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Combating malaria in Kenya through collaborative population health education: a systematic review and pilot case study

Hester Lacey, Nityanand Jain, Mai Sugimoto, Masako Shimato, Ieva Reine, and Kevin Oriaf

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ABSTRACT
Background: Malaria continues to be a public health problem in Kenya, with an estimated 37.2 million people at high risk of the disease. The disease burden is compounded by inequalities in health service availability, housing, socioeconomic conditions, and access to education.

Objectives: We aimed to determine the status of community-based, health education interventions. Based on the findings, to develop an educational module for medical students to combat malaria in Kenya.

Methods: A systematic review was conducted to identify different educational interventions, their successes and limitations, and legal challenges leading to low uptake and adherence to malaria prevention interventions from 2000–2023. Consequently, a 6-week online educational pilot was conducted with healthcare students from Kenya, Japan, the UK, and Cyprus.

Results: Despite developing a national malaria strategy and monitoring and evaluation strategies, Kenya has not been able to meet the incidence reduction targets set by the World Health Organisation, underscoring the need for more work in identifying the barriers to implementing strategies and optimising the distribution of public health interventions. Student teams proposed innovative solutions, including two-tier malaria control strategies, maternal malaria clinical education, community awareness through schools and NGOs, and a 10-year health system strengthening and immunisation plan.

Conclusions: Public education regarding prevention strategies and increasing their adoption remains a key challenge in combating malaria in Kenya. In this regard, digital tools can facilitate international collaborative health education and exchange of best practices, allowing students and faculty to engage across boundaries and prepare them to be future-ready physicians connected to the global community.

KEYWORDS
Collaboration, education, Kenya, malaria, medical students, prevention, Sub-Saharan Africa

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Introduction

Malaria is a potentially fatal communicable disease that is responsible for a significant burden of morbidity and mortality globally [1]. It is often caused by the parasite *Plasmodium falciparum*, which is spread by mosquitoes that act as biological vectors. The disease is characterised by an acute febrile illness that rapidly progresses to cerebral, haematologic, and neurologic complications, followed by death. The disease is endemic in large parts of Africa, in southern Asia, and in the Central and South American regions [1]. In 2021, nearly 3.3 billion people worldwide were at risk of malaria (50% of the global population), with the number of documented cases increasing by about two million to reach 247 million in the 84 endemic countries [1–2].

Most of the increase in cases occurred in countries in the World Health Organisation (WHO) African Region, reflecting the continued disproportionate disease burden in Sub-Saharan Africa (SSA). The region reported 95% of the world’s cases and more than 90% of its fatalities [1]. More than half of the world’s malaria cases occurred in just four countries – Nigeria, the Democratic Republic of the Congo, Uganda, and Mozambique. Although during the COVID-19 pandemic there was a slight increase in disease mortality in African countries, from 56% in 2019 to 58% in 2021, an estimated 593,000 people have died from malaria in the WHO Africa region [1]. Globally, Nigeria, the Democratic Republic of the Congo, Niger, and the United Republic of Tanzania accounted for more than half of malaria deaths (Figure 1).

Situation of malaria in Kenya

Kenya, a country in East Africa that borders the Indian Ocean, has a diverse climate that includes tropical coastal lowlands, temperate highlands, and arid northern regions. With a population of 51 million and a gross domestic product (GDP) per capita of approximately US$1,500, the country is classified as a lower-middle-income country. The local population continues to suffer from a high burden of morbidity and mortality. The national average life expectancy at birth is 66.8 years with the under-5 mortality rate being 43.4 deaths per 1,000 live births [3].

In line with global trends, malaria remains a significant public health concern in Kenya, although the prevalence of infectious diseases is gradually declining [4]. Approximately 3.4 million malaria cases and 12,000 deaths have been recorded in the country in 2021 [1]. Furthermore, the country has an estimated 37.2 million people at high risk of malarial infection, representing 70% of the population (Table 1). Those living in northwestern and south-eastern parts of the country are disproportionately affected, largely due to tropical climates, population emigration, and inequities in health service availability [5–6].

Challenges to effective malaria management in Kenya

The underlying causes of morbidity and mortality in Kenya stem from similar issues that plague other neighbouring SSA countries. Chronic underinvestment in Kenya’s health sector was highlighted during the Covid-19 pandemic, particularly the mismatch between the availability of health services and the demand for care [7]. The result was a severe shortage of doctors, nurses, and equipment such as personal protective equipment and oxygen. Geographic divisions created a significant rural-urban divide, with most hospitals and health workers in urban areas serving only 30% of the population [5]. Despite efforts by the government to improve the situation in recent years, corruption throughout the healthcare system has limited the success and change in the situation on the ground [8]. Healthcare institutions have been systematically weakened and the availability of health care to vulnerable populations reduced by multiple reports of theft of public funds [9–10].

Kenyan government also continues to underperform in scientific and health research. In 2022, Kenya’s expenditure on research and development was only 0.81% of GDP. This still falls short of the government’s target of 1% [11]. Other major challenges in the national health system include a lack of social capital and sustainable health financing mechanisms. This is exacerbated by a lack of investment in health education, including a lack of trained health workers, unequal access to basic medical and nursing education, and low-quality health education for those with access [12]. There remains a 32% gap between the availability of health workers in Kenya and the Sustainable Development Goals (SDGs) threshold index [13]. This despite a 110% increase in the density of health workers per population in the country between 2010 and 2020. Inequalities between men and women, as well as social, cultural, and political influences, have added to the plight [14].

Local social factors such as inadequate housing and living conditions, financial poverty, food and water insecurity, unemployment and lack of social services, and
limited access to secondary education contribute to the burden of disease [15]. Climate change is also a major contributor to the problem. Fluctuations in temperature and weather patterns have led to an increase in the transmission of vector-borne diseases over longer periods, and an increase in stagnant water, which serves as a habitat and breeding ground for mosquito vectors. Interestingly, as a direct result of changing weather patterns and rising temperatures, climate change is thought to explain the eightfold increase in malaria cases seen in western Kenya since the 1970s [16].

Food and water insecurity in the context of climate change weakens both the health of the population and the economy, resulting in a reduced capacity to cope with the increased burden of disease and a reduction in the resources available to support health systems [17]. Inequalities in access to safe drinking water, hygiene facilities, and adequate sanitation have a clear impact on malaria transmission, morbidity, and mortality [18]. Inequitable access to public health education also contributes to poor knowledge about malaria and other communicable diseases. Limited recognition of symptoms and a lack of understanding of measures to prevent the spread of malaria have promoted inappropriate care-seeking behaviours in rural indigenous communities [19]. This, in turn, perpetuates the spread and persistence of endemic disease outbreaks.

**Kenyan governmental initiatives to combat malaria**

Nevertheless, the Kenyan government has been at the forefront of adopting several innovations to reduce the burden of malaria. Kenya, along with Ghana and Malawi, was one of the first African countries to participate in the Malaria Vaccine Implementation Program in 2016, a pilot scheme to vaccinate children living in high transmission areas [1]. Based on the early successes of the pilot, it was decided to roll it out to all WHO African countries in 2021. The Kenya Malaria Strategy (KMS) and Monitoring and Evaluation (M&E) plan launched in 2019 aims to reduce malaria incidence and deaths to at least 75% of the 2016 levels by the year 2023. Strategies incorporated include the improved use of the national malaria treatment guidelines, increased utilisation of malaria prevention interventions, strengthening malaria surveillance, and providing leadership training and management for the implementation of the envisioned strategies [20].

Another goal is to increase the distribution of long-lasting insecticidal nets (LLINs), which have been shown to offer significant benefits in vector control and reduction of malaria spread, reducing mortality by an average of 5% in countries with the successful distribution. Despite the well-documented benefits of LLINs and successful distribution in the country in the preceding years (an 19% increase of households owning LLINs between 2010–2015), in 2020, Kenya managed to successfully
Table 1. Overview of select community malaria prevention policies and strategies implementation in Kenya.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN estimated population in million</td>
<td>–</td>
<td>53.77</td>
<td>53.00</td>
</tr>
<tr>
<td>Population at risk (low and high) in million (%)</td>
<td>–</td>
<td>53.77 (100%)</td>
<td>53.00 (100%)</td>
</tr>
<tr>
<td>Population at high risk in million (%)</td>
<td>–</td>
<td>37.74 (70%)</td>
<td>37.21 (70%)</td>
</tr>
<tr>
<td>Funding for Malaria Control (as reported by Kenyan Government; in million US dollars)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Malaria Control Programme</td>
<td>6.92</td>
<td>6.23</td>
<td>–</td>
</tr>
<tr>
<td>Global Fund to Fight AIDS, Tuberculosis and Malaria</td>
<td>14.49</td>
<td>48.43</td>
<td>–</td>
</tr>
<tr>
<td>PMI/USAID</td>
<td>34.00</td>
<td>34.00</td>
<td>–</td>
</tr>
<tr>
<td>UK Government*</td>
<td>–</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Commodities Distribution and Coverage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of LLINs delivered (in millions)</td>
<td>1.79</td>
<td>1.34</td>
<td>17.91</td>
</tr>
<tr>
<td>Modelled % of population with access to an ITN</td>
<td>61.20</td>
<td>46.20</td>
<td>57.40</td>
</tr>
<tr>
<td>No. of people protected by IRS (in millions)</td>
<td>2.01</td>
<td>1.79</td>
<td>2.08</td>
</tr>
<tr>
<td>No. of RDTs distributed (in millions)</td>
<td>4.18</td>
<td>7.22</td>
<td>5.93</td>
</tr>
<tr>
<td>Household Survey Results, Kenyan Malaria Indicator Survey 2020</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% households with at least one ITN</td>
<td>–</td>
<td>49.00</td>
<td>–</td>
</tr>
<tr>
<td>% households with at least one ITN for every two persons who stayed in the household the previous night</td>
<td>–</td>
<td>28.70</td>
<td>–</td>
</tr>
<tr>
<td>% population with access to an ITN</td>
<td>–</td>
<td>39.60</td>
<td>–</td>
</tr>
<tr>
<td>% population who slept under an ITN last night</td>
<td>–</td>
<td>34.90</td>
<td>–</td>
</tr>
<tr>
<td>% of ITNs that were used last night</td>
<td>–</td>
<td>80.20</td>
<td>–</td>
</tr>
<tr>
<td>% pregnant women who slept under an ITN</td>
<td>–</td>
<td>39.80</td>
<td>–</td>
</tr>
<tr>
<td>% children &lt;5 years who slept under an ITN</td>
<td>–</td>
<td>42.00</td>
<td>–</td>
</tr>
<tr>
<td>% children &lt;5 years with fever in the past 2 weeks for whom advice or treatment was sought</td>
<td>–</td>
<td>63.60</td>
<td>–</td>
</tr>
<tr>
<td>Governmental Policies on Malaria Prevention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITNs/LLINs are distributed free of charge</td>
<td>Policy exists and implemented in 2020-2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITNs/LLINs are distributed through ANC</td>
<td>Policy exists and implemented in 2020-2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITNs/LLINs are distributed through EPI/well baby clinic</td>
<td>Policy exists and implemented in 2020-2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITNs/LLINs are distributed through mass campaigns</td>
<td>Policy exists and implemented in 2020-2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRS is recommended by malaria control programme</td>
<td>Policy exists and implemented in 2020-2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDT is used for IRS</td>
<td>No Policy exists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPTp is used to prevent malaria during pregnancy</td>
<td>Policy exists and implemented in 2020-2021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMC or IPTc is used</td>
<td>No Policy exists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria diagnosis is free of charge in the private sector</td>
<td>No Policy exists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria diagnosis is free of charge in the public sector</td>
<td>Yes, both microscopy and RDTs are free</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDTs are used at community level</td>
<td>Policy exists and implemented in 2020-2021</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


*The funding for the British (UK) Government is based on the data made available by the British Government and not based on the estimates reported by the Kenyan Government.


Distribute just 1% of the LLINs available [1]. While some of this disparity is attributable to the impacts of the Covid-19 pandemic, it might be also indicative of the pervasive health system infrastructure weakness in techniques to successfully distribute medical devices and ensure adequate access to population health measures across the country. Moreover, the country saw a reduction of over 30% in malaria testing in 2020 [1]. Nonetheless, the incidence of mortality related to malaria has decreased in Kenya in 2020 compared with 2015. However, the mortality incidence failed to meet the WHO target of a 40% reduction in endemic countries over these five years. Furthermore, the unintended use of LLINs by the locals, for example, using the nets to keep fruits and vegetables, hinder the success of prevention programmes. This highlights that there remains work to be done to improve the detection, treatment, and prevention of malaria in Kenya.

Methods

Given the foregoing discussion, we decided to conduct a literature review to determine the general status of malaria education and educational interventions that have been reported related to malaria prevention in Kenya. Health education was chosen as a criterion because it can provide the knowledge necessary for the adoption and enforcement of appropriate prevention and care-seeking behaviours [21]. It can also help dispel myths and bridge trust between traditional and Western medicine. There is evidence that health education can have a profound impact on the spread of infectious diseases and the overall development of a community [22]. Furthermore, as evidenced by the inappropriate use of LLINs, we believe that without proper instruction and education, any preventive intervention cannot be expected to produce the desired success rates.
**Search strategy**

A comprehensive review of available literature was performed by accessing the following academic databases in the Ovid platform:

i. **MEDLINE** – a biomedical database by National Library of Medicine (NLM) covering literature on the allied health fields and the biological and physical sciences, humanities, and information science as they relate to medicine and health care. Information is indexed from approximately 5,600 journals published worldwide [23].

ii. **The Excerpta Medica Database (Embase)** – a biomedical and pharmacological literature database maintained by Elsevier with over 40 million abstracts and indices from more than 8,500 peer-reviewed journals, as well as in-press publications and conferences [24].

iii. **Emcare** – a nursing specific database by Elsevier covering content not found in other nursing and allied health databases and features more than a thousand journals not covered by Elsevier’s Embase database. Coverage includes allied health, education and training, development and management, midwifery, health, and healthcare economics, clinical medical and healthcare social work, psychiatry and mental health, and traumatology, emergency, and critical-care medicine [25].

iv. **The Allied and Complementary Medicine Database (AMED)** – a bibliographic database of the British Library covering journals in complementary medicine, palliative care, and several professions allied to medicine [26].

v. **The Health Management Information Consortium (HMIC)** – a compiled database of data from the Department of Health’s Library and Information Services (DHLIS) and King’s Fund Information and Library Service (KFILS). The DHLIS consists of more than 170,000 records from publications, journal articles, and grey literature relating to health and social care management information. The KFILS database consists of over 70,000 records including books, pamphlets, government reports, abstracts of journal articles and a wide range of grey literature [27].

We searched for the following search terms in both subject headings and keywords – ‘Malaria’, ‘Kenya’, and ‘Education’ using AND boolean function. The search included papers published from January 2000 to February 2023. The reference lists of the included articles and the citing articles were screened manually to identify potential studies that met the inclusion criteria. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used for the present study. Since the review was initiated as an educational scoping project, the study protocol couldn’t be registered retrospectively with online databases.

**Selection criteria**

The present systematic review included studies that investigated the level of education about malaria and its prevention in the local Kenyan population. Studies that investigated the role of educational interventions, success and/or failure of educational policies and public health campaign were also included. The included studies were limited to English language, were available as full-text papers, and investigated or presented findings related to human participants. There was no limitation on the study design. Participants from all regions of Kenya and from all socio-demographic backgrounds were included to capture the full spectrum of heterogeneity in the local communities. Studies reporting on non-Kenyan populations, published in non-English language, non-human studies, non-peer-reviewed, and non-education related malaria prevention interventions were excluded.

**Screening process**

The Ovid platform was used to identify and remove duplicates. Next, two reviewers (H.L. and N.J.) screened the titles and abstracts of the retrieved studies independently to assess the appropriateness of the remaining studies (based on inclusion and exclusion criteria). The full texts of the included studies were then examined by the same reviewers. Disagreements and conflicts were resolved by a third reviewer (M.S.) following a consensus-based discussion.

**Risk of bias assessment**

The appropriate Cochrane Collaboration’s tools for assessing risk of bias were utilised for qualitative assessment of the risk of bias in the included studies (based on individual study design e.g. Rob2 tool for randomised controlled trials and ROBINS-I tool for interventional
studies) [28]. Two reviewers (H.L. and N.J.) independently rated each study whilst conflicts were resolved by the third reviewer (M.S.). Each item in the checklist was rated as high concern, low concern, some concerns, or no information. However, the overall perceived risk of bias assessment was classified as low, moderate, and high.

**Narrative synthesis**

A narrative synthesis of the findings was used to synthesise the data. A meta-analytical approach was considered to be not appropriate and hence, not adopted due to the high degree of heterogeneity in the study methodologies, outcomes, and designs. The results were summarised in a tabular presentation to highlight the key findings and drawbacks for each of the included studies. The implications of the results were grouped and reflected with provision of possible solutions.

The SP model was utilised to produce a strategic plan to increase awareness and education about malaria and its prevention methods in the local population. The model can be replicated when producing a strategic plan to target malaria—to identify specific interventions (Product), where the product will be used or discovered, including online platforms (Place), the cost of a product or service (Price) including demand, production cost, and price point, and how the product will reach the target population (Promotion) for successful distribution. The final pillar identifies possible issues in the implementation of the strategy (Pitfall).

**Results**

A total of 463 records were retrieved from the databases based on our search strategy. 218 records were removed as duplicates and a further 218 were excluded after title and abstract screening. The full text of the remaining 27 records was subject to eligibility and suitability assessment for inclusion in the review. Four more studies were removed at this point, leaving 23 studies for inclusion in the narrative synthesis (Figure 2). The studies were then categorised according to the target population or measure. Accordingly, three studies addressed healthcare provider interventions [29–31], six addressed community interventions [32–37], three addressed interventions related to HIV infection [38–40], three addressed interventions related to pregnancy [41–43], and two addressed interventions related to blood disorders [44–45]. Final six studies highlighted the legal and research-based interventions for preventing malaria [46–51].

Based on our risk assessment, we found that 60% of our studies had overall low risk of bias while the remaining 40% studies showed moderate concerns (Figure 3). Most of the concerns were raised regarding the bias in measurement of the outcome and bias due to missing outcome data. This could be explained as most of the included studies were self-reported survey-based studies or studies that relied on data collected from national registries. Since these surveys were more quality-of-life questionnaires than interventional surveys, hence we assigned them some concerns rather than high risk. Given these findings, all studies were eligible for inclusion in the present review.

**Healthcare providers education and initiatives**

The first component addresses the need to provide educational materials to health workers in Kenya to improve their skills in detecting and treating malaria. This solution is supported by the broader political and social direction of regional and national governments in the WHO African Region, where epidemiological and public health training initiatives focusing on communicable diseases, including HIV, tuberculosis, and malaria, have been increasing annually. Past experiences in implementing enhanced training initiatives in the country have shown that there is a modest yet direct link between the provision of malaria identification and treatment training and improvements in dispensing and consultation practices (Table 2).

In a study by Wasunna et al. health workers in Bondo District, a highly malaria-endemic region, received enhanced training developed and delivered by experienced national malaria program trainers [29]. The authors reported that only half of the health workers had access to the provided training manual, visual materials, and job aids, even though 2/3rd of the health workers had received this training. Alarmingly, more than one-third of participants said they had no access to the national malaria guidelines. The authors also found that after the training, prescribing of artemether-lumefantrine (AL), the first-line treatment for febrile paediatric patients, increased by a modest 8% (from 77% to 85%). However, this increase was attributed to a combination of factors in addition to the training. These included an increase in the number of times the first dose was administered at the health facility and counselling of
parents on how to handle the child in case of vomiting of the drug [29].

Another important aspect is the training of the next generation of healthcare providers [30]. Medical and nursing students are an untapped resource within the healthcare and education community that can be successfully leveraged in joint efforts to identify and disseminate malaria control strategies in Kenya. The use of social media, online healthcare communities, and the proliferation of telemedicine, online conferencing, and networking opportunities within the undergraduate community make the new generation of medical students uniquely positioned to utilise their online platform. The platforms can be exploited for learning from and educating each other, as well as increasing awareness and understanding of their local health threats within the local community and globally. As noted by the Lancet Commission on Education of Health Professionals for the twenty first Century, a third generation of educational reforms are needed to ensure that health professionals are competent to participate as ‘members of locally responsive and globally connected teams that improve health equity within and between countries’ [52].

In this context, Hiatt et al. suggested using existing inter-country collaborations such as the Inter-University Council for East Africa (IUCEA) to reform regional medical curricula [31]. Specifically, the authors have argued...
for introducing and implementing Population Health Sciences, an interdisciplinary field at the intersection of basic, clinical, behavioural, and social sciences [53]. For example, in addition to teaching medical students about malaria’s microbial pathogenesis, it is important to teach them about risks of infection, factors that promote and prevent infection, and social and cultural factors that influence vulnerability. In addition, there is a need for continued south-north cooperation for technology transfer and capacity building in the local context. The Medical Education Partnership Initiative (MEPI) Partnership for Innovative Medical Education-Kenya (PRIME-K) is one such example. Since its inception in 2011, the undergraduate program has strengthened and promoted modern patient care practices and research interests, while emphasising the social and cultural determinants of relevant health issues in the country [54].

**Community education and initiatives**

The second component aims to educate the community about the importance of malaria (mortality, impact on life) and what behavioural changes they can make to reduce it (Table 3). In addition, local community initiatives are to be encouraged and supported, and trust in Western health approaches is to be built. The dispensing of over the counter (OTC) antimalarial drugs by drug retailers for the treatment of malarial fever in children has been shown to be a successful intervention in Kenya [55]. Success was achieved through a program

<table>
<thead>
<tr>
<th>Study</th>
<th>Perceived Overall Risk of Bias Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adebisi et al (2022)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Atiel et al (2011)</td>
<td>Low</td>
</tr>
<tr>
<td>Cuadros Branscum, and Crowley (2011)</td>
<td>Low</td>
</tr>
<tr>
<td>Fauci (2005)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Greatex-white and Monaghan (2014)</td>
<td>Low</td>
</tr>
<tr>
<td>Gruskin et al (2013)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Halliday et al (2012)</td>
<td>Low</td>
</tr>
<tr>
<td>Hiatt et al (2017)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Madewell et al (2022)</td>
<td>High</td>
</tr>
<tr>
<td>Monekosso (2014)</td>
<td>Low</td>
</tr>
<tr>
<td>Mwai et al (2013)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Ng’ang’a et al (2019)</td>
<td>Low</td>
</tr>
<tr>
<td>Odhiambo et al (2012)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Owiti (2020)</td>
<td>Low</td>
</tr>
<tr>
<td>Roos et al (2021)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Suchdev et al (2014)</td>
<td>Low</td>
</tr>
</tbody>
</table>

*Figure 3.* Risk of bias assessment using the relevant Cochrane Collaboration’s risk of bias tools. Yellow indicates moderate concerns while blue indicates low risk.
developed by the Kenya Medical Research Institute (KEMRI)-Wellcome Trust Collaborative Research Program and the Kenyan Ministry of Health (MoH), which educated communities about the need for home management of malaria and the availability of antimalarials in local drug stores [32]. Although such interventions are often associated with high development costs and require the support and interest of community members, the costs to achieve the targets are not so high as to discourage the implementation of such initiatives altogether.

In fact, with the support of contributions from private companies, donors, and multilateral international organisations such as the IMF and the World Bank, the budgetary requirements can be met [32]. The remaining costs can be fulfilled from the local governmental budget. These findings have been corroborated using a larger randomised trial across 10 districts of Kenya by the Kenyan MoH [33]. The government launched a two-day program to train about 450 private medicine retailers (PMRs) in three endemic districts of Kenya, with total funding ranging from US$5,000 to US$6,000 per district. The implementation costs were supported by the United Nations Children’s Fund (UNICEF) and the Global Fund to Fight AIDS, Tuberculosis, and Malaria (GFATM). Approximately 6–8 months after training, it was found that trained PMRs were 8.8 times more likely than untrained PMRs to sell amodiaquine to surrogates with correct use advice. In addition, trained PMRs were 29.8 times more likely to report having the correct knowledge about the dosage of amodiaquine when compared to untrained PMRs [33].

Enhancing awareness of malaria and local healthcare interventions strategies are key areas for improvement within local communities in Kenya, as identified by low awareness of core interventions including house screening programs [36]. The education level of the household head (guardian) has been shown to have a significant impact on ownership and use rates of insecticide treated nets (ITNs). Compared to households with a primary education or higher, households with not educated heads were less likely to own and use an ITN [34]. Primary and secondary education levels, however, did

### Table 2. Studies evaluating interventions for the education of healthcare workers.

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Aim</th>
<th>Study Design</th>
<th>Key Findings and Conclusions</th>
<th>Limitations of the Study</th>
</tr>
</thead>
</table>
| Wasunna et al. [29] | Evaluation of enhanced in-service training and provision of job aids in the prescription of artemether-lumefantrine (AL) to febrile children in a highly endemic area of Kenya. | Pre- and post-intervention cross sectional surveys of government health facilities, structured interviews of health workers, and exit interviews with caretakers of sick children <5 years. | - Nurses (pooled – 80%) and clinical officers (pooled – 15%) were the main beneficiaries of the enhanced training.  
- Only 25% of the healthcare facilities provided malaria diagnostic services.  
- Modest improvements in dispensing and counselling practices following enhanced in-service training.  
- No significant improvements in reported case-management tasks were observed. | - Incomplete exposure of health workers to in service training, thereby, limiting observed improvements.  
- Complete exposure and implementation required to see full effects. |
- Targeting this will need sustainable educational support initiative and internal fundings, expanding locally based postgraduate training programs and addressing medical practice issues, and expanding number of training doctors in public medical schools. | - No quantitative analysis, limiting reliability and validity of results. |
| Hiatt et al. [31] | A perspective of integrated training in population health for undergraduate medical and nursing education and proposal of concepts in health sciences education. | Narrative review of literature case studies on innovative changes in the undergraduate medical education. | - Malaria remains a chief cause of adult mortality in Kenya, but more notably of child mortality.  
- To increase the quality, scope of expertise, and retention of health care workers in East Africa, training for doctors, nurses, and other health professionals should incorporate the perspectives and skills of population health science to improve skills, knowledge and ability relating to malaria in Kenya. | - Sources/search strategy not outlined.  
- Option based limiting validity of findings. |


<table>
<thead>
<tr>
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<th>Study Aim</th>
<th>Study Design</th>
<th>Key Findings and Conclusions</th>
<th>Limitations of the Study</th>
</tr>
</thead>
</table>
- If the same impact were achieved through district programmes, the economic cost would reduce to $0.84, varying between $0.37 and $1.36 in the sensitivity analysis.  
- Likely to be considered highly cost-effective in comparison with standard benchmarks for interventions in low-income countries. | - Relatively high initial financial cost for development phase and setup - may not be applicable/suitable for all districts or feasible nationwide. |
| Abuya et al. [33] | Evaluating the impact of Ministry of Health (MoH) training programs on the knowledge and practices of medicine retailers in three districts in Kenya. | Cluster randomised controlled trial (RCT) | - Large-scale retailer training programs within the national malaria control framework led to significant improvements in retailers’ practices in selling and advising on the use of antimalarials to clients across three districts in Kenya. | - Methodological factors reduce reliability of results and risk bias - surrogate clients used, close supervision not possible, reduced power for within district analysis, 6–8-month time frame only limiting temporal assessment, loss of randomisation in one district. |
| Atieli et al. [34] | Examining Insecticide treated nets (ITN) ownership and underlying factors for among-household variation in use, and malaria transmission in two highland regions of western Kenya. | Cross-sectional surveys were conducted on ITN ownership (possession), compliance (actual usage among those who own ITNs), and malaria infections. | - In malaria endemic regions, gap between ITN ownership and usage is high with greater usage recorded during the high transmission season.  
- Despite ITN ownership reaching more than 71%, compliance was low at 56.3%. The compliance rate was significantly higher during the rainy season compared with the dry season (62% vs. 49.6%).  
- Other important factors affecting the use of ITNs include household education level of at least primary school level, significantly high numbers of nuisance mosquitoes, and low indoor temperatures.  
- Malaria prevalence in the rainy season was about 30% lower in ITN users than in non-ITN users, but this percentage was not significantly different during the dry season. | - Cross sectional surveys - reporting bias, correlation not causation, recruitment bias in respondents.  
- Only 600 houses sampled and 300 selected - small sample size limiting utility of results. |
| Amadi et al. [35] | Investigating trends and local knowledge on malaria and to develop a framework for malaria control for communities in Baringo, Kenya. | A mixed method approach integrating eight focus group discussions, 12 key informant interviews, 300 survey questionnaires and two stakeholders’ consultative forums. | - Misconceptions about the cause and mode of malaria transmission existed.  
- Gender-segregated outdoor occupations such as social drinking, farm activities, herding, and circumcision events increased the risk of mosquito bites.  
- Baraza, radios, and mobile phone messages were identified as effective media for malaria information exchange.  
- Supplementary strategies identified included unblocking canals, clearing Prosopis bushes, and use of community volunteers and school clubs to promote social behaviour change.  
- Implementing a community-based framework can support significant reductions in malaria prevalence by minimising both indoor and outdoor malaria transmissions. | - Primarily methodological focus group discussion - reporting bias.  
- Key informant interviews - unclear how respondents were recruited.  
- Questionnaires - not validated assessment tools. |
Stomach acid also cause malaria [35]. The education that consuming sugar rich foods and having excess

Madewell et al. [37] To investigate which health
care and public health improvements could have
prevented the most still-births and deaths in
children younger than 5 years using data from the
Children’s Health and Mortality Prevention Surveillance
(CHAMPS) network.

Another study showed that while more than 90% of
these two studies. Unexpectedly, dependence on health
services/providers remained at 35 to 40% in both studies
[35–36]. These findings suggest that different modes of
delivery, depending on region and level of education,
needing to be considered for truly effective malaria preven-
tion strategies. This is supported from the experience by
Madewell et al. who also suggested the need for a five-

pillars intervention for community education including
improved clinical management, infection prevention,
inclusion of health-seeking behaviour, health education,
and nutritional support for children [37].

Targeted education and initiatives for risk groups

The first group to be identified as at risk is the popula-
tion living in regions with a high endemicity of HIV
and malaria and/or mothers with a positive HIV test
result (Table 4). A study by Wafula et al. found that
infant mortality was highest among babies born to
parents with no education, followed by those with pri-
mary education and those with secondary education or
higher [38]. Furthermore, babies born in a health
facility were less likely to die compared to those born at home. Infant mortality was also significantly associated with HIV and malaria endemicity. Another study reported malaria as a risk factor for HIV coinfection [39]. Considering these findings, it has been suggested that community education for both infections could be conducted simultaneously. This could be done by merging existing outreach programs. Such an approach would not only be cost effective but would also be feasible to implement in a society with a shortage of labour [40].

Pregnant women were the next risk group discussed in the literature (Table 5). Studies have shown that maternal and infant mortality due to malaria in pregnancy (MiP) remains high in the country despite the provision of ITNs and intermittent preventive treatment in pregnancy (IPTp) [42]. A shortage of skilled midwives appears to be the second reason for such high rates. This increases reliance on unskilled traditional birth attendants (TBAs) rather than health facilities [41]. In addition, this dependency is based on the personal preferences of the women, their level of education, socio-economic and geographical inequalities, and the skills of the TBAs. Finally, changing climate patterns influence the spread of vector-borne diseases, including malaria [43]. The authors have time and again called upon the international organisations, including the WHO, to provide the necessary basic educational training to the TBAs and to develop standardised templates for the semi-inclusion of TBAs in the mainstream health care systems. This would help TBAs properly counsel and advise pregnant women [41], while expanding the coverage of modern medical interventions.

The final risk group consists of children with blood disorders including anaemia and inherited blood disorders (Table 6). It has been shown that malarial infection in school children can impair cognitive performance and lead to poor educational achievements, mostly due to absenteeism and consequent grade repetition [56–58]. Malnutrition and parasitic helminthic infections are other important factors that need to be addressed through school educational programmes. These comorbidities are vital to be addressed since there seems positive association between malarial burden and anaemia [44]. Furthermore, malaria is a risk factor for anaemia. Hence, educational interventions targeting school children must also consider involving combating anaemia and educating about inherited blood disorders like glucose-6-

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**Table 4. Studies evaluating interventions for HIV at-risk and positive population.**

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Aim</th>
<th>Study Design</th>
<th>Key Findings and Conclusions</th>
<th>Limitations of the Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wafula, Ikamari, and K’Oyugi [38]</td>
<td>Investigating probable factors behind the upsurge in infant mortality in Kenya during the 1988-2003 period.</td>
<td>Analysis of dataset from dataset drawn from the Kenya Demographic and Health Surveys of 1993, 1998 and 2003.</td>
<td>Malaria endemicity has significantly contributed to the observed rise in infant mortality in Kenya during the 1988-2003 period.</td>
<td>Retroactive analysis, only 3 years of survey data used. Correlation only demonstrated not causation.</td>
</tr>
<tr>
<td>Cuadros, Branscum, and Crowley [39]</td>
<td>To examine the association between malaria and HIV prevalence in East Sub-Saharan Africa.</td>
<td>Population survey of Kenya, Malawi, and Tanzania.</td>
<td>Efforts aimed at controlling and preventing malaria and HIV should be stepped up to avert an upsurge in infant mortality.</td>
<td>Not validated survey - risking observer bias and reporting bias from the respondents. Incomplete population assessment. Only assessed correlation, not causation.</td>
</tr>
<tr>
<td>Mwai et al. [40]</td>
<td>Assessing the role and outcomes of community health workers in HIV care in sub-Saharan Africa.</td>
<td>Systematic review</td>
<td>Community health worker-supported programmes may be more affordable than traditional health facility programmes and promote screening for opportunistic and other co-infections including malaria amongst those with HIV, reducing transmission rates, improving compliance with prevention strategies, and facilitating early treatment.</td>
<td>Not specifically focussed on malaria. Some included studies were of limited quality, such as insufficient attention to minimising bias, or controlling for confounding.</td>
</tr>
</tbody>
</table>
phosphate dehydrogenase (G6PD) deficiency which was reported to be associated with a lower malarial prevalence among young males [45].

**Legal and research-based educational interventions**

Governmental support is critical in achieving the public education needs. However, systematic underfunding and understaffing of the healthcare facilities has resulted in periodic shortages of drugs, diagnostic kits, and bed nets. Furthermore, underdeveloped districts faced difficulties with allocating budget in line with national guidelines leading to closure of some dispensaries in the absence of substitute nursing staff [35]. Another key challenge identified has been the hasty decentralisation of power to county administrations leading to weak communications and poor resource allocation and management [35]. For the management of malaria, the erstwhile single point of control Division of Malaria Control...
(DOMC) was split into a National Malaria Control Programme (NMCP) at the national level and Malaria Control Unit (MCU) at the county level. The key regulatory and legal issues limiting research and development in Kenya have been presented in Table 7 [46-51].

Case study discussion

Despite developing a national malaria strategy and monitoring and evaluation strategies, Kenya has not met incidence reduction targets set by the WHO. This underscores the need for more work not only in identifying strategies for malaria prevention, detection, and treatment, but also in identifying the barriers to implementing strategies and optimising the distribution of population health interventions. Based on the results of the literature review, we conducted a pilot 6-weeks long malaria prevention educational programme for 16 undergraduate healthcare students (11 female and 5 male students) from Kenya, Japan, the United Kingdom, and Cyprus. The programme consisted of a mix of asynchronous learning modules and live conference sessions. The students were randomly grouped into four teams and matched with a local Kenyan facilitator (faculty member) and were required to brainstorm implementable and sustainable solutions to the issues raised above. When grouping, care was taken that each group had at least one Kenyan student. Each team was asked to produce a final creative output submission that summarised the root cause identified, the corresponding solution idea, and a 5P model (Table 8).

Team 1 proposed a two-stage strategy to control malaria. First, ensuring that malaria doesn’t result in a service disruption (e.g. appropriate use of chemoprophylaxis) and minimising the effects of malaria on the community (e.g. loss of education for children and working days for adults). The second is the improvement of public health knowledge of the factors that might protect an individual against malaria. One such example was the misuse of nets, highlighting the importance of understanding factors affecting net compliance, alongside providing nets to communities. Inadequate human resources at the health facility level to promote health education on malaria prevention and control, discontinuation of or halts in awareness campaigns, and failure of policy implementers to adequately roll out implementation processes that support malaria reduction are some of the external factors that have contributed to undesirable outcomes. In addition, external funding that supports malaria control and the use of mass media to communicate to the community on the proper measures of malaria control and management were also emphasised.

The need to address maternal malaria mortality through clinical education and training was outlined by Team 2. The training program could be delivered through online hosting, asynchronous and synchronous workshop days, and using role-playing, peer coaching, and team-based learning to reinforce the Malaria-in-Pregnancy (MIP) protocol. To implement the program, they envisioned a multidisciplinary consortium of local influencers or leaders, medical professionals, public health experts, a budgeting team, teachers, and an evaluation team to assess the impact of the workshop afterward. Wi-Fi and computer access will also be a requirement. Worksheets to help participants learn, computers, and prevention posters are also needed. Financially, the curriculum would cost approximately £3,000 (456,000 Kenyan shillings) per centre. The team aimed to use student volunteers wherever possible to reduce staff costs. The program includes workshops that are designed to teach a targeted audience, specifically those who have already undergone medical training and possess professional knowledge. Because of the small size of the target population, the workshop itself will be easier to carry out.

Team 3 identified four fundamental problems with the situation of malaria in Kenya. The first is the limited evidence on malaria for pregnant women. Second, drug misuse where some pregnant women overdose or underdose antimalarials. The third is the modification of the drug which makes some pregnant women allergic to it. And finally, the increase in the rate of miscarriages due to malarial infection. The team’s solution was to work with local schools and non-governmental organisations (NGOs) to spread awareness of indoor-residual spraying (IRS) use through lectures, information, education, and communication (IEC) materials like booklets, T-shirts, water bottles, bracelets, and community meetings. Provision of a range of materials allows provision of factual healthcare information and supports malaria awareness on a wider scale, promoting increased accessibility and advertising of strategies while maintaining the educational strength of the intervention.

A 10-year plan was discussed by Team 4 with a mission to identify the target communities for malaria, starting with mothers and children. It includes strengthening the health system by educating health workers on the importance of medical records, having a strict infectious disease policy (e-learning and scheduled meetings), and providing transportation to all to the hospital within the
<table>
<thead>
<tr>
<th>Study</th>
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<th>Study Design</th>
<th>Key Findings and Conclusions</th>
<th>Limitations of the Study</th>
</tr>
</thead>
</table>
| Fauci [46]            | Considering the public health challenges of emerging and re-emerging infectious disease. | Narrative review.                | • Considerable progress has been made in malaria research over the past years.  
• Completed malaria genome sequencing can now be used in the design of effective drugs and vaccines as well as in other areas of malaria control.  
• A trial of a malaria vaccine showed 30% efficacy in preventing infection and nearly 60% efficacy in preventing severe disease.  
• Malaria accounts for 8.6% of the published epidemiology and public health research output in the WHO/AFRO region.  
• From 1991 to 2010, epidemiological and/or public health training and research capacity-building initiatives increased in the WHO/AFRO by 10.1% per annum.  
• Most externally funded research focuses on HIV/AIDS, TB, and malaria. External funding influences the research topics being addressed - priorities from external funders and those from African countries don't necessarily correlate closely.  
• Bed nets reduce community infant mortality by 26%. There is low coverage of intermittent preventive treatment of malaria in pregnant women.  
• Malaria prophylaxis provided a protective efficacy against clinical malaria of 25.7% even in the presence of high coverage of ITNs. | No quantitative data - limiting validity/reliability of findings.                              |
| Nachega et al. [47]   | To establish the current and prospects of epidemiology and public health training and research in the WHO African region. | Bibliometric analysis of published epidemiological research. | • Reversal in the decline of childhood mortality associated with an increase in clinical and severe malaria prevalence in the community and in health facilities despite high ITN coverage and good anti-malarial drug policy.  
• Lack of stocks of essential anti-malarial drugs (Artmether/lumefantrine), increased malaria transmission, and disruption of services during civil unrest may have contributed to this recorded mortality increase.  
• Bed nets reduce community infant mortality by 26%. There is low coverage of intermittent preventive treatment of malaria in pregnant women.  
• Malaria prophylaxis provided a protective efficacy against clinical malaria of 25.7% even in the presence of high coverage of ITNs. | Bibliometric analysis only - no population epidemiological data.  
No quantitative support for conclusions regarding funding sources/bias of research data. |
| Odhiambo et al. [48]  | Evaluating ITPs, burden of malaria parasitaemia and anaemia, treatment strategies and immunological correlates of malaria infection, and treatment and vaccine efficacy and effectiveness trials. | Narrative review.                | • Legal empowerment programmes can combat a wide range of human rights violations that undermine individual and public health, with potential to provide marginalised communities with legal and human rights knowledge and training, as well as with provision of legal representation, promoting accountability for human rights violations, to reduce stigma and discrimination.  
• Formal structures for referring clients to legal and non-legal services were found to be crucial to the ability of all three programmes to meet the demand for services.  
• Important priorities determined were adolescent health, cancer, child health, health promotion/disease prevention, malaria.  
• Lacing clinical nursing and midwifery research in these areas as well as nurses and midwives trained to conduct research. | Limiting linking of household and infant data to health facility data.  
Funded by political institutions - risk of reporting bias.  
Observational findings only. |
| Gruskin et al. [49]   | Evaluating law, health, and human rights programmes in Kenya, and how implementation of programmes can improve health outcomes, and how they can be integrating into health services. | Evaluation of three Open Society-funded legal integration programmes. | • Legal empowerment programmes can combat a wide range of human rights violations that undermine individual and public health, with potential to provide marginalised communities with legal and human rights knowledge and training, as well as with provision of legal representation, promoting accountability for human rights violations, to reduce stigma and discrimination.  
• Formal structures for referring clients to legal and non-legal services were found to be crucial to the ability of all three programmes to meet the demand for services.  
• Important priorities determined were adolescent health, cancer, child health, health promotion/disease prevention, malaria.  
• Lacing clinical nursing and midwifery research in these areas as well as nurses and midwives trained to conduct research. | No quantitative data.  
Difficulties recruiting control group, reducing group comparison.  
Difficulties understanding how human rights terms and concepts are understood by different people. Anecdotal data only. |
| Sun et al. [50]       | To establish priorities of clinical nursing and midwifery research in Kenya, Malawi, and South Africa. | Expert consensus survey.         | • Legal empowerment programmes can combat a wide range of human rights violations that undermine individual and public health, with potential to provide marginalised communities with legal and human rights knowledge and training, as well as with provision of legal representation, promoting accountability for human rights violations, to reduce stigma and discrimination.  
• Formal structures for referring clients to legal and non-legal services were found to be crucial to the ability of all three programmes to meet the demand for services.  
• Important priorities determined were adolescent health, cancer, child health, health promotion/disease prevention, malaria.  
• Lacing clinical nursing and midwifery research in these areas as well as nurses and midwives trained to conduct research. | Qualitative data only. |

(continued)
first year of implementation. The goal being to increase the number of births recorded in hospital records from 47% to 60% in five years. This could be achieved by implementing a financial incentive scheme that gives expectant mothers vouchers when they give birth in hospitals. Also, standardising the idea of giving birth in hospitals using media, posters, and conducting prenatal classes for mothers. Finally, through the widespread use of malaria vaccines and ensuring that at least 80% of the population is up to date with their immunisation, as well as by improving the health records of everyone within the community, to reduce the number of malaria cases by 20% in 10 years.

The participants were then sent a post-course completion survey about six months after the course completion (Figure 4). The survey results indicated an overall satisfactory and encouraging reflections from the participants. The participants were able to incorporate the

Table 7. Continued.

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Aim</th>
<th>Study Design</th>
<th>Key Findings and Conclusions</th>
<th>Limitations of the Study</th>
</tr>
</thead>
</table>
- Overdependence on countries abroad for medicines - imports accounting for 70-90% of drugs.  
- Poor supply chain systems. Patent issues and limited investment on research and development.  
- Lack of government investment in the pharmaceutical sector - high unpooled source of payment for medical services and products including out-of-pocket spending by the populace which accounts for as high as 70% of total health expenditure in the region.  
- Lack of effective pricing and price regulations, with high levels of circulation of fake and counterfeit medicines.  
- Unfavourable manufacturing conditions - drug production in Africa is typically done using small plants with low capacity and output.  
- Limited health workforce – lack of sustainable health financing mechanism, inadequate infrastructure of supply chains and technical know-how, thus limiting access to affordable medicines. | - No quantitative analysis.  
- Supplementary data were also gathered from country reports, newsletters, commentaries, policy briefs and other reports as well as direct google search - limiting reliability of findings. |

Table 8. The 5P model discussing four possible strategies for preventing malaria in Kenya.

<table>
<thead>
<tr>
<th>SP Layer</th>
<th>Strategy 1</th>
<th>Strategy 2</th>
<th>Strategy 3</th>
<th>Strategy 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Materials to educate health workers about the situation and medical knowledge of malaria.</td>
<td>Asynchronous and synchronous workshops (role plays, peer coaching and team-based learning) to reinforce malaria-in-pregnancy protocol.</td>
<td>IEC (information, education, and communication) materials, such as booklets, T-shirts, water bottles, and wristbands.</td>
<td>Promoting hospital birth via provision of free hospital packages including meals, postpartum care, diapers, and milk bottles, etc, and financial incentives.</td>
</tr>
<tr>
<td>Place</td>
<td>International and national organisations and consortiums</td>
<td>National level</td>
<td>Local community, schools</td>
<td>Local community, hospitals, clinics, schools</td>
</tr>
<tr>
<td>Price</td>
<td>Financial costs to provide educational material is expected to be around 8 USD per person.</td>
<td>Human resources and materials required to carry out the workshop are estimated to be around 8 USD per person.</td>
<td>Education material costs around 2.5 USD, other promotional resources cost around 1 to 5 USD.</td>
<td>The total estimated costs for hospital packages are just over 3 USD per person per year.</td>
</tr>
<tr>
<td>Promotion</td>
<td>Promoting alongside existing local initiatives.</td>
<td>Through clinical education and trainings using online platforms.</td>
<td>Through gatherings in collaboration with local NGOs.</td>
<td>TV, newspapers, radio, involvement of popular figures such as celebrities.</td>
</tr>
<tr>
<td>Pitfalls</td>
<td>Lower compliance in the absence of supervision checks and follow-ups; high developmental costs; difficult outreach.</td>
<td>Long term monitoring is needed; requires structural changes in educational system; interest of healthcare providers.</td>
<td>Need to instil confidence and compliance in people; logistical issues; financial issues.</td>
<td>Logistical issues; need to change local policies; financial issues.</td>
</tr>
</tbody>
</table>
knowledge gained in the case study with their curricular activities. As one pharmacology student remarked that she was able to better understand the disease’s social impact and health burden especially in the context of the anti-malarial drugs. Other participants agreed that they were able to kindle a different view of handling malaria cases by applying a preventive approach (bottom-up) as opposed to curative approach (top-down). All participants appreciated and recommended the multi-national approach of these training sessions which helped them to establish peer-to-peer connections and understand the approaches adopted by other countries. Furthermore, such approaches lead to quality outcome by enriching the strengths of each other and improved quality of patient care both amongst local and international students.

The adopted 5P model approach was also appreciated by the participants – ‘I now have a better idea of coming up with an intervention, evaluating and assessing its feasibility’. The course allowed the participants to gain insights to the requirements of implementing an effective public health program including the need for accurate and timely information systems for disease surveillance and programme implementation. Furthermore, the participants developed vital digital skills and analytical skills required for modern medicine. This pilot case study programme highlights the pervasive benefits mobilisation end education of the student healthcare community can have on promoting malaria understanding, knowledge and prevention strategies within local networks and communities worldwide.

Finally, we would like to highlight that our pilot case study with 16 students is surely not representative to provide a national or international outlook. Surely similar case studies with larger cohorts are needed in the future to understand the true impact of such programmes in

Figure 4. Results of the post-course completion survey (n = 16). (A) the results indicating general attitude of the participants. (B) The results indicating opinions about the course.
malaria prevention. Secondly, Kenyan participants in our case study had identified ‘infrastructure limitations, access to reliable internet, technological literacy, and resource availability’ as critical areas that require modernisation and attention. These factors also limit their participation in international forums and sessions. Whilst the first two require governmental and private sector investments, the latter two can be partially addressed by using such case study-based programmes. For example, Kenyan medical university libraries lack access to latest medical literature, online resources, and textbooks or have uncatalogued substandard resources [59]. Whilst international collaborations can help in providing such resources [60], they might not be tailored or suitable for the local situations, requiring the need for input from local scholars and researchers [61]. Hence, in our opinion, inclusion of local students in such case studies/workshops represent our efforts to help develop and curate quality online resources that are specific to Kenyan medical education system and practices. In future, we plan to regularly update these resources whilst making them more easily accessible to students, enabling them to access the latest medical information.

Conclusions

One of the key challenges of successful and sustainable implementation of strategies to tackle malaria in Kenya and broader Sub-Saharan African region is that of the need for education of both public and professionals. Addressing this requirement requires sustainable internal and external sources of funding of public health initiatives and educational initiatives to ensure ongoing sustainable practices and continued audit of initiative success, identification of challenges, and updating of initiatives and strategies with local epidemiological data and broader public health research. Collaborative health education approaches using digital tools can enable cross-border engagement of undergraduate and graduate students that can enable the prospective doctors to be future ready and connected with the larger global community.

Acknowledgments

The authors are thankful to the participants in the case study training that was conducted under the guidance of the TOMO Global Health Project, an online program with the aims of sustainably fostering global health leaders of low- and middle-income countries through asynchronous learning.

Ethical Approval

Not applicable. All data presented in the study has been collected from open-source platforms with proper citation and/or from media sources. Participation in the case study training was voluntary, unpaid, and consented by the participants.

Consent to publish

The participants in the case study provided consent for publication of their reviews as verbatim or in summarised form if it didn’t lead to individual identification.

Author Contributions

N.J. conceptualised the review while M.S. (Masako) conceptualised the case study. H.L. and N.J. were responsible for methodology, visualisation, data collection, and synthesis of results. M.S. (Mai) was responsible for validation and review. M.S. (Masako) and N.J. were responsible for funding. K.O. was responsible for project management and supervision. H.L., M.S. (Mai), and N.J. wrote the initial draft of the paper while all authors were responsible for revisions. All authors have read the final version and agreed to the manuscript for publication.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability Statement

The data for systematic review has been provided in the manuscript. All course material and additional guidance on conducting case study courses can be obtained upon reasonable request (for non-commercial and training purposes only) by contacting the corresponding authors.

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