Impact of COVID-19 on Malaria Elimination: Juxtaposing Indoor Residual Spraying and Mobile Phones in Buhera Rural District, Zimbabwe

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Abstract

Background

Globally, malaria remains one of the leading health problems decimating population in Africa with an estimated 228 million cases of malaria and 405 000 deaths occurred worldwide in 2018. In Zimbabwe, like other sub-Saharan countries, is fighting both elusive malaria and COVID-19 that continues to overwhelm the already overburdened healthcare system. Zimbabwean rural healthcare centres including Buhera district experience dire impact of malaria and COVID-19 pandemic. Therefore, the study presents the impact of COVID-19 on malaria control measures and reflects on indoor residual spraying (IRS) activities pre and post the outbreak of COVID-19 while introspecting milestones and challenges encountered when executing IRS activities; and opportunities to integrate mobile technologies into malaria elimination.

Methods

A retrospective study of malaria cases and IRS reports was carried out. Malaria cases per each health centre from 2015-2020 were collected from DHIS in Buhera rural district.

Results

The study shows that the overall IRS acceptance rate in 2015, 2016, 2017, 2018 and 2019 was 100%, 58.5%, 66.6%, 52.8% and 83.3%, respectively. The absolute rooms sprayed in 2017 are 2.55% above those sprayed in 2016 but are 8.46% below those sprayed in 2015. The coverage failed to reach impact levels in most of the wards due but not lack of resources, limited to inadequate community sensitization, and competing programmes which were running concurrently with IRS. Also, the study revealed that malaria confirmed cases increased tremendously in 2020 as compared to the previous years, particularly from 2015-2019 because of delayed IRS coverage, COVID-19 restrictions, heavy rains, differed and inconsistent social and behaviour change communication, lack of community engagement, delayed procurement of equipment and lack of funding among others.

Conclusions

The study revealed that moving from malaria prevention to elimination is possible in low malaria incidence areas in Buhera rural district. However, new challenges including cyclones and COVID-19, disrupts of movements of medical equipment, delayed IRS activities, social and behaviour change communication and IEC campaigns and mandatory national lockdowns. It is therefore imperative to integrate mobile phones into malaria control strategies during COVID-19 pandemic to strengthen awareness campaigns while maintaining COVID-19 regulations.

Background

An estimated 229 million cases of malaria and 409 000 deaths which occurred worldwide means that malaria remains one of the leading killer diseases particularly in Africa which experienced 215 million of the estimated malaria cases and 384 000 malaria deaths in 2019[1]. However, there has been substantial progress in malaria control globally owing to intensified efforts including malaria control and elimination strategies, policies, funding, and cross-border malaria initiatives which are in line with the sustainable development goal (SDG) 3 target 3.3. These malaria initiatives, policies and strategies accelerate and sustain malaria control and elimination at national, regional and global levels. Although the African region contributed more malaria cases, there has been significant progress because most countries in sub-Saharan Africa have adopted aggressive strategies to mitigate malaria pandemic.

In sub-Saharan Africa countries including Zimbabwe, malaria dominates public health problems ahead of other diseases such as tuberculosis (TB), human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS) [2]. Zimbabwe is one of the member states of Elimination 8, a malaria strategic policy which aims to eliminate malaria in

Southern African Development Community (SADC), through cross-border initiatives and coordinated and synchronized malaria control programmes[3]. In Zimbabwe, the number of reported malaria cases fluctuates between approximately 300,000 and 500,000 cases per year, with a notable sustained downward trend in recent years[4]. Such achievement has led to the reorientation of focus from malaria control to elimination[5] in Matabeleland North, Midlands and Mashonaland West Provinces and the Government promoted the implementation of malaria pre-elimination operations in some districts[3]. However, despite enthusiasm and reorientation of focus from malaria control to elimination in low transmission areas, there is limited evidence that malaria burden has decreased significantly. For instance, approximately 310,000 malaria cases were reported in 2019 countrywide, equivalent to an incidence rate of 22 cases per 1,000 population[6]. This represented a 19% increase in the number of cases reported in 2018 (approximately 260,000), and the number of malaria deaths also rose from 236 in 2018 to 266 in 2019[6].

Most epidemic-prone districts are located within Manicaland and Mashonaland East. Out of the sixty rural districts in Zimbabwe, fifty-one are high burdened and malarious with varying transmission intensity, and malaria outbreaks predominantly occurring in the eastern and northern border districts[7,8]. This happened despite the implementation of malaria prevention and activities such as vector control, intermittent preventative therapy in pregnancy (ITPp), case management, social and behaviour change communication (SBCC) among others intervention strategies. Vector control management includes the implementation and distribution of insecticide-treated bed nets (ITNs) or long-lasting treated nets (LLINs) and IRS and utilization of artemisinin-based combination therapy (ACT) in malarial areas experiencing continuous malaria transmission.

In Manicaland province, which is the focal point of the study, malaria is unstable and seasonal, closely influenced by environmental factors such as land surface temperature, rainfall and precipitation patterns[9,10]. Also, [11,12] reported that increased malaria transmission is attributed to limited funding, drug resistance insecticide resistance, inadequate epidemic preparedness and response, continuous dwindling of resources, and technical and operational challenges. Therefore, the study analyses IRS activities from 2015-2020 for malaria control while introspecting milestones and challenges encountered and opportunities to integrate mobile technologies into malaria control strategies in vulnerable rural communities so that it can complement indoor residual spraying.

The rise of digital technologies in Zimbabwe's healthcare system

The introduction of e-health strategy 2012 - 2017 was a paradigm shift towards the adoption of mobile health, telemedicine systems, electronic health record (EHR) in Zimbabwe's health system to expedite health data access, sharing, remote, monitoring of patient and synchronization of medical activities. The health system was once amongst the best in sub-Saharan Africa and later severely suffered in the period 2000 to 2009 due to several factors including hyperinflation, political instability[13], policy inconsistencies, lack of funding, lack of infrastructure, and the outbreak of preventable and treatable conditions such as Human Immunodeficiency Virus (HIV) infection and acquired immune deficiency syndrome, TB, acute respiratory infections, hypertension and malaria[14]. This calls for robust, effective and provision of health information systems, disease prevention, monitoring and control strategies and collaborative efforts with different stakeholders as part of a strategic response to malaria and other communicable diseases, which requires the use of mobile technology to complement existing techniques. Subsequently, Zimbabwe's health system adopted the monthly reporting system, Tally system, rapid disease notification system (RDNS) and Weekly Disease Surveillance System (WDSS) to disseminate health information. However, these systems were not completely fully functional in some areas[2]. For example, [15] highlighted that sending health data from district health facility to the national level using Tally system would take up to a month, thereby, affecting timely surveillance, monitoring and reporting. Besides the challenge of timeliness, there was no real-time integration of health data amongst the Tally system, RDNS and WDSS; and overburdened healthcare professionals with parallel-reporting hence making it difficult to integrate and consolidate reports. To counter the weaknesses and challenges of the previous health information dissemination systems, Zimbabwe through the Ministry of Health and Child Care installed national health information Systems (NHIS) in 2010 to capture, and manage surveillance and integration of health data at district, provincial and national level. The NHIS was successfully implemented through the district health information system, which was rolled out to sixty-three districts, eight provincial offices and four city health information offices in 2013. The transition from paper-based reporting system to national health information systems strengthen and integrate health information system activities in all provinces and districts. The introduction of national health information systems, district health information systems version 2 (DHIS2), malaria control and elimination strategies was enhanced by training of workforce and funding from local and international stakeholders which resulted in achieving significant progress in 2014. This was evidenced by the complete, faster, more accurate, more reliable and more efficient system for surveillance of malaria, tuberculosis, human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS)[12].

Information, education and communication (IEC), community sensitization and Disease Surveillance

Since the advent of national health information system in Zimbabwe, mobile phones have played a significant role in improving health service delivery through enhanced reporting and surveillance of malaria and other pandemics. For instance, the Ministry of Health and Child Care through Zimbabwe Health Information and Support Project (ZimHISP) introduced mobile-phone-based Weekly Disease Surveillance System (WDSS) in more than seventy-five per cent of health facilities countrywide. WDSS was developed using open-source software called Frontline SMS, to enhance health facilities to transmit data using short messaging services (SMS) text messaging to a central server that automatically transfers the data to DHIS2[16]. The WDSS is also used to relay health information such as malaria indoor residual spraying, human immunodeficiency virus infection viral load and other health information related to male circumcision. The WDSS specifically used by healthcare professionals for disease and event reporting. Also, Econet Wireless group developed EcoHealth app, which provides paid mobile phone health advisory service for each text message. EcoHealth was launched after the success of Ecocash, mobile money platform that sends and receive money. EcoHealth allows users to track important information related to health delivery at a cost by offering health tips and sending reminders to subscribers. This reflects that there is little use of the responsive technology for diseases monitoring, awareness, reporting and surveillance. Also, [17] highlighted that the future of Zimbabwe's health system relies on the adoption of emerging technologies to effectively monitoring, diagnosing, sharing of information, reporting, creating awareness and surveillance of pandemics including malaria, while maximizing the use of available resources.

The advent of COVID-19 which has drawn a lot of attention from health services providers has potential to spur malaria cases, hence continued sensitizing vulnerable communities through information, education and communication (IEC) programmes are critical pre-prevention activities in rural districts to increase acceptance and enhance uptake of malaria interventions. Pre-COVID-19, rural health centres in Buhera have been disseminating information through community gatherings, posters, brochures, billboards, and pamphlets among others, which is no longer feasible during the pandemic. It is therefore important to use innovative information dissemination methods such as mobile phones, radio, and television to reinforce social behaviour change, enhance community engagement and creating malaria and COVID-19 awareness. Mobile phone messages, radio and television awareness campaigns should incorporate information on malaria and COVID-19 symptoms, appropriate prevention measures, and emergence numbers of the nearest health centres.

Methods

Study area and population

Zimbabwe experiences seasonal variations of malaria transmission, Manicaland province being amongst highly malaria burdened provinces in Zimbabwe[18]. Manicaland province is made up of seven districts; Buhera, Chimanimani, Chipinge, Makoni, Mutare, Mutasa and Nyanga. Based on cumulative from 2005-2014, Buhera district was the leading pack in malaria incidences [19]. The country started using indoor residual household spraying, particularly using benzene hexachloride (BHC), dichloro-diphenyl-trichloro-ethane (DDT) in the 1940s[20], and later switched to pyrethroids and organophosphate[21], while, long-lasting insecticidal nets were first introduced in 2010[22]. Buhera is prone to public health problems including malaria, cholera, anthrax and rabies episodes. There are thirty-four (34) health centres in the district comprising of three hospitals and thirty-one clinics, with Birchenough Bridge hospital and Murambinda mission hospital being the referral centres. Buhera district has an estimated population of 245,878, with four constituencies and a total of thirty-three administrative wards (IRS being implemented in twelve wards)[23]. Buhera rural district adopted IRS and LLINs (although bed nets were last distributed in 2014), together with case management as vector control management interventions for reducing malaria transmission. In Buhera rural district, LLINs are regularly distributed through mass campaigns, prioritizing people living in high malaria prevalence wards in the district. Also, IRS coverage is done according to previous malaria prevalence in the wards.

Data source

The study analyzed malaria cases from 2015-2020 and indoor residual spraying (IRS) reports from 2015– 2019. Malaria cases per each health facility and IRS reports were obtained from Buhera district health office, which is under the arm of the Ministry of Health and Child Care under the ethical clearance number MRCZ/A/205.

Ethical approval

Intermittent residual spraying reports were obtained under the ethical clearance number MRCZ/A/205, which was obtained from the Medical Research Council of Zimbabwe (MRCZ) operating under the MoHCC.

Results

The IRS activities for the year 2020 was delayed, not yet done at the time of writing due to COVID-19 pandemic, hence the unavailability of 2020 IRS report.

IRS implementation schedule

In Buhera, IRS is implemented in twelve wards with high malaria perennial and high malaria sporadic as shown in Figure 1 camp wards. The reports show that the IRS is implemented in the form of teams and camps that are divided according to malaria prevalence in the wards. The number of teams and camps varies with respect to the implementation strategy. In some cases, the camps and teams were grouped into three camps of three teams each. The designated camps were Birchenough, Muzokomba and Mudawose as shown in Figure 1. Each camp was to cover four wards based at the same campsite. Three teams usually camp at Muzokomba covering wards 24, 25, 26, and 27. Another set of three teams usually camp at Betera covering wards 18, 20 and part of ward 23 then move to Masasa to cover ward 22 and part of ward 23, and four teams camp at Birchenough Bridge (BB) covering wards 28, 29, 30 and 33. The movement of IRS teams in their respective wards is shown in Figure 1. Malaria season is usually from November to April in Zimbabwe but in most cases, IRS is done during malaria peak time, that is, between January and April[21].

Five-year intermittent residual spraying (IRS) comparative ward coverage from 2015 to 2019

Table 1 shows IRS coverage from 2015 to 2019, with the total number of targeted rooms and sprayed rooms and their respective wards. IRS acceptance rate is the rate at which indoor residual spraying activities are accepted in the targeted rooms of the targeted area, while callbacks refer to the return of IRS activities for the second or more times, to improve coverage in the affected areas[24]. The IRS acceptance rate per ward and or per year was calculated by dividing the total number of targeted rooms by the total number of sprayed rooms and multiplies the result by 100 to get the percentage. Therefore, the overall IRS acceptance rate in 2015, 2016, 2017, 2018 and 2019 was 100%, 58.5%, 66.6%, 52.8% and 83.3%, respectively. The acceptance rate of sprayed rooms in ward 18 for the year 2015, 2016, 2017, 2018 and 2019 was 100%, 66.9%, 62.9%,0% and 92.3% respectively, while, ward 20 has acceptance rate of 100% in 2015, 66.9% in 2016, 75.1% in 2017 and 14.4% in 2019. Ward 22 has acceptance rate of 100% in 2015, 69.3% in 2016, 66.5% in 2017, 72.2% in 2018 and 88% in 2019. In 2017, there was not much difference between the targeted rooms and the rooms sprayed, with notable difference only in ward 33 which was influenced by accelerated growth. Acceptance was generally low across all the wards, except for ward 26 which had an acceptance of 84.27%. The lowest acceptance rate was in ward 23 which registered 56.72%. The absolute rooms sprayed in 2017 are 2.55% above those sprayed in 2016 but are 8.46% below those sprayed in 2015. Acceptance rate dropped in the two concurrent years, dropping from 71.72% in 2015 to 69.21% and 67.53% in 2016 and 2017 respectively. Callbacks were instituted in the wards with low coverage, wards 18, 20, 23, and ward 30, however, insignificant rooms were sprayed during callbacks as the community continued to resist despite prior engagement with the community leaders. In 2018, acceptance was generally low across all the wards, except for ward 26 which had an acceptance of 84.27%. The lowest acceptance rate was in ward 23 which registered 56.72%. In 2019, the overall sprayed rooms coverage was 83.3% against target and population protected was 95.5%. The coverage failed to reach impact levels in most of the wards due, but not limited, to inadequate community sensitization, as well as a competing programme which was running concurrently with IRS. Ward 33 and 30 are problematic wards since the community is preoccupied with their irrigation activities, hence refusal rate and the locked rate was very high.

Sprayed rooms

Figure 2 shows the distribution of sprayed rooms from 2015-2019. Ward 22 had the highest IRS coverage in terms of rooms sprayed from 2015-2019. This high distribution might be attributed to sensitization awareness, promotion and marketing of the programme, while ward 30 recorded slightly low sprayed rooms in 2015,2016, 2017,2018 and 2019. Ward 30 and 33 are problematic areas with very high refusal affected by competing farming and marketing activities. Ward 26 had a sudden decline in acceptance, compared to the previous years when the ward was one of the best performing wards with coverage above impact levels.

Comparative analysis of wards IRS coverage and achievements at wards level

The overall acceptance rate stood at 67.42% and the overall coverage achieved was 66.58% as shown in Table 2. There was not much difference between the targeted rooms and the rooms sprayed, with notable difference only in ward 33 which was influenced by accelerated growth. Acceptance was generally low across all the wards, except for ward 26 which had an acceptance of 84.27%. The lowest acceptance rate was in ward 23 which registered 56.72%. The absolute rooms sprayed in 2017 are 2.55% above those sprayed in 2016 but are 8.46% below those sprayed in 2015. Acceptance rate dropped in the 2 concurrent years, dropping from 71.72% in 2015 to 69.21% and 67.53% in 2016 and 2017 respectively. Callbacks were instituted in the wards with low coverage, wards 18, 20, 23, and ward 30, however, insignificant rooms were sprayed during callbacks as the community continued to resist despite prior engagement with the community leaders.

In 2018, the acceptance was generally low across all the wards, with the highest coverage achieved in ward 26 with 75% as shown in Table 3. The lowest coverage was achieved in ward 30 which had 51%. Wards 18 and 28 were not sprayed as fuel shortage affected operations at Birchenough and Mudawose campsites. Ward 20 had only 21% of the rooms reached with only 14% being sprayed. The overall coverage for the targeted wards stood at 53% but the coverage for the sprayed wards excluding those not sprayed was 66%. Acceptance was greatly affected by poor warning and poor deployment, due to shortage of fuel. It was also affected by poor promotion and marketing of the programme and the new chemical.

In 2019, the overall sprayed rooms coverage was 83.3% against target and population protected was 95.5%. The coverage failed to reach impact levels in most of the wards because of limited inadequate community sensitization, as well as the competing programme which was running concurrently with IRS. Ward 33 and 30 are problematic wards since the community is preoccupied with their irrigation activities, hence refusal rate and the locked rate was very high.

There was a steady decline in coverage from 2016 to 2018, which can be attributed to several challenges including poor marketing of the programme, high refusal, and poor resource inflow especially operational resources among others. In the 2019 season, the coverage improved in some wards culminating to a better coverage than three preceding seasons though not enough to reach impact levels. Vigorous marketing and awareness of the programme at village/ward level are required to improve the uptake of the programme; however, poor resource inflows affect the implementation of the programme.

Distribution of malaria cases from 2015-2020

Malaria data from satellite health facilities are entered into district health information system 2(DHIS) on weekly basis. Satellite health centres report aggregated monthly malaria confirmed cases (tested positive) and suspected cases (tested by rapid diagnostic test or blood slide) using T5 forms[25]. Once data is entered, it then becomes accessible nationally through NHIS. Satellite health facilities report malaria cases using WhatsApp, SMS, phone call and frontline app. Once the malaria data is entered, it becomes accessible electronically at the district level, provincial level up to national level. This follows the malaria outbreak detection and response surveillance system reporting structure shown in Figure 3.

Following malaria outbreak detection and response surveillance system reporting structure shown in Figure 3, malaria cases collected from DHIS from 33 rural health facilities in Buhera rural district from 2015-2020 are shown in Table 6.

Low malaria confirmed deaths and cases were recorded in 2018 which shows a clear reduction in malaria burden, as shown in Table 6, which brought hope and prospects to policymakers, funders, healthcare professionals and the community to move towards malaria elimination[3]. However, there was a sharp increase of confirmed malaria cases in 2019 because of new challenges including changes in vector behaviour [26], high refusal of IRS activities, resistance to insecticides and anti-malarial medicines[27], invasion of new areas by vectors, vectors in various combination of sympatry, changes in vector proportions, outdoor malaria transmission, climate change[9], abuse of LLINs, lack of meticulousness of spray operators and lack of digital tools to sensitize affected communities about malaria as well as IRS activities[8]. Also, the outbreak of COVID-19 pandemic stalls the progress and gains achieved in the previous years as depicted in Table 6, although 2020 results alone may not be sufficient to warrant a trend. The confirmed malaria cases increased from 1376 cases in 2019 to 2981 cases in 2020. This is attributed by several factors including imposed COVID-19 stringent restrictions, delayed IRS activities, postponement of recruitment and training of IRS teams and disruption of movements of medical equipment [28,29].

Malaria hotspots and distribution in Buhera rural district

After collecting confirmed malaria cases from 2015-2020, we mapped malaria hotspots using QGIS 3.10.5 software. Cumulative confirmed malaria cases per each health facility were mapped into their respective wards in Buhera district. Health facilities were grouped into several categories such as malaria-free, low malaria sporadic, high malaria sporadic and high malaria perennial as shown in Figure 4. These categories are based on malaria prevalence rate on each health facility. Figure 4`shows that high malaria perennial wards are ward 28 (Chapanduka) and ward 33 (Birchenough Bridge). Ward 30, 29, 25,21,23,20 and 23 were identified as high malaria sporadic wards and low malaria perennial wards, respectively. This means that indoor residual spraying activities and resources should be intensively done in high malaria perennial wards and high malaria sporadic wards. However, there are some low malaria sporadic wards with low transmission and reported cases as well as malaria-free wards which are close to malaria elimination as shown in Figure 4.

Social and behaviour change communication (SBCC) in changing malaria landscape in Buhera rural district

SBCC is one of the malaria control strategies in Zimbabwe aimed at increasing utilization of correct malaria prevention and control measures. After programme inception, data indicated high refusal rates and locked rooms especially in wards 28,23,24,18 and 33 as shown in Table 2. The correlation between high refusals and locked rooms suggested that the locked rooms could have been just smart refusals linked to fear of the impact of chemical spraying, ignorance, uncertainty, perceived side effects of the insecticide[30], odour, and conspiracy theory about the chemical affecting fertility and people exposing their poor quality household possessions. After SBCC campaigns communities anticipated chemical change, though it was based on resistance management.

The new strategy to involve and engage the local leadership, chiefs, headman, village heads and the community might reduce resistance. The phenomenon primarily focused on problem identification, analysis and possible solutions in a participatory manner to enhance community engagement in order to reduce high IRS refusals. This was employed in all areas targeted for callbacks and all areas to be covered by the IRS. Principally communities agreed to work together and to provide guides in most instances. SBCC activities in rural health centres are carried out by nurses and environmental health technicians through scheduled and ad-hoc health education sessions to patients and vulnerable populace[31]. In some instances, malaria posters and pamphlets written in local languages are used to relay malaria messages in hard-to-reach areas. In urban areas, walls at local shops and branded public transport vehicles also facilitate SBCC[31]. However, the effectiveness of these SBCC malaria interventions is not yet known or document especially in high malaria risk zones. Therefore, introducing mobile technology to complement existing strategies is seen as a positive move to enhance malaria control.

Challenges of malaria elimination strategies in Buhera district

Despite the remarkable progress in combating malaria in Buhera district, the district is faced by multiple challenges. These include the shortage of resources, low or non-response to field challenges including high refusal of IRS, competing programme and activities such as farming and food distributions demanding same resources (i.e human and time) also affected acceptance, inconsistent SBCC messaging threatening the success of the programme and poor programme promotion, awareness and marketing strategies among others. Buhera district's malaria elimination progress is also threatened by other challenges affecting the NMCP as explained by [21]These challenges include changes in vector behaviour, resistance to insecticides and anti-malarial medicines, invasion of new areas by vectors, vectors in various combination of sympatry, changes in vector proportions, outdoor malaria transmission, climate change, lack of meticulousness of spray operators, lack and inconsistency of funding, lack of political-will[12], low utilization and distribution of treated nets in the district, outdoor transmission, lack of community engagement, lack of information and commitment, lack of mapping malaria models in low-transmission settings[32]. These challenges are likely to slow down malaria elimination in Buhera district.

Opportunities for integrating mobile phones in malaria prevention and elimination in Buhera rural district

Since the country is prepared to introduce Integrated Vector Management (IVM) as part of the vector management and elimination, there is a need to adopt and utilize mobile phones to strengthen BSCC and malaria information, education, and communication irrespective of locality. Also, [8] stated that there was a notable decline in exposure to malaria messages despite relatively high ownership of radios, televisions and mobile phones among the households sampled in the malaria indicator survey conducted in 2016. This affects the knowledge of people living in high malaria incidences as it correlates to lack of information such as signs and symptoms of malaria as well as perceived dangers of malaria. In addition, COVID-19 presents a challenge to disseminate information while maintaining physical distancing especially in rural communities where inequality in access to information and the digital divide is common. Hence, the need for best alternative solutions to information, education, and communication such as low cost-effective mobile technologies including mobile phones to disseminate malaria information. Studies by[33–36] indicated that integration of mobile phones in malaria prevention and elimination strengthens information, education and communication as well as improve case detection and management of malaria. The high mobile phone penetration of over 90 per cent makes mobile phones a readily available means of communication even in Zimbabwe`s resource-constrained areas[37]. Malaria vector prevention could focus on disseminating malaria information and knowledge of the symptoms and danger signs of malaria as well as the importance of indoor residual spraying[8] because of their pervasiveness and ubiquity. For instance, [38]suggested that mobile phones connected to the existing technologies such as cloud computing, geographical information systems, could be utilized to map malaria hotspots, migration patterns of infected people, malaria detection and reporting. Also, [39]identified vertebrate blood meals in the malaria vector (*Anopheles arabiensis*) using mid-infrared spectroscopy, while[40] applied GIS and machine learning classifiers to understand spatial variations of malaria that are linked to remotely sensed data in Vietnam.

Also, [41] also applied the convolutional neural network (CNN) image analysis for malaria diagnosis, and detect malaria from microscopic images. However, the integration of these existing technologies and mobile phones to tackle malaria may be independent; and could be utilized for various purposes such as predicting malaria incidences[9], malaria diagnosis[41], detecting malaria, identification of malaria-infected cells, malaria screening, predicting insecticide resistance[42], predicting of mosquito species, mapping malaria hotspots and associated climatic factors[10], malaria cell image classification[43] among others. This shows that there are so many unprecedented opportunities to embrace emerging technologies in malaria prevention and control strategies in Zimbabwe.

How COVID-19 slows down malaria control and prevention measures in Zimbabwe?

COVID-19 pandemic continues disrupting international, regional, national, provincial and districts malaria control programmes complicating malaria surveillance and monitoring activities as well as slowing down planning and resource mobilization processes, especially in low-income tropical malaria-endemic countries [44]. Considering that the malaria burden is highest in low-income tropical countries with little capacity to fund malaria control and eradication programs, the fight against malaria in these regions is likely to be hampered[45]. Access to healthcare has generally been limited, while malaria interventions, such as seasonal malaria chemotherapy and distribution of insecticide-treated bed nets, have been suspended due to lockdowns[46]. Likewise, the repurposing of anti-malarials for treatment of COVID-19 shared symptoms and the shift in focus from the production of malaria rapid diagnostic tests (RDTs) to COVID-19 RDTs is a cause for concern in malaria-endemic regions[47]. The use of chloroquine and its derivatives in COVID-19 treatment is likely to facilitate the rebound of chloroquine-resistant malaria parasites. This will hinder the possible use of chloroquine and its derivatives in the fight against malaria in the future and thus further dampen the prospects of malaria elimination from Africa.

Recently, WHO emphasized that malaria control programmes in malaria-endemic countries should be done while protecting the vulnerable communities and healthcare professionals against COVID-19 pandemic[48]. Despite WHO' recommendations, sub-Saharan African countries including Ghana, Côte d'Ivoire and Comoros deferred the insecticide-treated bed nets and indoor residual spraying campaigns amid COVID-19 pandemic[49]. However, the current COVID-19 pandemic continues disrupting malaria prevention and control programme, movements of medical equipment and recursive national lockdowns with stringent access to health care could lead to additional loss of life[50]. Also, WHO warned that up to 769 000 people could die of malaria this year in sub-Saharan Africa, more than double the number of deaths in 2018, if the focus on COVID-19 leads to a disruption of interventions for malaria[51]. Also, [49,52] state that the association between malaria and COVID-19 pandemic is devastating in malaria-endemic countries with myriad health problems such as fragile healthcare system, scant healthcare professionals, poor healthcare facilities and infrastructure and limited financial resources. This threatens progress made towards malaria elimination in malaria-endemic countries in the past years[53,54]. Such progress was largely successfully because of the effective implementation of malaria control and prevention measures, including the distribution of long-lasting insecticide-treated bed nets, indoor residual spraying, and antimalarial treatments. In the context of the ongoing pandemic, implementing and sustaining these malaria control and prevention measures require innovative measures to save both vulnerable communities and healthcare professionals especially in vulnerable rural resource-constrained areas.

Zimbabwe with no exception especially the vulnerable rural communities, mosquito vector control largely depends on indoor residual spraying and also the mass distribution of long-lasting insecticide-treated nets[20]. Indoor residual spraying is the most dominant vector control intervention that has been implemented by the Ministry of Health and Child Care to reduce malaria in malaria-endemic districts. However, indoor residual spraying poses the highest risk of exposure to COVID-19 because IRS teams frequently and physically engage with the community when recruiting participants, training, meeting authorities, executing household visits, and in some instances conduct contaminated objects and surfaces[44]. Also, the imposed by COVID-19 measures restrict movements of people both rural and urban areas making it difficult to recruit IRS operators, training, conduct meetings and gather the community. COVID-19 restrictions also cause delays in the procurement of resources and planning for seasonal IRS. Typical delays caused by COVID-19 include increased time taken to deliver personal protective equipment and IRS chemicals, and other consumables[55], postponement of recruitment and training of IRS teams due to disruption in the movements of medical equipment, closed borders and recursive national lockdowns. Owing to COVID-19 restrictions especially movements of people[56], the recruitment and training of IRS teams require a new different approach and innovative means. Coupled with a lack of adequate personal protective equipment and the scarcity of knowledge on the possible interaction between malaria and COVID-19 both in terms of presentations and shared symptoms, this has left many frontline health workers with fears and anxieties[28]. It is therefore imperative for both health workers including IRS teams and community to receive training and information pertaining to COVID-19 and IRS activities that impose risks and how to mitigate them effectively. This increases the cost of additional resources and training required to fight both the pandemic and elusive malaria, without redirecting resources.

Notably, IRS coverage is done based on classifying areas into different malaria risk zones in a stratified manner, prioritizing malaria hotspots areas followed by lower-risk areas. This should be done timeously usually from early November to April to spray mosquito breeding sites. However, due to the postponement of the recruitment and training process, IRS activities were delayed leading to malaria outbreak. For instance, as of April 2020, few months after the pronouncement of COVID-19 national lockdown, Zimbabwe recorded a cumulative 135,585 malaria cases and 131 deaths, mostly from malarious provinces such as Manicaland, Masvingo and Mashonaland East[57]. This calls for the need for robust and resilient innovative measures to expedite IRS activities and equip communities with knowledge of malaria and COVID-19 prevention measures.

Potential integration of IRS and mobile phones in malaria control to enhance IEC in Buhera rural district

Moving from malaria prevention to complete elimination is a daunting task that requires collaborative efforts from regulators, institutions, funders, researchers, community among others to integrate and coordinate malaria prevention and control strategies. To achieve complete malaria elimination, the inclusion of emerging technologies and computational models in the future national malaria communication strategy is inevitable. This means re-establishment of sound e-health strategy in collaboration with the Ministry of ICT, Postal and Courier Services. The following suggestions can be incorporated in the future malaria information, education and communication programmes:

- Integration of mobile phones to create malaria awareness, community engagement, communicate IRS chemical changes and LLINs to avoid high refusal when executing IRS activities
- Re-establishment of e-health strategy which might lead to e-health policy in Zimbabwe.
- Mobile phones enhance real-time reporting, monitoring and surveillance of malaria cases because of their pervasiveness and ubiquity.
- Resource mobilization through funding and research collaborations with local and international institutions
- Development of multi-sectoral (Ministry of ICT, Postal and Courier Services, Ministry of Health and Child Care and other stakeholders) framework and guidelines for the adoption and use of ICTs in the health sector to facilitate the adoption of e-health for easy monitoring, diagnosis and surveillance of malaria and other preventable and treatable pandemics.
- Creating malaria awareness and promote IRS and LLINs, strengthening information, education, and communication on malaria through low-cost and feasible information dissemination platforms.
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Recommendations for malaria control at ward level are as follows

- IRS is field-based and in the event of challenges should seek field solutions
- Conduct client satisfaction survey and feedback meetings to note areas of improvement and identify areas which were missed during the IRS and or LLINs programme
- Community dialogue especially pre and post IRS meetings in areas with high refusal rates to come up with a plan to address issues surrounding refusals

- Baseline data verification is needed.

Conclusion

Moving from malaria prevention to elimination is possible in low malaria incidence areas in Zimbabwe. However, in some areas, the goal of malaria elimination remains bleak because of challenges including continuous dwindling resources for vector control, changes in vector behaviour, the emergence of resistance to medicines and insecticides, climate change, environmental degradation, diversity in ecology, breeding habitats, and community habits, changes in vector behaviour, resistance to insecticides and anti-malarial medicines, invasion of new areas by vectors, vectors in various combination of sympatry, changes in vector proportions, outdoor malaria transmission, climate change, lack of meticulousness of spray operators, lack and inconsistency of funding, political conflicts, low utilization and distribution of treated nets in the district, outdoor transmission, lack of community engagement, lack of information and commitment, lack of mapping malaria models in low-transmission settings.

After synthesis of the IRS reports from 2015 to 2019, it emerged that, it is imperative to integrate mobile phones and IRS as part of the malaria control strategies. Disseminating malaria information through mobile phones could strengthen social and behaviour change communication and also IEC campaigns by facilitating delivering vector control messages especially in resource-constrained areas.

The acquisition of mobile phones in most of Zimbabwe's rural areas is increasing, making mobile phones the most feasible communication gadget for people in resource-constrained areas[17]. Also, many of Zimbabwe population (over 67%) lives in rural areas[58] and heavily depends on mobile phones for communication and making payments using mobile money platforms such as EcoCash, One-Money, MyCash and Tele-Cash because of cash shortages[59]. Owing to this proliferation, mobile phones especially short messaging service (SMS) could be utilized to promote and market IRS programme and campaigns in malaria hotspots area and high-risk population in Buhera rural district. Applying mobile phones in malaria prevention and control strategies can enhance case detection, monitoring, surveillance as well as strengthening information, education, and communication activities and campaigns while maintaining COVID-19 regulations[60]. However, with technology, it is common that functionalities of gadgets are underutilized (people know how to receive and make calls only)-implying owners require more education on how to maximize utilization of their gadgets.

Abbreviations

%: Per cent

ICT: Information and Communication Technologies

IEC: Information, Education and Communication

IRS: Indoor residual spraying

IoT: Internet of Things

IVM: Integrated Vector Management

ITN: Insecticide-treated mosquito net

LLIN: Long-lasting insecticidal net

MoHCC: Ministry of Health and Child Care

MRCZ: Medical Research Council of Zimbabwe

NMCP: National Malaria Control Programme

SBCC: Social and Behaviour Change Communication

WHO: World Health Organization

Declarations

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Availability of data and materials

Data used in this study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study received ethical clearance from the Medical Research Council of Zimbabwe (MRCZ) and Buhera district health office under the ethical clearance number MRCZ/A/205.

Consent for publication

The authors take full responsibility for publication.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

EM, RM, MNS and ST conceived the research. EM and ST participated in the ethical clearance process and fieldwork. EM, RM, MNS and ST contributed to draft the manuscript, editing reviewing and revision of manuscript. All authors read and approved the final manuscript.

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Tables

Table 1: Intermittent residual spraying coverage from 2015-2019

	Targeted rooms					Sprayed rooms				
	Year 2015	**Year 2016**	**Year 2017**	**Year 2018**	**Year 2019**	**Year 2015**	**Year 2016**	**Year 2017**	**Year 2018**	**Year 2019**
Ward 18	4239	5531	5007	4230	4230	4239	3689	3151	0	3905
Ward 20	5487	6196	5850	5706	5706	5487	4146	4395	822	4771
Ward 22	7025	7801	8197	7901	7901	7025	5407	5456	5702	6953
Ward 23	4854	7425	6850	7411	7411	4854	3871	4121	5295	6847
Ward 24	5376	6635	6851	7101	7101	5376	5232	4469	5122	6121
Ward 25	6430	6969	6004	7493	7493	6430	4464	4380	4445	6253
Ward 26	3687	4374	7620	6505	6505	3687	2366	5386	4878	4821
Ward 27	4633	5563	5563	4733	4733	4633	2927	2906	2884	3973
Ward 28	5965	5808	5965	6244	6244	5965	2758	3587	0	6422
Ward 29	4733	7321	7321	6326	6326	4733	2966	4358	4387	4199
Ward 30	2921	3727	3727	3641	3641	2921	1778	2557	1858	2729
Ward 33	5286	6187	6136	8312	8312	5286	3428	5233	4557	5993
Total	60636	73537	75091	75603	75603	60636	43032	49999	39950	62987

Table 2 2017 Wards IRS coverage and achievements

WARD	TARGET ROOMS	TARGET POP	H/H seen	ROOMS SPRAYED	ROOMS REFUSED	ROOMS LOCKED	ROOMS SEEN	ACCEPTANCE	COVERAGE	POP PROTECTED	% Pop Protected
18 Nyashanu	5007	7489	1082	3151	382	655	4188	75.24	62.93	5179	69.15
20 Betera	5850	7972	1590	4395	455	744	5594	78.57	75.13	7280	91.32
22 Masasa	8197	11550	2240	5456	855	1296	7746	70.44	66.56	9628	83.36
23 Chirozva	6850	9441	2246	4121	1923	1222	7266	56.72	60.16	7864	83.30
24 Muzokomba	6851	8828	1992	4469	1463	1030	6962	64.19	65.23	7550	85.52
25 Zangama	6004	9093	2172	4380	1857	1109	7346	59.62	72.95	8140	89.52
26 Mutepfe	7620	6675	1928	5386	298	707	6377	84.46	70.68	8717	130.59
27 Mutiusinazit	5563	6774	1271	2906	783	951	4640	62.63	52.24	4970	73.37
28 Chapanduka	5965	9213	1760	3587	1153	1382	6122	58.59	60.13	7083	76.88
29 Chabata	7321	7887	1788	4358	782	1062	6202	70.27	59.53	7496	95.04
30 Gunura	3727	4114	1005	2557	330	683	3570	71.62	68.61	3456	84.01
33 B/B	6136	8106	2176	5233	1496	1420	8149	64.22	85.28	8091	99.81
TOTAL	75091	97142	21250	49999	11777	12261	74162	67.42	66.58	85454	87.97

Table 3 2018 Wards IRS coverage and achievements

Ward	Targeted/h	targeted rooms	targeted pop	Number of h/h seen	Rooms					% of rooms sprayed	Population	
					Sprayed	Refused	locked	total rooms seen	% s sprayed		protected	% pop protected
18	1082	4230	7489	0	0	0	0	0	0	0	0	0
20	1590	5706	7972	332	822	230	146	1198	63	14	1222	15
22	2240	7901	11550	2549	5702	1963	924	8589	484	72	9980	86
23	2246	7411	9441	2434	5295	980	554	6829	347	71	9243	98
24	1992	7101	8828	2211	5122	1572	961	7655	531	72	8033	91
25	2172	7493	9093	2338	4445	2204	1152	7801	738	59	7988	88
26	1928	6505	6675	2118	4878	1312	806	6996	908	75	7464	112
27	1271	4733	6774	1416	2884	1461	617	4962	569	61	4839	71
28	1760	6244	9213	0	0	0	0	0	0	0	0	0
29	1788	6326	7887	2258	4387	1834	1789	8010	961	69	6761	86
30	1005	3641	4114	973	1858	656	1083	3597	350	51	2737	67
33	2176	8312	8106	2329	4557	2416	1646	8619	705	55	6868	85
Totals	21250	75603	97142	18958	39950	14628	9678	64256	5656	53	65135	67

Table 4 2019 Wards IRS coverage and achievements

Ward Number	Targeted Rooms	Sprayed Rooms	% Rooms Sprayed	Targeted Population	Population Protected	% Population Protected
18	4230	3905	92.32	7489	6200	82.79
20	5706	4771	83.61	7972	7491	93.97
22	7901	6953	88.00	11550	11466	99.27
23	7411	6847	92.39	10730	10730	100.00
24	7101	6121	86.20	9142	9142	100.00
25	7493	6253	83.45	9980	9980	100.00
26	6505	4821	74.11	7345	7345	100.00
27	4733	3973	83.94	6774	6399	94.46
28	6244	6422	102.85	9709	9709	100.00
29	6326	4199	66.38	7887	5854	74.22
30	3641	2729	74.95	4114	4129	100.36
33	8312	5993	72.10	9023	9023	100.00

Table 5 Overall IRS performance coverage comparative analysis: 2015 to 2019

Year	Targeted Rooms	% Sprayed Rooms	Targeted population	Population Protected	% Population Protected
2015	60608	90.1	94252	94252	100
2016	73537	66.3	97214	82632	85
2017	75091	66.5	97140	85454	87.97
2018	75603	53	97142	65135	67
2019	75603	83.31	101715	97468	95.82

Table 6 Pre and Post-COVID-19 outbreak confirmed malaria cases

Period	Year	Malaria confirmed cases(tested positive)	Malaria deaths
Pre-COVID-19 outbreak	2015	974	18
	2016	1015	8
	2017	2286	12
	2018	701	1
	2019	1376	13
Post-COVID-19 outbreak	2020	2981	18
Grand Total		9333	70

Figures

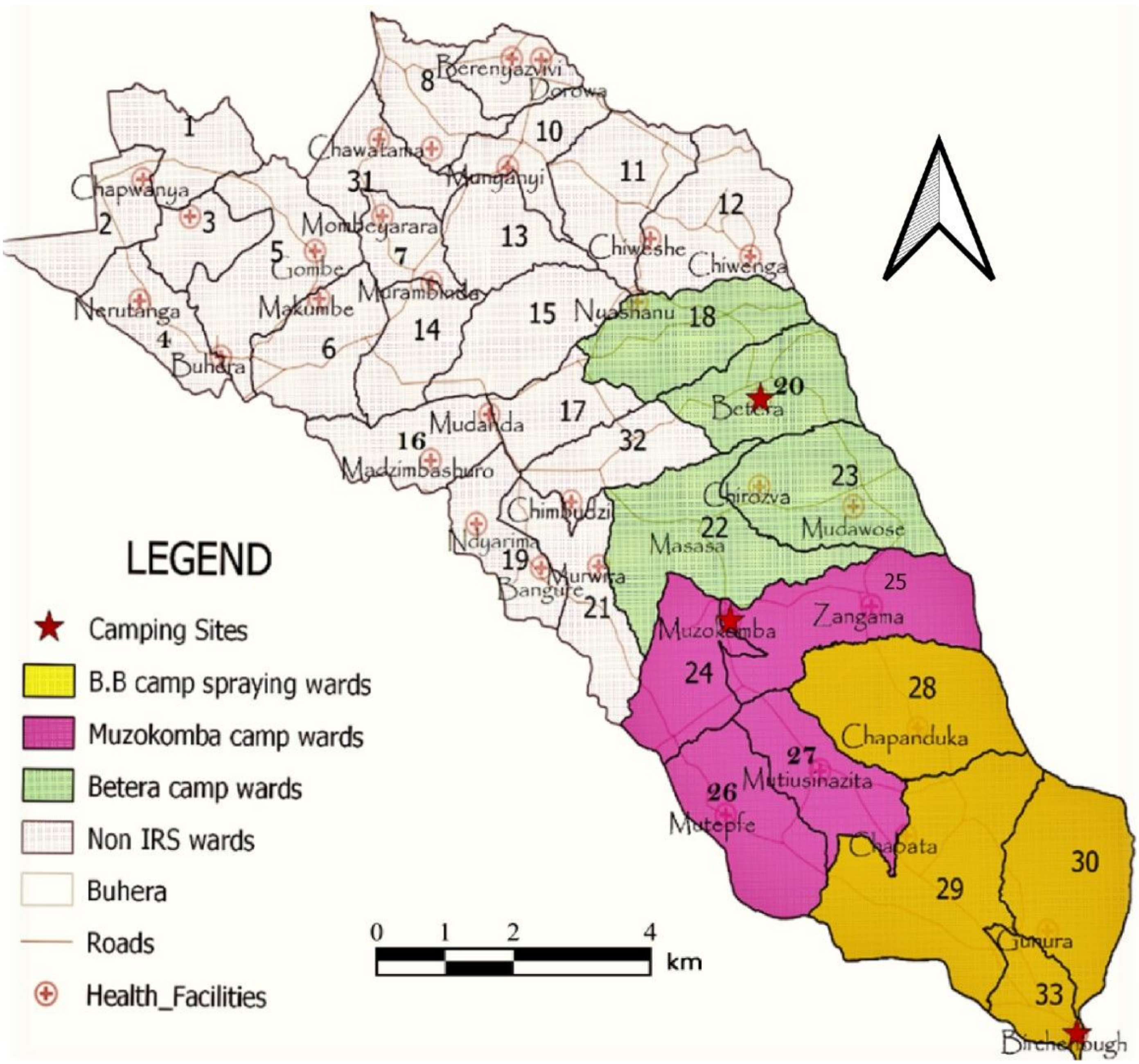

Figure 1

Buhera map showing camp wards. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

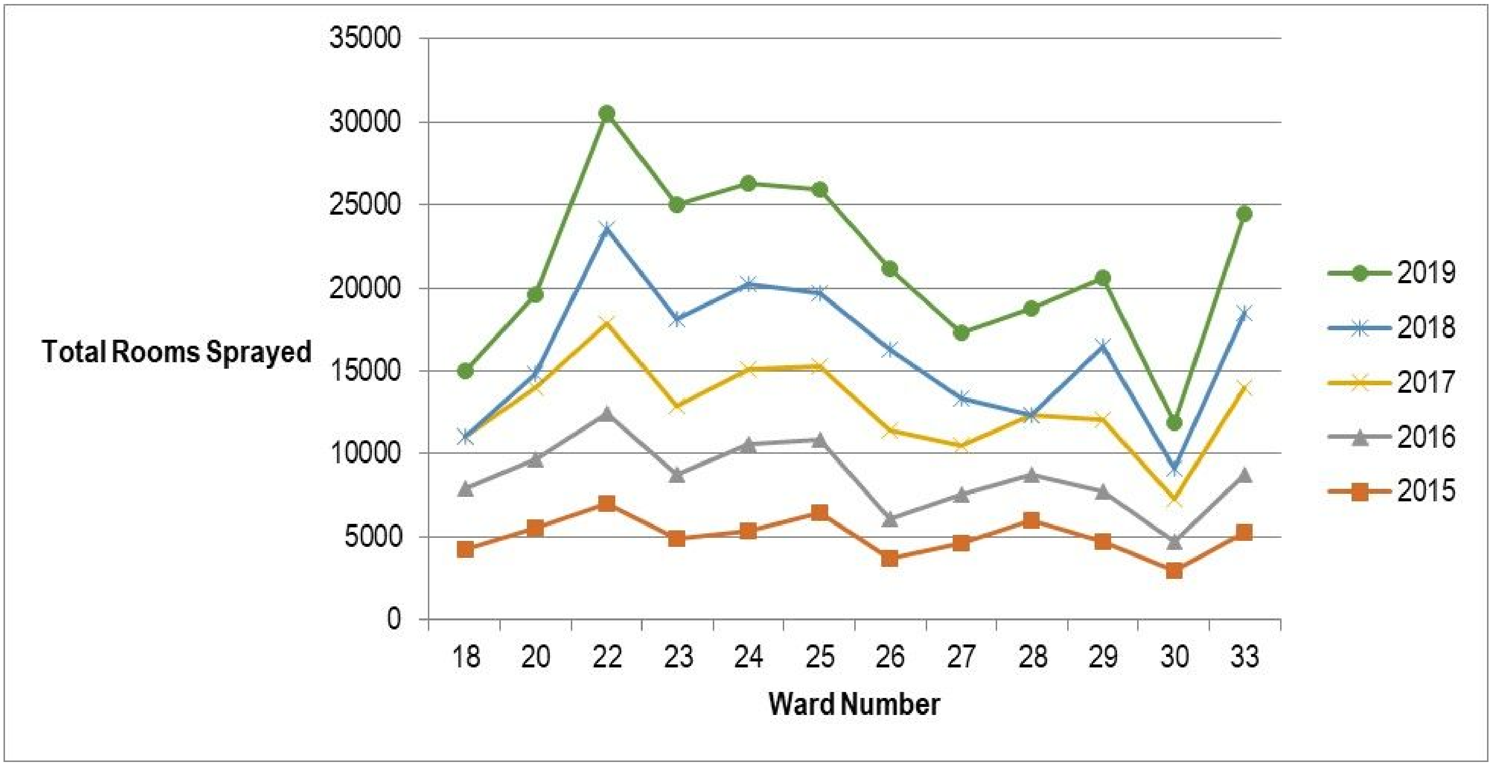

Figure 2

Sprayed Rooms from 2015-2019

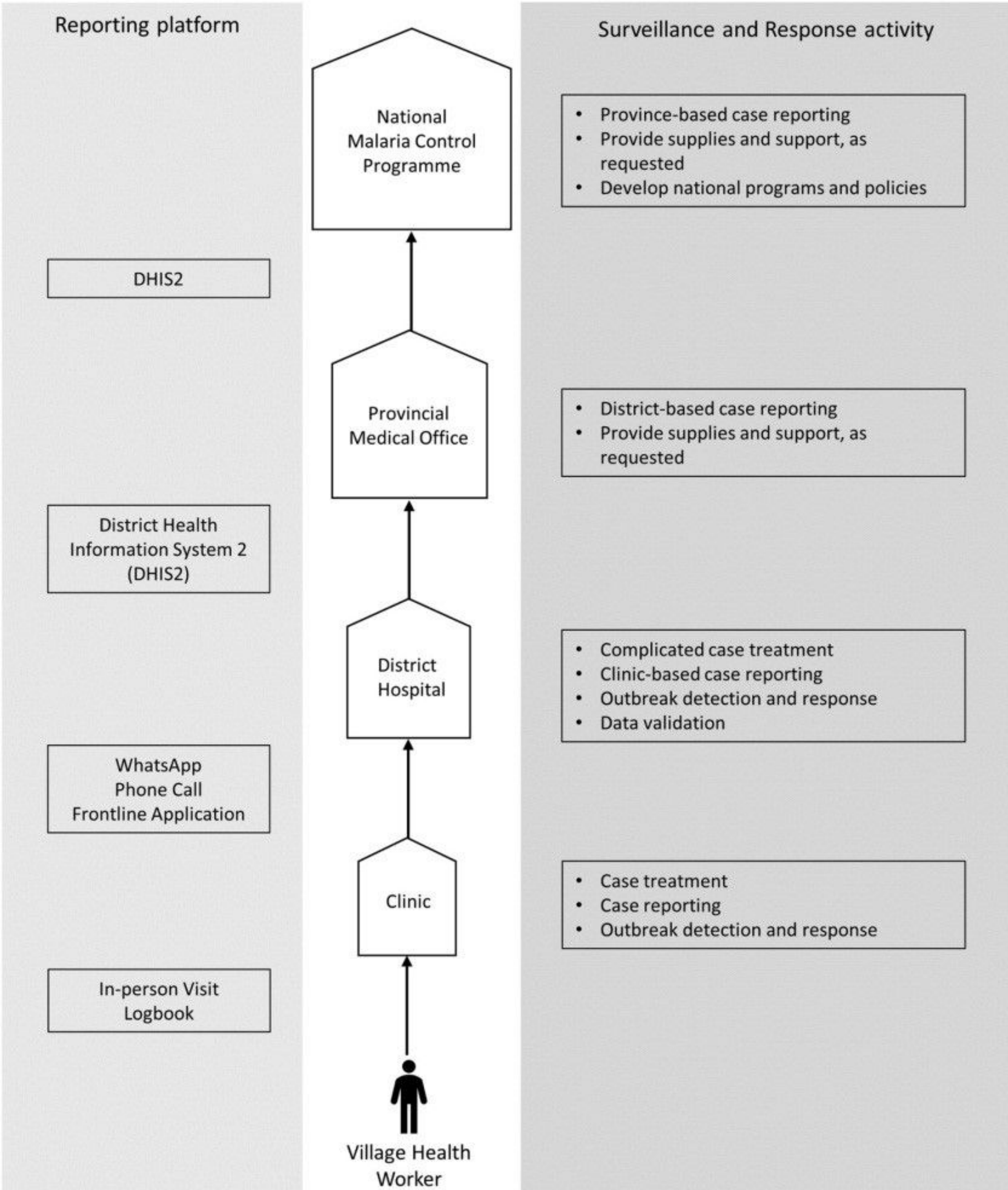

Figure 3

Zimbabwe's malaria outbreak detection and response surveillance system reporting structure[2]

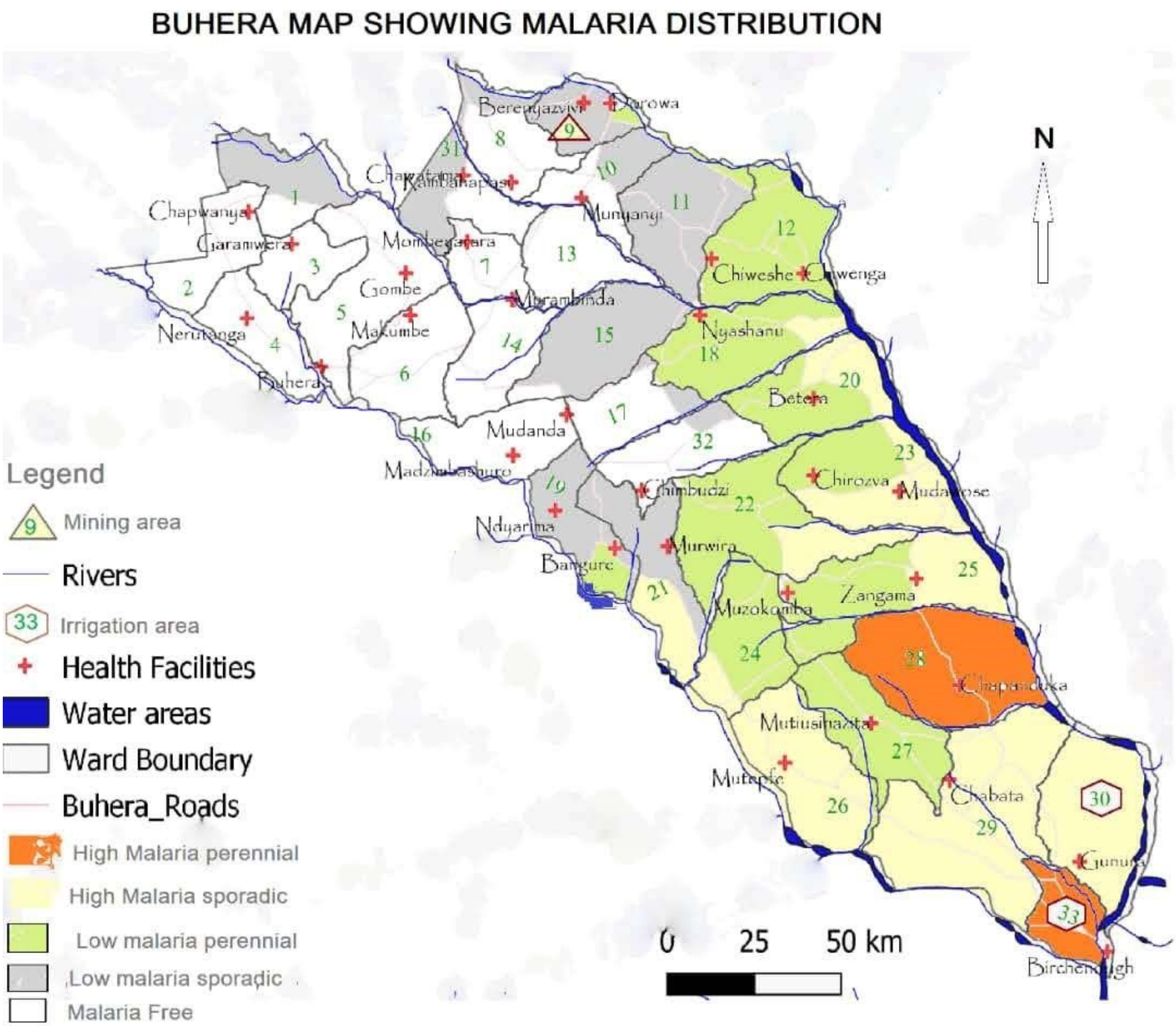

Figure 4

Malaria hotspots areas and distribution. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.