

REVIEW

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Key contributors to malaria elimination in the People's Republic of China: a scoping review

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Abstract

Malaria continues to cause high levels of morbidity and mortality despite concerted efforts to control the disease. The global burden is predominantly shouldered by countries in which the disease is highly endemic. In juxtaposition, the majority of evidence on progress towards malaria elimination has been documented in countries where baseline transmission was low. A notable exception is the People's Republic of China, in which the last indigenous case of malaria was recorded in 2016 after reporting over 30 million cases across various transmission strata in 1949. This review examined the extent, range, and nature of the literature addressing key contributors to malaria elimination in China. PubMed, Embase, Web of Science, ProQuest, Google Scholar and the WHO website were searched for relevant articles, and the JBI guidelines were followed for evidence selection, data extraction, and presentation of findings. The 17 articles that satisfied the eligibility criteria demonstrated the centrality of high-level political commitment in the elimination of malaria in China. The national malaria strategy was regularly updated to reflect evolving priorities, and the health system building blocks were strengthened to meet strategic targets. A whole-of-society approach to malaria was adopted, with intersectoral, interprovincial, regional, international, and community-mobilizing collaboration mechanisms established. Collaboration with academic institutions resulted in advantageous discoveries such as artemisinin, the current global gold standard for the treatment of malaria. The impact of malaria-specific interventions was augmented by China's economic growth. The findings of the review highlight the importance of adopting a comprehensive approach to malaria control that addresses the structural determinants of ill-health alongside downstream interventions.

Keywords China, Malaria, Elimination, Control

Background

On October 6, 2021, the World Health Organization (WHO) announced that a malaria vaccine has been recommended for the first time in history [1]. The vaccine had taken 30 years to be developed and held promise of ameliorating one of the longest-standing conundrums

in human history [1, 2]. The Chinese Canon of Medicine—Nei Ching—had described recurrent fevers with signs and symptoms that closely resemble malaria as early as 2700 BCE, and malaria antigens were isolated from Egyptian mummies dating back to 3200 BCE [3, 4]. Despite the resources pledged to control the disease, including one costly eradication attempt, the world continues to report over 200 million cases and 500,000 malaria deaths annually [2, 5]. In addition to its impact on health, malaria results in substantial economic losses to affected individuals and populations [6]. While effective vaccines have been critical to the control of multiple

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life-threatening diseases and are expected to expedite progress towards malaria eradication [2], the elimination of malaria in countries prior to the recommendation of malaria vaccines underscores the existence of other contributors to effective malaria control.

As of June 2024, forty-three countries and one territory have been certified malaria-free by the WHO. To be certified malaria-free, a country must provide evidence of zero indigenous cases of malaria for at least three consecutive years [7]. The certification of China had received peculiarly heightened attention, with the number of publications about China far exceeding that of any other certified country. The elimination of malaria in the world's most populous country is a likely contributor to this enhanced coverage, as is China's interest in expanding its global presence [8]. Perhaps more importantly, however, is the fact that China is a vast country in which different malaria transmission patterns co-existed. Over 30 million malaria cases were recorded in the country in 1949, the same year the People's Republic of China (PRC) was proclaimed [9]. Many cases were reported from the country's southern provinces, where malaria was highly endemic [10]. The elimination of malaria from this region represents a divergence from the norm, as elimination tends to occur in settings where baseline transmission was already low [11].

In contrast, the global malaria burden is grossly skewed towards high-transmission settings. Twenty-nine countries account for 96% of malaria cases globally, with over half of the world's malaria deaths concentrated in just four countries: Nigeria, the Democratic Republic of the Congo, the United Republic of Tanzania and the Niger [5]. The documentation of progress from regions with a comparable baseline is thus pertinent to synthesize evidence relevant in similar settings where elimination will produce the highest impact. Despite the presence of scholarly works describing the Chinese experience, the literature is dominated by expert opinion articles in which different hierarchical perspectives have been presented to describe how and why progress has taken place in China. As no systematic or scoping review has been previously conducted on the subject matter, the aim of this review is to comprehensively summarize the fragmented knowledge on China's journey; identifying and prioritizing factors that have collectively led to the elimination of malaria from the country.

The review objective is to examine the extent, range, and nature of the literature addressing contributors to malaria elimination in China. The scoping review methodology was selected to fit the exploratory nature of mapping the key characteristics of China's experience, as opposed to systematic reviews in which specific hypotheses are interrogated.

Methods

The scoping review methodology was selected to fit the exploratory nature of the question. This review was carried out in accordance with the JBI Manual for Evidence Synthesis [12], with an a priori protocol developed before undertaking the review. The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA- ScR) was used to enhance reporting transparency [13].

Review question

What is the extent, range and nature of the literature covering the key contributors to malaria elimination in The People's Republic of China?

Eligibility criteria

Articles covering contributors to malaria elimination in China were included in this scoping review. As the primary objective is to document a comprehensive review of China's malaria journey from endemicity to elimination, only articles published on or after 1st January, 2018 were considered, with the primary search process concluding on April 29th, 2024. The search was subsequently updated to include literature published up to June 25th, 2024. A peer-review condition was not imposed on articles to be included, since the majority of literature covering the topic are editorial, commentary and letter-to-the-editor articles, which are not typically subject to the same peer-review standards as their primary research counterparts. Articles must, however, be published in a peer-reviewed outlet in order to be eligible for inclusion. Relevant grey literature published by the World Health Organization, a reliable source of health-related information, was also included in the scoping review. No language restrictions were imposed on the search in accordance with the JBI guidelines [12]. Articles addressing malaria elimination in multi-country settings were excluded as they tend to provide brief recounts of individual country experiences and emphasize comparative analysis, deviating from the review's purpose of exhaustively analysing the specific context of China. Literature restricted to pre-determined interventions, regions within China, and/or stages of malaria control have been excluded, as it is likely to overlook the impact of social determinants of health.

Search strategy

PubMed, Embase, Web of Science and ProQuest were searched for relevant literature. Additional sources include the Google Scholar search engine and the official website of the World Health Organization. An initial

limited search was conducted in PubMed and Google Scholar to analyse key words and generate the search strings used in the formal search process (Table 1).

Article selection

The obtained search results underwent a three-tiered screening process. Articles were sorted by title in the initial screening stage, and studies with irrelevant or duplicate titles were excluded. Eligible studies advanced to the secondary screening of abstracts, and studies with relevant abstracts were subsequently subject to full-text review. The search and screening processes were duplicated to improve sensitivity and specificity. Studies that were considered relevant both times automatically advanced to data extraction. Studies that were judged relevant in one round but not in the other were cross-checked in a third round and forwarded to data extraction accordingly. The reference lists of eligible articles were examined for further literature of relevance. The process for source identification and inclusion is summarized in Fig. 1.

Data extraction

Standard descriptive information charted include the title, author(s), methodology, language and year of publication for each article, along with key results relevant to the primary objective i.e. contributors to malaria elimination in China. Full texts were reviewed, analysed and relevant information extracted in two separate charting forms, which were subsequently combined into a unified table for data interpretation.

Results

Overview

The selection criteria were fulfilled by 17 articles (Table 2). The majority of articles (n=15) were published

in or after 2021, the year China was certified malaria-free. 16 of the featured publications are expert opinion articles and one is an observational study. 15 publications are written in English and two are in Standard Chinese.

Key contributors to malaria elimination in China

Political commitment

The scholarly narrative on China’s elimination cascade has governance at its core. While the majority of articles cite the Chinese governments’ fervent commitment as the chief contributor to the country’s success with other factors subsequently listed, close inspection of the literature reveals the positioning of other factors as extensions of this political engagement, rather than distinct entities in their own right [9, 15, 16]. The innovative approach of China for malaria control, for example, was another recurring contributory theme, with Tu Youyou’s discovery of artemisinin-based combination therapy (ACT) frequently brought up as a specimen [17, 18]. However, the discovery of artemisinin is consistently attributed to the government’s Project 523: “...as early as 1967, the Chinese government launched the 523 Project...this project led to an outstanding result regarding the discovery and extraction of artemisinin from *Artemisia annua* by Tu Youyou and her team” [18]. The vitality of government leadership in other areas covered, such as strengthening China’s health system, mounting a coordinated malaria response, and securing donor funds for control activities, further reinforces their characterization as dependent variables [19].

Strategic adaptability

The adaptability of Chinese policies is illustrated by reviewing the history of malaria control in the PRC. Classically divided into five phases, each phase of malaria control in China has implemented a mix of interventions guided by the corresponding national plan. These plans, in turn, have been informed by the peculiarities of malaria transmission in each era [20]. During the first phase (1949–1959), the priority was to set the epidemiological baseline and the organizational infrastructure for malaria control. By the end of the first phase, malaria transmission nationwide was clear and pilot operations for infection control were launched [21]. Malaria control in the PRC faced its most serious threat during the decades of the second phase (1960–1979); when massive malaria epidemics erupted as a result of prolonged political unrest and natural disasters [10]. The predicaments of this period, however, have reinvigorated efforts to control the disease. National strategies featured countermeasures tailored to subnational stratifications, and inter-provincial cooperation mechanisms were established.

Table 1 Databases/search engines and search strings

Database/Search engine	Search string
PubMed	(malaria[Title]) AND (Chin*[Title]) Publication date: 2018/01/01 -2024/6/25
Embase	(malaria AND Chin*):ti Publication years: 2018–2024
Web of Science	(malaria AND Chin*)(Title) Publication date: 2018/01/01–2024/06/25
ProQuest	title(malaria) AND title(Chin*) Limit to: Peer-reviewed Publication date: 2018/01/01–2024/06/25
Google Scholar	allintitle: malaria AND China Date: 2018–2024
WHO (Newsroom)	Health topic: Malaria Country/region: China

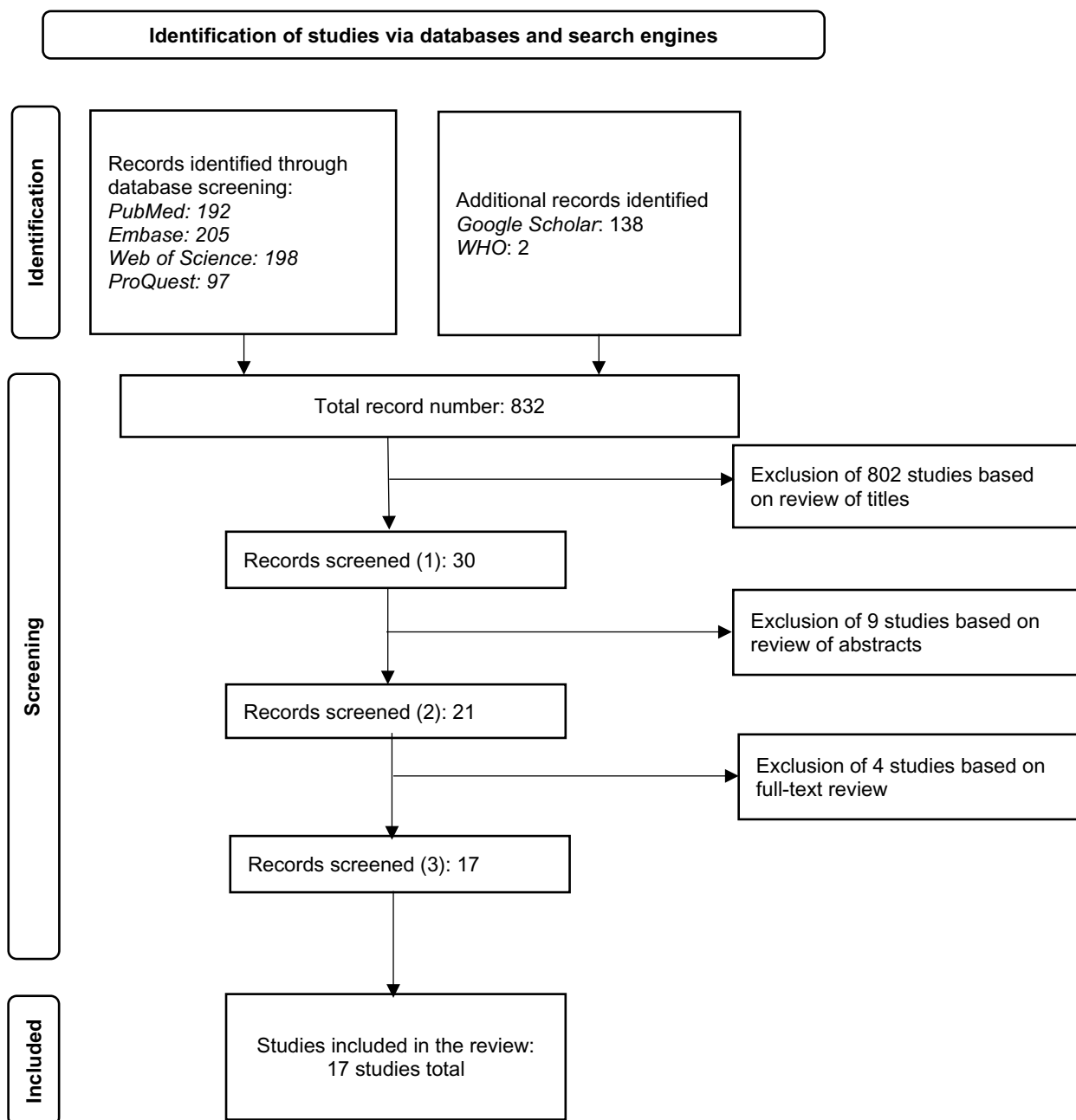


Fig. 1 Flow diagram for the scoping review process, adapted from the PRISMA statement by Moher et al. [13]

The renowned 523 Project, the parent project for artemisinin, was also a product of this time period. Malaria epidemics were under control by 1979, and disease incidence had dropped by 91.3% from its 1970 baseline [10]. The downward trend of the late second phase persisted into the third phase (1980–1999), bolstered by the country’s economic growth. By 2000, the maiden year of the fourth phase (2000–2009), malaria was under control in all but two provinces: Yunnan and

Hainan. A strategic elimination plan had long been on the table, with pilot elimination programmes launched in select counties around the country. The National Malaria Elimination Action Plan (NMEAP) was officially endorsed in 2010, and came to be known as the fifth phase of malaria control in China [22]. Strict surveillance and response policies were enforced, reference laboratories were set up to improve case detection, and interprovincial collaboration was maximized.

Table 2 Overview of included articles

Author(s)	Language	Year of publication	Type of article/methodology	Key contributors to malaria elimination in China
Badmos et al.	English	2021	Letter to the editor	<ul style="list-style-type: none"> 1- Political and financial support from the Chinese government 2- Regional coordination with countries with comparable epidemiological profiles 3- A robust national health information system, including the “1–3–7” surveillance and response strategy
Burki	English	2021	News	<ul style="list-style-type: none"> 1- High-level political commitment 2- National oversight role with implementation flexibility at the provincial and county levels 3- Evidence-based innovations: <ul style="list-style-type: none"> A- Discovery of Artemisinin B- Roll-out of ITNs prior to WHO recommendation C- The “1-3-7” strategy
Chen et al.	English	2021	Editorial	<ul style="list-style-type: none"> 1- The socioeconomic development and concomitant urbanization of China 2- Innovative approach to malaria control: <ul style="list-style-type: none"> A- The discovery of artemisinin B- The “1-3-7” approach
Chen et al.	Chinese	2022	Commentary	<ul style="list-style-type: none"> 1- Innovations such as artemisinin and ITNs 2- Multisectoral collaboration 3- The “1-3-7” strategy
Feng et al.	English	2018	Observational	<ul style="list-style-type: none"> 1- Country-owned efforts: <ul style="list-style-type: none"> A- The development of detailed strategies, national guidelines, and operational plans by the central government B- The mobilization of various sectors as well as the community C- Continuously updated surveillance system D- Establishment of a reference laboratory system for quality assurance 2- Country-led efforts: <ul style="list-style-type: none"> A- Regional and intersectoral collaboration B- Standardization of the data management process C- Sustained financial support for malaria control from the Chinese government and the Global Fund
Feng et al.	Chinese	2021	Review	<ul style="list-style-type: none"> 1- Strong government leadership and cross-departmental cooperation 2- A rapid and sensitive monitoring and response system, including the “1-3-7” strategy 3- Effective capacity building in epidemiological investigation, laboratory diagnosis and control activities 4- Continuous technological innovation and evidence-based practice 5- Proactive international cooperation
Feng et al.	English	2022a	Practice	<ul style="list-style-type: none"> 1- Strong government leadership, with emphasis on multisectoral collaboration, evidence-based strategic planning, and adequate funding 2- An efficient and adaptive surveillance and response system, which includes the “1-3-7” strategy 3- Sustained capacity building for healthcare personnel via regular training 4- Demand-driven science and technology advancements: <ul style="list-style-type: none"> A- The discovery of artemisinin B- Large-scale field testing of ITNs prior to WHO recommendation C- The development of the “1-3-7” approach 5- Intra-national collaboration between malaria-endemic provinces, as well as international collaboration with organizations such as the WHO and the Global Fund 6- An LMIC-friendly step-by-step scaling-up of control activities 7- Socioeconomic progress
Feng et al.	English	2022b	Perspective	<ul style="list-style-type: none"> 1- Political commitment 2- Consistent efforts 3- Innovative strategies and technologies 4- Adaptive approaches
Nkfusai et al.	English	2022	Commentary	<ul style="list-style-type: none"> 1- Provision of a universal package of free healthcare services 2- Multisectoral collaboration between official state bodies, 3- Innovative approaches 4- Adherence to the “1-3-7” strategy 5- Elimination of mosquito breeding sites 6- Stepping up surveillance to reduce the risk of imported malaria

Table 2 (continued)

Author(s)	Language	Year of publication	Type of article/methodology	Key contributors to malaria elimination in China
Wang et al.	English	2022a	Commentary	<ol style="list-style-type: none"> 1- A highly adaptive approach, both in terms of strategy development and implementation 2- Investment in the development of national reporting systems, institutions, and capacities to feed into strategy development 3- Global health cooperation with other states and non-state agencies
Wang et al.	English	2022b	Opinion	<ol style="list-style-type: none"> 1- Government leadership in malaria control with a whole-of-government approach 2- Community mobilization and engagement in health promotion campaigns 3- Contextually tailored interventions 4- Pilot testing of interventions before scaling up 5- Regional alignment and joint control activities between provinces 6- Establishment of professional, well-resourced institutes at various managerial levels for malaria control
WHO	English	2021b	Feature story	<ol style="list-style-type: none"> 1- Multisectoral collaboration 2- Innovative tools and strategies 3- Unwavering political commitment 4- Poverty reduction 5- Provision of free healthcare packages
WHO	English	2021c	News	<ol style="list-style-type: none"> 1- Government leadership 2- Innovative approach to malaria control 3- Provision of basic health services free of charge 4- Multisectoral collaboration 5- Cooperation with the Global Fund to strengthen malaria control 6- Implementation of the "1-3-7" strategy
Xiao et al.	English	2020	Recollection	<ol style="list-style-type: none"> 1- Consistent government investment, multisectoral involvement, and collaboration with international organizations 2- Sustained capacity building of healthcare personnel through regular trainings
Yin et al.	English	2022	Editorial	<ol style="list-style-type: none"> 1- Political commitment 2- Malaria prevention and treatment provided under universal health coverage 3- Robust surveillance and response system 4- Quality-assured diagnostic services under the supervision of reference labs 5- Multisectoral and cross-border cooperation
Yin et al.	English	2023	Review	<ol style="list-style-type: none"> 1- Political commitment with organizational, technical, and financial support for malaria control 2- An efficient health system with qualified personnel 3- Evidence-based and contextualized malaria interventions 4- Community participation in health promotion, vector control, and epidemiological investigation 5- Interprovincial and international cooperation with agencies such as the WHO and the Global Fund 6- Innovative approach to malaria control
Zhou et al.	English	2021	Editorial	<ol style="list-style-type: none"> 1- High-level political commitment 2- Multisectoral and regional coordination 3- Innovative research 4- Integration of western and traditional Chinese medicine 5- Active community participation 6- International cooperation to ensure practice standardization 7- Socioeconomic development

The strategic target set by the NMEAP was met three years ahead of schedule, with indigenous malaria transmission dropping to zero in 2017 [9].

Capacity building

Capacity building refers to the development of the health system infrastructure to meet the requirements

of implementing planned control interventions. The National Institute of Parasitic Diseases (NIPD) and the Chinese Centre for Disease Control and Prevention (CDC) were both established after the foundation of the PRC, and the national malaria control and prevention network was extended down to the grassroots level [10]. Another essential component of malaria control, the surveillance system, underwent numerous reformations. The county-based, mail-delivered system of the 1970s and early 1980s was replaced with computerized reporting sheets in 1985. The national surveillance system had to be further adjusted as the country moved to adopt the elimination strategy, and the National Information System for Malaria Control and Elimination was launched, with the “1-3-7” approach becoming the standard surveillance and response method [15]. In this model, all malaria cases had to be reported within one day, followed by case confirmation and epidemiological investigation within three days and the completion of foci investigation and response in seven days. The “1-3-7” had since received international acclaim and was later incorporated into WHO publications [17]. The healthcare cadre in charge for surveillance, response, and laboratory diagnosis underwent regular training that was sustained even after malaria was eliminated nationwide [18, 23].

Multi-axial collaboration

The Chinese government’s multi-axial mechanisms encompass six collaborative themes: multisectoral, provincial, regional, international, community-oriented, and partnership with academic institutions. A notable example of multisectoral action is The National Malaria Elimination Action Plan (2010–2020), having been signed by representatives from over 13 ministries and governmental bodies [24, 25]. Examples of similarly robust multisectoral ventures from earlier malaria control phases are relatively scarce, although the reference of Yin et al. [10] to malaria inclusion in the draft document for national agricultural development (1956–1967) may qualify as an example of the state’s early interest in involving non-health sectors in malaria control. Conversely, a number of large-scale interprovincial projects have been established throughout the twentieth century, including the Middle Five Provinces Malaria Joint Control and Prevention Programme in 1974 and the Southern Three Provinces Malaria Joint Control and Prevention Programme in 1992 [26]. The political interest in forging regional consensus grew as China moved to adopt the elimination strategy and the prospect of cross-border malaria transmission became increasingly worrisome [21].

Mounting a coordinated cross-border response was predictably more complicated than in-country coordination; the last known case of indigenous malaria

transmission in China occurred in Yunnan, a province that shares borders with three malaria-endemic countries [9]. However, China’s proactive approach to developing joint mechanisms, as well as the shared interest in reducing the malaria burden across the Greater Mekong Subregion (GMS) proved effective in halting disease reestablishment in the Chinese border provinces. On a broader scale, China’s relationship with the international community has been mutually lucrative, with China’s growing financial and political weight resulting in the country’s transition from recipient to donor status, as illustrated by the changing dynamic between China and the Global Fund [17, 19].

The collaboration between the Chinese community and government manifests in China’s Patriotic Health Campaign. Members of the community participated in mass health promotion campaigns to improve sanitation and modify mosquito habitats [27]. However, the literature’s lack of reference to the involvement of community members in the decision-making process suggests a largely top-down management orientation. The role of Civil Society Organizations (CSOs) is another notable omission from the literature, indicating the lack of substantial contributions by CSOs to malaria control in China (See 4. “Discussion”).

The final collaborative axis, the political-academic duo, is showcased by the close alignment of scientific output with national needs and the timely incorporation of research findings into control strategies. A classic example is the launch of the confidential Project 523 in 1967 in response to the spread of chloroquine-resistant malaria during the Vietnam War. Professor Tu Youyou, who led one of the project teams at the time, experimented with *Artemisia annua*, and the extracted active ingredient, artemisinin, was shown to have potent anti-malarial properties. The discovery earned Youyou the 2015 Nobel Prize in Physiology or Medicine, with artemisinin derivatives the current gold standard for malaria treatment [9, 28]. Furthermore, policymakers in China highly prioritized locally generated evidence, as demonstrated by the widespread distribution of insecticide-treated nets (ITNs) well before their recommendation by the WHO [18].

Conducive economic policies

The impact of economic policies on malaria control is examined from two perspectives: direct expenditure on health and the effect of economic megatrends on malaria epidemiology. The considerable upscale in the health system’s organizational capacity to meet strategic control targets is indicative of increased health expenditure, as is the provision of packages of basic health services to citizens free of charge [19, 22]. The introduction of the

Global Fund in 2002 further augmented the resources available for healthcare and malaria control in China. The country applied for five Global Fund rounds dedicated to malaria—R1, R5, R6, R10, and the National Strategy Application—before losing eligibility in 2014. The impetus created by the Global Fund was sustained, however, as the government moved to bridge the deficit [18].

While the impact of economic megatrends in China was somewhat overshadowed in the literature by the emphasis on direct health expenditure, some insight can still be derived. The Chinese economy's enormous growth provided leverage for the government's capacity to implement malaria control measures, such as the labour-intensive 1-3-7 strategy, regular cadre training, drug procurement and health promotion campaigns. Another, more nuanced, point of view took into account the impact of rising living standards on malaria epidemiology. As the GDP per capita increased from ¥385 in 1978 to ¥70,000 in 2019, so did the population's ability to access improved sanitation, nutrition and healthcare [18, 29].

Discussion

The findings of the review illustrate that malaria elimination in China was the outcome of a government-led tetrad of strategic adaptability, health system strengthening, multi-axial collaboration mechanisms, and favourable socioeconomic megatrends. The intimate correlation between malaria epidemiology and political crossroads in China, as showcased in the dramatic fall in malaria incidence following the proclamation of the PRC in 1949 and the massive epidemics that followed the turmoil of Mao's Cultural Revolution in 1966, demonstrates the decisive role of politics in the country's elimination journey [30, 31]. It may be argued that these changes were strongly confounded by the country's economic circumstances at the time, rather than being a direct product of deliberate political action, as was the case with many countries in Europe and North America where malaria elimination was largely a spontaneous by-product of economic prosperity [32]. Socioeconomic progress is, of course, also contingent on the financial policies enforced by the state; yet the findings of this study suggest a stronger link between political action and malaria burden reduction in China. Indeed, the vigour of malaria control in the PRC cannot be fully accounted for without the broader context of the long standing politicization of health in China [33, 34]. The Chinese Communist Party (CCP) and its predecessor, the Nationalist Party (GMD), have both embraced public health as an important constituent of their visions, divergent as they were [33]. As a result, the reduction in malaria and other communicable diseases in the PRC was frequently in excess of what was expected

from the country's parallel level of economic development [30].

This correlation between malaria control and political action is well-recognized and has been long reported in academia, including the audit report produced by the United States Agency for International Development in 1976, in which the malaria epidemics that succeeded the Global Malaria Eradication Programme (GMEP) were said to "have been very largely related to the unwillingness of national governments to make the requisite resources available when in fact such resources existed" [35]. The failure of the GMEP itself has been attributed to the lack of genuine political commitment among member states [2]. The political imperative has since frequently reprised in scholarly works addressing malaria from a public health standpoint [35–37]. Nonetheless, literature prioritizing more technical elements of malaria control is arguably more abundant [38], with the de facto global blueprint for malaria, the WHO's Global Technical Strategy, representing an outstanding example of technical alignment. The need for political commitment does feature in the rationale of the GTS, but is not tangibly translated into the strategy's operational framework [39]. This disposition to gloss over the political roots of underdevelopment, including ill-health, is not uncommon in NGO-engineered international policies [40]. The postulation is reflected in the WHO's persistent prescription of evidence-based preventive and case management interventions for malaria control [41, 42]. However, the grossly off-track malaria trends necessitated rethinking the GTS's approach, culminating in the launch of the High Burden to High Impact (HBHI) initiative in 2018. Political commitment is declared a flagship element by the HBHI, re-centring the role of government leadership in the malaria narrative [43]. The second and third elements of the HBHI initiative call for the departure from a one-size-fits-all approach and the adaptation of strategy to context, corresponding to the strategic adaptability of malaria control in China. As the catastrophes of the GMEP unfolded in many parts of the world, malaria in China was strategically manoeuvred [2, 21]. The GMEP involved a highly rigid and inflexible approach to malaria eradication, primarily via uniform spraying of the residual insecticide dichlorodiphenyltrichloroethane (DDT). By failing to respond to local realities, the project suffered from repeatedly prolonged schedules and exploding costs, eventually leading to its abandonment in 1969 [2]. China's policies, on the other hand, have shown remarkable adaptability over time and to varied local conditions, with the disease gradually phased out over seven decades [10].

The effectiveness of proposed strategies, adaptable or otherwise, is contingent on the capacity of health systems

to implement the propositions. The decisive role of health systems in malaria responsiveness is entrenched in the report produced by the Lancet Commission on Malaria Eradication, in which the feasibility of an eradication campaign is hinged on strengthening national health systems [44]. The confluence between malaria control and health systems cannot conclude without venturing into the health information component, an independent predictor of progress in malaria control [45]. A functional surveillance system is a prerequisite for effective malaria control in all countries regardless of their placement in the endemicity continuum [39], with robust surveillance and response mechanisms constituting the most important pillar for the successful elimination campaigns in Algeria, China, El Salvador, Paraguay and Sri Lanka [46]. As countries near elimination, multisectoral collaboration is increasingly employed for case detection and reporting [28, 46]. The well-known recommendation of involving multiple sectors in malaria control is, for the most part, a rational rather than an empirical decision, as evidence for multisectoral action in malaria control remains generally inconclusive [45]. Nevertheless, multisectoral action continues to be strongly supported by academia. In the analysis by Herdiana et al. [47], the recommended response to the lack of robust evidence is the continued implementation of inter-sectorality with improved documentation of indicators to address knowledge gaps. This viewpoint is shared by global organizations; the Multisectoral Action Framework for Malaria, a joint project between the United Nations Development Programme (UNDP) and the Roll Back Malaria Partnership, places multisectoral action at the heart of adequate malaria responsiveness [32].

The premise of the second and third collaborative axes in China, provincial and regional joint projects, is the transcendence of malaria to man-made borders. Regional initiatives in GMS were successful in reducing malaria mortality across common border regions through information and skill transfer between neighbouring states, and the region is currently on track to meet the milestones of the *WHO Strategy for malaria elimination in the GMS (2015–2030)* [48]. On a larger scale, China's relationship with the global community has morphed over the last few decades with the country's increasing international presence. The partnership between China and the Global Fund, China's most noteworthy benefactor in its pre-elimination era, illustrates the reconfiguration. China successfully bid for Global Fund support on five different occasions between 2002 and 2013, but lost fund eligibility as the country's economy grew and the malaria burden dwindled [49]. Today, China is the 20th largest public donor to the Global Fund, with a total investment of US\$81 million to date [50]. The PRC-Global

Fund partnership is generally held favourably, since the five rounds of Global Fund support have met their objectives [49]. However, the Global Fund's legacy in China has been also described as “deeply mixed”, with the gains of providing financial leverage, bridging the normative gap between China and the global community, and engaging civil society in policymaking juxtaposed with low-value-for-money projects and unintended negative consequences for China's civil society [51]. Malaria control projects in China have been predominantly top-down, with community members strongly encouraged to engage in the implementation of pre-determined activities but excluded from decision-making. The lack of civil society participation in decision-making was a recurring source of contention, with one incident leading to the suspension of all Fund grants allocated to China and the resumption of operations only after Chinese authorities guaranteed sufficient civil society participation. While CSO involvement did increase afterwards, the policy led to the proliferation of inefficient NGOs, many of which emerged to harvest funds with little interest in service provision [51].

The last collaborative axis, linking the Chinese government with academia, has produced transformative discoveries as well as policy-informing research. The research trends in China have closely followed research needs for malaria control, as illustrated by the amount, focus, and author affiliation of malaria research in the country. Over 16,000 malaria articles were published in Chinese academic journals between 1980 and 2019. The keywords “antimalarial drugs” and “*Anopheles sinensis*” were frequently in use as the strategic interest in drug development and vector control peaked during the 1980s and 1990s, but their usage declined in later decades in favour of keywords such as “imported case”, “surveillance” and “elimination” when the national agenda shifted towards elimination. The majority of highly cited authors were from public institutes of parasitic diseases and CDCs, cutting down the time required to translate research output into national and subnational strategies [52]. The scarcity of bibliometric publications from other countries renders a comprehensive analogy challenging, however, one study from Malawi interestingly found that the Malawi-Liverpool Wellcome Trust Programme is the most common author affiliation of malaria research in Malawi [53]. This hegemony of a politically and economically independent global entity is likely to have ramifications on the dynamic between research and policymaking in Malawi, just as the affiliation of reputable authors with public institutions did in China.

The last thematic area addresses the economics of malaria control and elimination in China. Systematic data collected from countries all over the globe reveal a

positive feedback mechanism between malaria and socio-economic development [54]. Malaria incidence declines as countries move up the socioeconomic ladder, irrespective of health system ranking and/or the implementation of malaria-specific interventions. Earlier in the discussion section, it was concluded that China deviates from the standard format, with malaria control gains exceeding what would be expected from the country's vis-à-vis degree of economic development. Deviation, however, is not disjunction; the steady decline of malaria in China over the previous four decades has corresponded with substantial economic growth [15]. The impact of China's prosperity on malaria is particularly evident in the country's ability to absorb the shock of the market-oriented health sector reforms in the 1980s without incurring significant losses in control gains. The reforms, however, jeopardized the country's capacity to respond to the 2003 SARS outbreak, and the devastating consequences that ensued led to extensive revision of China's health policy [55]. The government's commitment to the resource-intensive surveillance requirements of malaria elimination reflects the reinvigorated interest in public health in the post-SARS era [56, 57].

Knowledge gaps

While the overarching principles of malaria elimination in China have been summarized in this scoping review, more in-depth research is required to break down the political processes of how, why and by whom was priority allocated to malaria in China, in order to produce conclusions that are informative from a policy-making perspective.

Study limitations

While the search process was as inclusive as permissible within the limits of feasibility, it is possible that more results could have been obtained if a reviewer proficient in the language and research culture in China was included, as valuable insight would have been gathered from local information sources. However, since the majority of included articles are authored by Chinese academics, there is reason to believe that the local perspective has been accounted for in this scoping review. Furthermore, the decision to omit articles focusing on specific interventions and/or regions in China, as well as articles published prior to malaria elimination from the country, may have led to the exclusion of relevant literature. However, had the study lost sight of the greater scope of events, the results would have been skewed to overrepresent the impact of micro-level interventions to the detriment of the study objective.

Conclusion

The malaria-free certification of China in 2021 was the result of a series of structural reforms initiated by the government seven decades earlier. The successive governments of the new-found state prioritized malaria; national strategies were geographically stratified and regularly updated, and the health system was scaled up to meet strategic targets. Collaboration was critical to malaria elimination in China; regional initiatives were established to control cross-border malaria, while international organizations supported the transition from control to elimination. A whole-of-society approach to malaria control was adopted; non-health sectors were involved, scientific endeavour was encouraged, and community members were mobilized. These malaria-specific interventions have occurred in concomitance with socio-economic development and improving living standards; independent predictors of malaria burden reduction. The documentation of China's journey re-centres the role of the social determinants of health in the malaria narrative, challenging the contemporary global health paradigm in which downstream interventions are given precedence.

Acknowledgements

I acknowledge Professor Elfatih Malik for his valuable input.

Author contributions

Manuscript conceptualization, literature review, article selection, data extraction, and report writing were undertaken by S.E.

Funding

The research expenses have been exclusively covered by the author.

Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Received: 25 July 2024 Accepted: 22 August 2024

Published online: 27 August 2024

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