and external. Individuals with an internal locus of control believe they have control over the events and health outcomes in their lives through their own efforts, actions, and decisions. Conversely, individuals with an external locus of control believe that external factors, such as luck, fate, genetic factors, or the quality of healthcare they receive, rather than their own actions, have a greater influence on the events and health outcomes in their lives [35, 36]. Individuals with an internal locus of control are more likely to take responsibility for their actions, engage in proactive health behaviors, and feel empowered to make changes. An internal locus of control is typically associated with better health outcomes, higher levels of health-promoting behaviors, and greater adherence to a healthy lifestyle, such as maintaining a healthy diet and exercise regimen. Conversely, individuals with an external locus of control may feel less empowered to change their circumstances and might adopt a more passive approach to health behaviors [35, 36].

Self-determination theory focuses on the role of motivation in human behavior. It distinguishes between intrinsic and extrinsic motivation. Intrinsic motivation involves engaging in behavior because it is inherently interesting or enjoyable. In contrast, extrinsic motivation involves engaging in behavior to obtain external rewards or to avoid negative outcomes [37, 38]. The theory posits that individuals have basic psychological needs – autonomy, competence, and relatedness – that, when satisfied, foster optimal functioning and well-being. It emphasizes the importance of creating supportive environments that enhance these needs to foster motivation and improve health outcomes. In this theory, autonomy refers to the need to feel in control of one's own behaviors and goals; competence is the need to gain mastery and feel effective in one's activities; and

relatedness is the need to feel connected to others and experiences a sense of belonging [39]. Dengue fever control is often regarded as a governmental program. Communities at the risk of dengue fever frequently lack a sense of belonging, which may contribute to the failure to engage them in local dengue fever control efforts. More attention should be paid to the autonomy, competence, and relatedness of the targeted populations to foster their intrinsic motivation. Therefore, it is crucial to consider community engagement strategies that emphasize participation and empowerment to enhance the effectiveness of dengue fever control programs.

An appropriate supportive atmosphere can promote behavior change, whereas a lack of a supportive environment may hinder behavior change [40]. A common perception is that the very slow progress of smoking cessation campaigns in China is, in part, due to the absence of a zero-tolerance social atmosphere and other environmental factors, such as cultural attitudes, social norms, and the lack of strict regulatory environments. The ecological model provides a valuable framework for systematically planning health education programs and related activities within a country. The model focus on the interaction between individuals and their physical and sociocultural environments, emphasizing multiple levels of influence, including individual, interpersonal, organizational, institutional, and policy factors. In the model, individual factors refer to personal knowledge, attitudes, and skills. Interpersonal factors involve relationships with family, friends, and peers that provide social identity and support. Organizational factors pertain to community norms, networks, and standards. Institutional factors relate to institutional policies and practices. Policy factors encompass local, provincial, and national laws and policies [40, 41].

The two top-level national documents, along with the "Three-Year Action Protocol", are national health policies [1–3]. Local and provincial governments are expected to adhere to these policies. Each health issue is typically managed by relevant agencies at the institutional level. These agencies are responsible for addressing specific health concerns and implementing related interventions. At the interpersonal and community levels, fostering a supportive environment is helpful for facilitating behavior change. However, the current situation is that most health education primarily focuses on disseminating health knowledge and conducting investigations into personal factors, such as knowledge, attitudes, and practices. In dengue fever, vector control and early detection of the virus are considered among the most effective strategies. Vector control measures, particularly chemical control, face significant challenges, including adverse health effects on residents, environmental pollution, and the development of mosquito resistance to insecticides. Environmental management is proposed as an ideal strategy due to its sustainability and safety. However, its effective implementation is often hindered by insufficient consideration of individual personality traits and environmental factors. The current study in health education for dengue fever also mainly focuses on investigating knowledge, attitudes, and practices, which may not fully address the complexities involved in implementing comprehensive vector control strategies [20]. The significant gap in integrating individual personality traits and environmental factors poses a challenge to enhancing environmental management for vector control and promoting prompt treatment-seeking behavior among individuals with suspected dengue fever. Addressing this gap can benefit environmental management, facilitate early detection of the virus, and enable timely isolation of patients, thereby preventing further transmission.

Theories related to promoting and supporting behaviors

Expectancy-value theory

Success is a common aspiration for anyone undertaking a task, and there is a universal desire for one's efforts to be meaningful. Expectancy-value theory provides a framework for understanding the issues of individual success and perceived value. This theory involves two key concepts: the first is individuals' beliefs about the likelihood of success (expectancies), which are shaped by past experiences, perceived difficulty, and self-efficacy, a concept also emphasized by SCT. Both expectancy-value theory and SCT highlight the importance of self-efficacy. In expectancy-value theory, self-efficacy influences expectancies, while in SCT, it is a core component that affects motivation and behavior. Understanding these theories can help in designing interventions and educational programs that enhance motivation by boosting self-efficacy and aligning tasks with individuals' values and expectations. The second concept in expectancy-value theory is the value (importance) individuals place on success, which significantly influences their motivation and behavior. This value encompasses intrinsic value (enjoyment derived from the activity itself), utility value (the perceived usefulness of the task), attainment value (the importance of doing well in the task), and cost (the perceived negative aspects of engaging in the task) [42–44]. The HBM particularly emphasizes the cost of actions, focusing on perceived barriers and benefits to

engaging in health-related behaviors. Both theories highlight the role of perceived costs and benefits in behavior change. While expectancy-value theory applies broadly to motivation and achievement, the HBM is specifically tailored to health-related behaviors.

In clinical settings, clinicians can leverage the principles of expectancy-value to develop more effective strategies for motivating patients and promote positive health behaviors. By understanding a patient's expectancies and values, clinicians can tailor interventions to improve adherence to treatment plans, dietary behaviors, and physical exercise. On a broader scale, public health initiatives can benefit from applying expectancy-value theory by designing programs that emphasize both the likelihood of success and the intrinsic and extrinsic value of health behaviors, thereby increasing community engagement and participation [44]. Effective dengue fever control requires not only the dissemination of knowledge but also the implementation of practical strategies that emphasize the importance of maintaining clean environments to reduce mosquito breeding sites and the prompt detection of dengue virus infections for isolation. However, the ease and benefits of maintaining clean houses and surroundings, along with the early detection of the virus, are often underemphasized and insufficiently interpreted beyond the delivery of knowledge. Combining educational efforts with practical interventions can enhance the effectiveness of dengue fever control programs [20].

Reinforcement contingency and stimulus-response theory

In health education, once a behavior is initiated, continuous reinforcement is essential to firmly consolidate its establishment. Intermittent reinforcement, where the behavior is reinforced only some of the time, is effective for maintaining established behaviors and preventing their extinction. This approach leverages the unpredictability of reinforcement to sustain the behavior over the long term, making it a valuable strategy in behavior modification.

Reinforcement contingency and stimulus-response theory are two theories primarily focused on behavior reinforcement. Reinforcement contingency refers to the relationship between a specific behavior and the consequence (reinforcer) that follows it, specifically involving the systematic application of rewards or consequences to influence behavior. This relationship describes how and when a behavior will be followed by reinforcement, thereby influencing the likelihood of the behavior being repeated. Reinforcement can be categorized into positive and negative reinforcement. Positive reinforcement involves adding a pleasant stimulus to increase the likelihood of a behavior (e.g., giving praise for completing a task); negative reinforcement involves removing an unpleasant stimulus to increase the likelihood of a behavior [45]. Contingencies refer to plans, strategies, and actions implemented to manage unexpected events, emergencies, or changes in circumstances. In behavior reinforcement, positive contingencies strengthen a certain behavior by increasing the likelihood that the reinforcer (consequence) will occur following the behavior. Conversely, negative contingencies weaken a certain behavior by decreasing the likelihood that the reinforcer will occur following the behavior [46].

The stimulus-response theory explains how individuals learn behaviors through interactions with their environment. A stimulus is any event or situation that evokes a response. Reinforcement, which can be delivered through various means such as verbal encouragement, written feedback, digital reminders, or social support, is crucial for promoting long-term adherence to health recommendations [47]. Behaviors followed by positive outcomes (reinforcements) are more likely to be repeated, while those followed by negative outcomes (punishments) are less likely to be repeated. Positive punishment involves adding an unpleasant stimulus to decrease a behavior, for example, scolding a child for misbehavior. Negative punishment involves removing a pleasant stimulus to decrease a behavior, for example, taking away a child's toy when they misbehave [47, 48].

In health education practice, after delivering health information, less effort is typically dedicated to maintaining recommended behaviors and developing them into sustainable lifestyles within the public health field. Insufficient reinforcement of environmental management has been identified as one of the reasons why outbreaks of dengue fever cannot be effectively avoided in Yunnan [30].

Research needs of health education in China

In recent years, the central level has prioritized health education as the foremost strategic task [1, 2]. The "Three-Year Action Protocol" serves as a short-term plan to accelerate the implementation of health promotion policies [3]. The ultimate aim is to create a sustainable impact on public health by embedding health education into the fabric of society, thereby improving health outcomes and reducing the burden of disease. For example, as chronic diseases, particularly cardiovascular diseases and diabetes, became

the leading contributors to the disease burden in China, obesity emerged as a primary underlying cause of these conditions. In response, a total of 16 national departments related to health, including the National Health Commission, the Office of the National Patriotic Health Campaign Committee, and the Ministry of Education, jointly released the *Implementation Plan for the Year of Weight Management Activity* [49]. The involvement of these 16 national departments underscores the importance of a coordinated, multi-sectoral approach to tackle obesity, aiming to integrate efforts across various sectors to promote weight management and healthy lifestyles. These high-level documents provide comprehensive policy support for health education in China, which is regarded as a multi-disciplinary science integrating various fields, including biomedicine, public health, behavioral psychology, health systems science, communication science, education science, and social science. This comprehensive approach aims to enhance health literacy, empower individuals to make informed health decisions and actions, and ultimately promote healthier lifestyles. However, it is difficult to predict the impact of weight management actions without actual outcomes from implementation research, which is now urgently necessary in various socioeconomic and cultural contexts.

The complexity inherent in health education makes it straightforward to discuss but challenging to achieve the desired outcomes. This complexity arises from the diversity of health issues, the varied target populations, and their unique contexts. The "Three-Year Action Protocol" focuses on disseminating the 66 core messages from *Health Literacy of Chinese Citizens – Basic Knowledge and Skills*. This initiative encourages the public to consciously adopt a civilized, healthy, green, and environmentally friendly lifestyle. It positions individuals as the primary responsible parties for their own health, thereby enhancing their ability to value, maintain, and enjoy healthy lives [3, 4]. It is unnecessary to discuss here that knowledge alone does not translate into behavior. China is a vast country with diverse ethnic groups and a wide range of geographic and cultural contexts. It should be recognized that diverse populations face unique health challenges, needs, and sociocultural contexts. The diversity of health problems poses challenges to health education efforts. Notably, the 66 core messages do not mention dengue fever, despite its significance as a major global public health concern. The 14th among the 66 core messages simply states, "Mosquitoes, flies, rats, cockroaches, and others can spread various diseases," without explicitly mentioning dengue fever [4]. These challenges and the complexity involved in cultivating and maintaining health behaviors, and eventually developing them into a lifestyle, should be widely acknowledged.

Implementation research targeting every health problem is needed in various contexts and locations. These extensive research efforts should include examining basic behavioral psychology, individual factors (such as knowledge and awareness, motivation, self-efficacy, and readiness to change), social factors (such as support systems, social norms, and peer influence), environmental factors (such as accessibility, workplace environment, community resources, and cultural context), healthcare system factors (such as provider-patient relationships, healthcare policies, and access to care), and socioeconomic factors (such as income, education, and employment) across various areas, populations, and their health problems. Based on these investigation results, a health education model targeting a specific health issue in a certain area can be developed through formative research and intervention trials.

In health education, for inherently simple health practices, such as taking an oral poliomyelitis vaccine, knowledge and information may suffice to prompt action. However, when designing programs aimed at acquiring or modifying complex lifestyle practices, such as smoking cessation, reducing alcohol and substance abuse, engaging in regular physical activity, adopting healthy dietary habits, and managing the environment for dengue fever control, it is crucial to examine foundational theories of health education. This involves using a formative research framework to develop a specialized intervention model tailored to specific health issues, areas, and populations, based on local needs and contexts.

A tailored intervention should align with the principles of the RE-AIM framework, which stands for Reach, Effectiveness, Adoption, Implementation, and Maintenance. This comprehensive model is used to evaluate the public health impact of health education interventions, ensuring that these interventions are not only effective but also widely adopted, properly implemented, and sustained over time, thereby maximizing their public health impact [50–54]. The following section will use the example of dengue fever control to interpret the formative research framework and the RE-AIM model, which help in assessing the impact and sustainability of health programs. The "Three-Year Action Protocol" also aims to strengthen the team of health education professionals by enhancing the capacity, professionalism, initiative, and creativity of medical and health institutions and personnel involved in health education. Conducting extensive research in the foundational science of health education will enhance the team's comprehension of

these core principles, thereby cultivating a more skilled and resilient team of health educators.

Designing a tailored health education intervention

The basic principles related to health education have been interpreted and discussed in the previous sections. More practically, the formative research framework and the RE-AIM model provide methodologies for developing effectively tailored intervention and evaluation models. However, systematic formative research is rarely conducted before initiating and scaling up a health education campaign. The RE-AIM model offers a structured approach to comprehensively evaluate the impact of health education interventions, identifying strengths and weaknesses across its five dimensions [52, 55]. The formative research framework combines qualitative and quantitative methods to provide information that aids in planning and tailoring intervention programs to meet the specific needs of a target population. It gathers insights and data that inform the development, implementation, and refinement of interventions, ensuring that they are locally tailored and responsive to the needs of the target population [54]. The proposed example illustrates the application of the RE-AIM model and formative research framework to design a tailored health education intervention program for dengue fever control. The interventions intend to decrease the density of *Aedes* spp. mosquitoes, thereby reducing dengue virus transmission, and to promote treatment-seeking behaviors among individuals suspected of having dengue fever. This facilitates early detection and isolation of dengue virus cases, thus reducing the infectious source. Its two special objectives are: (1) more than 90 % of households in every Dai ethnic community clear the larval habitats of *Aedes* spp. mosquitoes within and around their homes weekly during the rainy season (June–November) by the end of the first year; (2) more than 85 % of suspected dengue fever patients seek dengue virus detection in public health facilities within 24 h after the onset of fever symptoms during the rainy season (June–November) by the end of the first year.

Contextual understanding

Before planning the program, it is important to understand the multi-level context in which health education will be implemented. This involves evaluating the availability of health services and policies, assessing the level of knowledge about dengue fever among the Dai people, and understanding their attitudes and practices regarding required control behaviors. Furthermore, it includes identifying the barriers and facilitators to the program's implementation [41]. Following SCT, it is essential to first understand the individual's perceived connection between environmental clearance, appropriate treatment-seeking behaviors, and the reduction of dengue virus infection (expectancies about environmental cues). Secondly, it is important to consider their beliefs about how individual actions, such as environmental clearance and timely treatment-seeking for dengue fever, are likely to reduce the incidence of the disease (expectancies about the consequences of one's actions). Lastly, it is important to assess their self-efficacy (expectancies about one's competence) in regularly clearing the larval habitats of *Aedes* spp. mosquitoes around their homes and seeking appropriate laboratory-based diagnosis and treatment when they suspect dengue virus infection [14]. Previous studies in the literature indicate that the Dai People are aware of dengue fever and have knowledge about *Aedes* mosquitoes and their breeding sites. However, a low proportion of suspected dengue fever patients seek appropriate treatment [20, 28]. Early detection, prompt isolation, and treatment are key strategies for controlling dengue fever in China [56]. Given these findings, future health education should not focus solely on increasing knowledge itself. Instead, it emphasizes encouraging early medical care for suspected dengue fever cases to reduce complications, as well as promoting preventive behaviors to reduce transmission.

Needs assessment

The Yunnan authorities recognize dengue fever as a significant public health issue and have demonstrated strong political commitment to its control. However, a literature review indicates a lack of data on the target population's perceived susceptibility to dengue virus infection and the perceived severity of the disease. Furthermore, there is a lack of data available on the willingness of the Dai people to participate in dengue fever control activities. The public health sector does not fully understand the barriers to engaging the target population in dengue fever control [28, 29]. As suggested by the HBM, it is essential to assess the educational needs of the target population before developing intervention strategies [32]. This assessment should identify how many and which members of the Dai people are interested in dengue fever, feel susceptible to dengue virus infection, believe they are currently facing the problem of dengue fever, perceive dengue fever as a serious health threat, and believe that this threat can be mitigated by eliminating *Aedes* mosquito larval habitats in and around

their homes. Additionally, their willingness to seek timely laboratory-based diagnosis and treatment, considering perceived physical, emotional, temporal, and financial barriers should be evaluated. Both qualitative and quantitative research methods could be employed to gather comprehensive data on these beliefs, conduct a needs assessment, and explore strategies to engage the target population in control activities.

Stakeholder engagement

The Dai people, including community leaders and schools, are primary stakeholders. A significant portion of the Dai population (70.0 %) is Buddhists, believing that the Lord Buddha protects good people [20]. Temples, as integral sites of Dai culture, and Buddhist Monks are present in each Dai community. Involving temples and their Buddhist Monks might be beneficial for dengue fever control. Local people often choose over-the-counter (OTC) drugs as the initial treatment for diseases due to their high accessibility. This choice allows them to avoid the travel and waiting time associated with seeking treatment at public hospitals, as well as the additional costs for laboratory tests or physical examinations [20]. Therefore, drug stores and private clinics should be involved in referring suspected dengue fever patients. Additionally, the program should also communicate with health administrators to reduce overall costs in public health facilities. As drug stores are identified as stakeholders, it is advisable for relevant authorities, such as the Food and Drug Administration (FDA), to notify these drug stores to become involved in the program. In this scenario, it is essential for health administrators to collaborate with these authorities. If the local government, such as the county government, acts as the coordinator for all stakeholders, the implementation of the program would be more effective. Once stakeholders are engaged, the strategies outlined in Table 2 can be considered to enhance their competence [57].

As suggested by the expectancy-value theory, motivation in the target population is driven by the expectation of success and the perceived value of achieving that success. Therefore, it is essential to ensure they have confidence in the likelihood of success and recognize the importance and benefits of achieving success. Additionally, self-determination theory emphasizes supporting stakeholders' autonomy, competence, and relatedness. This approach should provide them with the freedom to make decisions, ensure they feel capable and effective in their roles, and foster a sense of connection and belonging within the dengue fever control program [37, 44].

Table 2: Strategies for enhancing stakeholder competence.

Strategie	Description
1. Education and training	Develop comprehensive training programs that encompass the necessary skills, knowledge, and best practices, including specifically tailored training activities, such as workshops, seminars, and online courses, to meet the unique needs of stakeholders
2. Capacity building	Enhance stakeholders' capacity through continuous professional development opportunities, mentorship programs, and access to resources
3. Engagement and participation	Actively engage stakeholders in the planning, implementation, and evaluation phases of the program to ensure they have a clear understanding of the program's goals and their roles in achieving them
4. Feedback mechanisms	Establish regular feedback loops that enable stakeholders to share their experiences, challenges, and suggestions, thereby identifying areas for improvement and fostering a sense of ownership and involvement among them
5. Resource allocation	Ensure stakeholders have access to essential resources, including funding, tools, and technology, to perform their roles effectively
6. Cultural competence	Enhance stakeholders' cultural competence by providing training in cultural awareness and sensitivity to ensure effective engagement with diverse populations
7. Collaboration and networking	Facilitate stakeholder collaboration and networking through formal partnerships, joint projects, and informal networking events
8. Recognition and incentives	Acknowledge and reward their contributions to local dengue fever control efforts through formal awards, public recognition, or other incentives to motivate and sustain stakeholder engagement
9. Clear communication	Provide regular updates on program progress, changes, and outcomes through clear and open communication channels to keep stakeholders informed and engaged
10. Support systems	Establish support systems, such as help desks, service hotlines, peer support groups, and advisory committees, to provide ongoing assistance and guidance to stakeholders

Iterative intervention development

The objective of the formative research is to design a customized intervention program, ensuring the efficient use of valuable and limited resources. Greater investment in developing the intervention model is likely to yield more effective outcomes. The iterative intervention development process provides a structured framework for creating effective intervention strategies and activities. This systematic and cyclical process involves initial development, pilot testing, feedback collection, and subsequent modifications with the purpose of optimizing the intervention's effectiveness and feasibility through continuous improvement based on empirical data and stakeholder input. This is particularly beneficial for developing tailored interventions, ensuring they are both evidence-based and user-centered [58].

Before developing interventions, it is crucial to identify the innovators, early adopters, early majority, late majority, and laggards within the target population, as outlined by the diffusion of innovations theory. This identification helps tailor strategies to effectively engage each group in the adoption process [23]. Program designers should, with reference to the transtheoretical model and the precaution adoption process model, identify the stages of behavior change or adoption process where most individuals in the target population currently reside to effectively facilitate the progression of recommended behaviors [20, 25]. Based on the theory of locus of control, program designers should identify individuals within the target population who possess an internal locus of control. These individuals are more likely to act as innovators, early adopters, and members of the early majority in the behavior change process, thereby advancing intervention activities [35, 36].

After understanding the context and identifying needs and stakeholders, program designers can apply the 5W1H principle, which involves considering Who, What, When, Where, Why, and How. This approach engages early adopters and members of the early majority in the interventions, advancing activity implementation and ensuring that all critical aspects of the intervention are thoroughly considered and addressed [59]. In the program, the beliefs of stakeholders regarding dengue fever are not fully understood at present. It remains unclear whether the target populations are genuinely interested in dengue fever [20]. In a situation where only about one-third of the participants are willing to seek treatment for dengue fever from public health facilities, the program requires collaboration between health authorities and the FDA to engage with drug stores and private clinics, encouraging them to refer suspected dengue fever patients for laboratory tests at public health facilities. However, there is no specific information indicating the FDA's active interest in dengue fever control [20]. Knowledge and awareness among the Dai people alone do not necessarily lead to the desired behavioral changes. The beliefs and perceptions of stakeholders are crucial for the success of dengue fever interventions. If stakeholders do not perceive dengue fever as a serious health problem, do not feel threatened by it, and do not recognize the benefits of dengue fever control measures, the program is unlikely to be effective. Therefore, intervention programs should initially focus on enhancing stakeholders' awareness and understanding of the health threat posed by dengue fever, and foster the belief that their actions can lead to meaningful change [60]. As suggested by ecological models, this process requires the support of laws and policies, followed by effective governmental coordination. This is essential for the health authority and the FDA to endorse the program activities before developing the intervention strategies.

Table 3 outlines the potential necessary intervention activities. The necessity of these activities, as well as the potential inclusion of additional activities, should be discussed with stakeholders and refined through pilot testing within the target population [58].

Pilot testing

To ensure the program is well-designed, culturally appropriate, and effective in achieving its objectives, all information, education, and communication (IEC) materials must undergo thorough testing. This process should involve evaluating the core information, communication channels, recommended delivery and mobilization skills, as well as the stimuli and rewards intended to promote the desired behaviors with seven essential steps (Table 4) [61, 62].

Implementation strategies

To implement health education effectively and ensure the successful delivery and adoption of desired practices, it is crucial to first establish a clear objective. An ideal objective should adhere to the SMART criteria: it must be specific, measurable, achievable, relevant, and time-bound [63]. In the program, objective 1 aims for that more than 90 % of households (M) in every Dai ethnic community (S) should clear the larval habitats of *Aedes* spp. mosquitoes (R) within and around their homes weekly (A) during the rainy season (June–November) by the end of the first year (T). Objective 2 targets that more than 85 % (M) of suspected dengue fever patients (S) should seek dengue virus detection in public health facilities within 24 h after the onset of fever symptoms (R) during the rainy season (June–November)

Table 3: Intervention activities for health education aimed at controlling dengue fever among the Dai ethnic community in Yunnan, China.

Intervention activity	Implementer
1. Information and interest reinforcement	
1.1 Develop core information for the drug stores	Designers
1.2 Develop core information for the communities	Designers
1.3 Identify effective communication channels and develop supportive tools for drug stores and the private health sector	Designers
1.4 Identify effective communication channels and develop supportive tools for peer community health educators	Designers
2. Identifying and training communicators	
2.1 Train staff in drug stores and health sectors without laboratory test for dengue fever as communicators	Health sector and FDA
2.2 Identify and train peer health educators in communities	Health sector
3. Intervention actions	
3.1 Staffs at drug stores and health sectors without laboratory tests for dengue virus refer suspected dengue fever patients to public health facilities for laboratory tests; this process can be enhanced by developing an application (app) to facilitate patient referrals	Health sector and drug stores
3.2 Community peer health educators mobilize and organize weekly efforts, such as the "Village Saturday Clear-up Campaign," to clear larval habitats of *Aedes* spp. mosquitoes	Health sector and communities
4. Monitoring and evaluation	
4.1 Local health authorities and the FDA monitor drug stores and health sectors for the referral of suspected dengue fever patients and for laboratory testing of the dengue virus	Health sector and FDA
4.2 Local CDC staff, community leaders, and health workers conduct weekly visits to each household to inspect for larval habitats of *Aedes* spp. mosquitoes, such as checking water containers for the presence of larvae	Local CDC and community administration
5. Stimulus and reward	
5.1 Recognize the performance of staff at drug stores and health sectors to enhance their sense of pride and self-efficacy associated with their achievement; If possible, provide rewards to staff with satisfactory performance, such as free laboratory testing for dengue virus	Health sector and FDA
5.2 Recognize the contributions of community members to enhance their sense of pride and self-efficacy associated with their achievement; If possible, provide rewards for households, such as free laboratory testing for the dengue virus for those without larvae and without discarded water containers during the last month's monitoring visits	Health sector and community administration

FDA, food and drug administration; CDC, center for disease control and prevention.

(A) by the end of the first year (T). Secondly, the ecological model emphasizes that multiple levels of environmental factors influence health behaviors. Therefore, the intervention should be supported by promising policies and conducive environmental factors. A study conducted within the target population revealed that the villager convention terms in a Dai ethnic village mandate daily cleaning of homes and surrounding areas by all families. Village leaders conducted two supervisory visits each week. If *Aedes* spp. larvae were discovered in a household, the family incurred a fine of 500 CNY. When larvae were found again in the same household, the fine increased to 1,000 CNY. Non-compliance with the villager convention terms might result in the suspension of piped water and electricity supply [20, 30]. This operation may raise two issues. The first is whether this practice is culturally appropriate, supported by the majority of community members, and aligned with local and national policies. The second issue is the achievability and sustainability of this practice. Considering the life cycle of *Aedes* spp. mosquitoes, it is not necessary to clean houses and the surrounding environment daily. Thirdly, regarding sustainability, unless a practice becomes a routine habit within the target population, it will be challenging for all families to consistently clean their homes and surrounding environments. According to the SMART objective, weekly clearance of *Aedes* spp. mosquito larval habitats is not only more achievable and feasible but also aligns with the mosquito's life cycle. Following scientific principles, the "Village Saturday Clear-up Campaign" may be more practical. With secured ongoing funding and local capacity, integrating environmental management into existing health systems and community structures could make weekly habitat clearance a sustainable activity and eventually a routine habit for every household. Additionally,

Table 4: Seven essential steps for pilot testing.

Step	Method description
1. Stakeholder consultation	Evaluate communication channels, recommended delivery methods, and mobilization strategies with educators and community representatives to ensure they are culturally appropriate and effective in achieving the intended outcomes in both content and approach
2. Pilot testing	Conduct a small-scale pilot test of the protocol using a sample from the target population to identify any issues related to content, message delivery, and materials; During the pilot testing, closely observe how the target audience interacts with the information, education, and communication (IEC) materials, and document any challenges they face in understanding the core information, utilizing the materials, and practicing the desired behaviors
3. Collect feedback	Utilize structured tools, such as well-developed questionnaires and interview guides, to conduct surveys, including focus group discussions or in-depth interviews, to gather feedback from participants and facilitators involved in the pilot test; the content collection should focus on aspects such as the clarity and comprehensibility of the core information, the visual appeal and design of IEC materials, their relevance and cultural appropriateness, the level of engagement and interest they generate, and their overall effectiveness in conveying the intended message and mobilizing the desired behaviors
4. Refine the protocol	Adjust the protocol as needed based on feedback, including content revision, material enhancement, and communication method modification
5. Iterative testing	Repeat the pilot testing and refinement process as needed to ensure the protocol is effective, well-received, and adopted by the target population
6. Final review	Conduct a final review with stakeholders to ensure that all feedback issues have been adequately addressed before the full implementation of the protocol
7. Documentation	Document the pretesting process, including the feedback received and the changes made thoroughly to ensure a clear record of how the protocol was developed and refined

with support from the FDA and relevant policies, staff at drug stores should cultivate the habit of referring suspected dengue fever patients for dengue virus testing [64]. Fourthly, the intervention activities should effectively promote the desired behaviors (Table 5) [65].

For simple behaviors that require minimal focus on efficacy, such as swallowing a tablet or screening for parasite infection, health practices may be straightforward to perform. However, changing complex behavior patterns remains challenging [32]. In the realm of environmental management, placing a greater emphasis on skill training is likely necessary to enhance self-efficacy. SCT posits that self-efficacy information is derived from four primary sources: enactive mastery experiences (performance attainments), vicarious experiences, verbal persuasion, and physiological states. Health educators are encouraged to leverage these sources to enhance practice efficacy [66]. Performance accomplishments are the most influential sources of efficacy information because they are based on personal mastery experiences. Vicarious experiences, gained by observing others' successes or failures, are the next most potent source and significantly contribute to lifelong learning. Role models, as sources of vicarious experiences, can encourage imitation, while verbal persuasion can motivate individuals to initiate action or reinforce their initial steps [14, 66]. In environmental management, vicarious efficacy information can be provided by showcasing the successful efforts of other communities as models for actively clearing larval habitats of *Aedes* spp. mosquitoes [23]. Verbal persuasion, often used in health education, is less powerful than performance accomplishments or vicarious experiences but can still complement more influential factors. It may also affect outcome expectations or incentives. Physiological states, particularly anxiety, can signal to individuals, accurately or not, that they are incapable of performing or maintaining a given action. Conversely, reducing negative affect can enhance self-efficacy. Setting short-term rather than long-term goals for certain desired achievements may help overcome negative physiological states and increase self-efficacy [32]. Another way to overcome negative physiological states is by structuring complex behaviors into a series of steps with increasing difficulty, allowing earlier tasks to be more easily mastered. With enhanced self-efficacy from initial performance achievements, individuals are better prepared to tackle more complex tasks.

Additionally, contracting between households and health service providers can be an effective strategy for enhancing self-efficacy in managing complex practices [32, 67]. Even in modest circumstances, households and providers can collaborate to establish and agree upon

Table 5: Effective behavioral-changing intervention activities.

No.	Activity description
1.	Regularly train healthcare workers, peer educators, and the target population through educational meetings and workshops to enhance their knowledge, attitudes, and skills
2.	Comprehensively train healthcare workers, peer health educators, and drug store staff in communication skills, cultural competence, and knowledge of dengue fever to enhance their ability to deliver behavior-centered health education
3.	Health educators should conduct outreach activities and deliver health education sessions in communities, schools, and workplaces to broaden their audience and ensure information accessibility
4.	Consider using digital tools and platforms such as mobile health (mHealth) apps, online courses, WeChat, webinars, and social media to disseminate health information, thereby enhancing reach and engagement, especially among younger populations
5.	Develop and implement practice-focused strategies targeting healthcare providers, drug store staff, and peer educators, such as reminder systems, audit and feedback, and performance incentives, to enhance adherence to the protocol
6.	Develop and distribute culturally appropriate and easy-to-understand educational materials – such as brochures, posters, videos, and interactive tools – to ensure that user-friendly materials are available in Dai ethnic languages when needed
7.	Involve community leaders and representatives in the planning and implementation of health education initiatives to enhance the programs' credibility and acceptance within the community
8.	Implement health education activities in schools for children and adolescents to achieve long-term sustainability, including integrating dengue fever content into the local curriculum, organizing extracurricular activities, and actively engaging parents
9.	Continuously monitor and evaluate the effectiveness of health education interventions to enhance their outcomes; simultaneously, make evidence-based decisions and adjustments based on the data collected

objectives for environmental management, such as eliminating larval habitats of *Aedes* spp. mosquitoes in and around their homes through a contingency contract. They can agree on a time frame for completion, with both parties signing a document that specifies the agreements. This technique is effective when properly implemented because it fosters a genuine alliance between households and service providers. Both parties are involved in selecting objectives that the household feels capable of achieving within the set time limit. When the household accomplishes the objective, their sense of self-efficacy is enhanced, preparing them to contract for new, more challenging ones. The inclusion of a material reward in the contract appears to be less significant than the sense of pride and self-efficacy that accompanies the achievement [32].

In summary, to ensure the successful implementation and sustainability of complex health intervention practices, it is essential to establish clear objectives, supportive policies, and a conducive environment. As suggested by the HBM and SCT, the success of a health education program includes the following strategies. Firstly, the target population must believe they are susceptible to the disease and understand its serious consequences, including the potential for death due to delayed treatment (perceived threat). Secondly, they must believe that dengue fever is preventable and that their actions can make a difference (outcome expectations). Finally, they must have confidence in their ability to successfully perform the recommended practices (self-efficacy).

Evaluation frameworks

A comprehensive evaluation framework includes assessments at all stages, from planning to long-term impact. Contextual investigations, needs assessments, and evaluations of program design and planning have been covered in earlier sections under formative research. This part will primarily focus on the stages from process evaluation onward [68]. The RE-AIM framework offers a comprehensive model for evaluating the impact of public health interventions. This model ensures that health education interventions are not only effective but also widely adopted, properly implemented, and sustained over time, thereby maximizing their impact [50]. Here, RE-AIM stands for Reach, Effectiveness, Adoption, Implementation, and Maintenance. Reach refers to the proportion of the target population that participates in the intervention, emphasizing the identification and understanding of the characteristics of those who are reached vs. those who are not. Effectiveness pertains to the impact of the intervention on important outcomes, including any potential negative effects, focusing on both intended health outcomes and unintended consequences. Adoption involves the proportion and representativeness of settings and intervention agents willing to initiate the program, focusing on understanding the characteristics of settings (e.g., schools, clinics, and communities) and key stakeholders (e.g., teachers, healthcare providers, and community leaders) that adopt the intervention. Implementation ensures fidelity to the protocol, including consistency and any adaptations made, focusing on how well the

intervention is delivered as intended. Maintenance refers to the extent to which the intervention is sustained over time at both the individual and organizational levels, focusing on long-term follow-up to determine the durability of the intervention's effects and the continued use of the recommended behaviors [50, 51]. To ensure that each dimension is considered from the outset, the RE-AIM framework can guide the development of the program. It provides a structured approach to comprehensively evaluate the impact of health education interventions and identify strengths and weaknesses across its five dimensions. By using the RE-AIM framework to evaluate programs, health educators can make evidence-based decisions to refine and improve their programs [52].

Process evaluation

The objective of the process evaluation is to gather data on the delivery of intervention activities through surveys, interviews, and focus group discussions with participants and facilitators. The data is used to assess the extent and quality of intervention delivery, participant satisfaction, and barriers to implementation [69, 70]. The process encompasses the inputs of human and financial resources, the implementation of interventions, and outputs such as the number of health education sessions delivered in a program. This approach evaluates reach, adoption, and implementation. Necessary adaptations should be identified and evaluated for implementation. In the program, reach evaluation indicators can include the proportion of individuals who attended the latest health education workshop out of the total eligible population. These adaptations assess whether health educators deliver the program content as designed and document any changes made to the program activities. For example, it evaluates the proportion of communities that carried out environmental management and the proportion of households that have cleared larval habitats of *Aedes* spp. mosquitoes in and around their homes in the last week. It also compares the characteristics of those communities and households with adapted practices vs. those without actions.

Outcome evaluation

The objective of the outcome evaluation is to assess the short-term and intermediate effects of the interventions by utilizing pre- and post-intervention surveys, knowledge assessments, and behavioral evaluations [70]. The effectiveness component of the RE-AIM framework focuses on evaluating both the intended health outcomes and any unintended consequences, including potential positive and negative effects. In the program, the primary outcome indicators include the percentage of households that clear *Aedes* spp. mosquito larval habitats in and around their homes weekly during the dengue virus transmission season, and the percentage of suspected dengue fever patients who seek diagnosis at public health facilities within 24 h of fever onset. Additional outcome indicators may encompass changes in knowledge about dengue virus transmission and prevention, shifts in attitudes toward recommended behaviors, self-efficacy in implementing control measures, and entomological indicators such as the human biting rate of adult *Aedes* spp. mosquitoes, larval habitat availability, and the percentage of habitats occupied by *Aedes* spp. larvae [70, 71].

Impact evaluation

Impact refers to the effectiveness of an intervention on final outcomes, including both positive and potential negative effects, as well as broader implications such as cost-effectiveness. In the program, the objective of impact evaluation is to assess the long-term effects of interventions on disease burden by utilizing data from national disease control information systems and specialized surveys [70]. Although the health education program alone may not significantly reduce disease burden, impact evaluation can assess its contributions to disease control efforts. In the program, impact indicators may include a reduction in the total number of dengue fever cases, a decrease in the percentage of severe cases among total dengue fever cases, a lower annual dengue fever incidence rate, fewer communities experiencing dengue fever outbreaks compared to the previous years, and improved cost-effectiveness relative to other measures such as chemical control with insecticides [72].

Sustainability and scalability evaluation

Sustainability is a key component of the maintenance dimension within the RE-AIM framework, which emphasizes evaluating both the sustainability and scalability of health interventions. This ensures that programs can be maintained and expanded effectively over time. The evaluation involves tracking the health behaviors of participants six months after the intervention and assessing whether the program continues to be implemented in its original settings. Formative research often includes pilot intervention studies; therefore, the evaluation of formative research should focus not only on sustainability but also on

scalability. The objective of evaluating sustainability and scalability is to assess the potential for sustaining and scaling up the program based on the results of process, outcome, and impact evaluations, as well as stakeholder interviews, cost analysis, and feasibility studies. Relevant indicators can include ongoing funding, the potential for integration into existing health systems, community support, and scalability potential [73].

Feedback and continuous improvement

Feedback is crucial for refining and improving interventions before full-scale implementation. Its objective is to use evaluation findings to adjust and enhance the design, planning, and implementation of intervention activities through regular feedback sessions, data analysis, and program reviews, ensuring interventions are well-suited to their intended contexts. This process involves gathering input from stakeholders, participants, and other relevant parties to identify strengths and areas for improvement. Methods for collecting feedback can include focus group discussion, interviews, surveys, and workshops. The insights gained from feedback help tailor the intervention to better meet the needs of the target population, ensuring that the program is both effective and feasible. Additionally, feedback can guide adjustments to the intervention design, implementation strategies, and evaluation methods, ultimately enhancing the potential for successful outcomes. Indicators of program modifications based on feedback should include improved outcomes and impact over time, as well as stakeholder satisfaction [74].

Reporting and dissemination

Reporting and dissemination are essential for translating formative research into practice and ensuring that findings are effectively communicated to relevant stakeholders. The objective of reporting and dissemination is to share intervention outcomes and evaluation findings with stakeholders and the broader community through reports, meetings, presentations, and publications. This process facilitates the scaling up of experiences and impacts policy and practice. Indicators can include the number and coverage of dissemination activities, stakeholder engagement, and the extent to which findings are utilized in policy and subsequent practices. To ensure clarity and focus when reporting and disseminating formative research outcomes, the following key items can be considered. The dissemination of formative research outcomes can be more effective in translating research into practice and influencing policy and decision-making by considering the following items. (1) The outcomes of formative research should be reported with clarity and comprehensiveness, including detailed descriptions of the methods, findings, and implications. The most significant findings and recommendations can be highlighted in the report to ensure that they are relevant and actionable for the intended audience. Clarity and consistency can be enhanced by employing standardized reporting guidelines. The language and presentation used should be clear and concise, accessible to non-specialist audiences, avoiding technical jargon where possible. (2) To ensure effective dissemination to diverse audiences such as clinicians, regulatory bodies, policymakers, and communities, it is important to consider their preferences and needs. (3) Engaging stakeholders throughout the research process is advisable to choose appropriate formats and media for dissemination, such as reports, presentations, publications, or digital media, tailored to the audience. This ensures that findings and recommendations are relevant and actionable. It may involve conducting feedback sessions, workshops, and collaborative meetings to discuss the implications of the research outcomes. (4) Establishing feedback mechanisms to collect input from stakeholders regarding the dissemination process and the utility of research findings can help refine future dissemination efforts and ensure that the research has a meaningful impact. (5) The impact of dissemination efforts on practice and policy should be evaluated by assessing whether the research findings have been adopted and implemented in public health practice, pharmacies, and the FDA, and by making necessary policy adjustments based on the outcomes [75].

Conclusions

In China, health education is one of the most important strategies in transitioning from a disease treatment model to a prevention model, and it is now facing significant challenges. Researching and employing fundamental health education theories to develop and implement tailored health education intervention programs is one of the alternatives for addressing these challenges across various health issues, healthcare systems, cultural contexts, and resource availability.

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