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The use of Long-Lasting Insecticidal Nets (LLINs) to combat malaria and its economic consequences in India

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Abstract

A potentially fatal illness called malaria is transmitted to people by certain kinds of mosquitoes. Malaria can have severe detrimental effects on citizens in a society, including increased mortality, and adverse consequences on the economy, living standards and healthcare. One of the most effective ways to avoid malaria is to sleep beneath Long-lasting insecticidal nets (LLIN) because they provide a chemical and physical barrier for mosquitoes. In addition to being prevented from biting someone sleeping beneath an LLIN by the netting, mosquitoes that attempt to do so are additionally killed by the pesticide covering. However, these LLINs are under-supplied in nations like India which accounts for 3% of the global malaria burden, per the WMR 2019. This is an effective solution that is not distributed to everyone and is one that not everyone knows about, which is why it fails to solve the problem. The widespread distribution of LLINs can help eradicate Malaria in India and save countless lives.

Keywords: Malaria, Insects, Mosquitoes, Insecticide, Bed-nets, India, Maharashtra, Insecticidal Nets, Economics, Anopheles Mosquitoes, World Health Organisation, Disease, Mortality, Rural.

Objectives

The objectives of this study are:

1. To study the prevalence of Malaria in the world and in India (primarily Maharashtra)
2. To study what Insecticide-treated bed nets (ITNs) are and their impact on the world
3. To understand the need for Long-Lasting Insecticidal Nets (LLINs) in today's world
4. To study the possible use of LLINs in India to combat Malaria
5. To study the formation and structure of LLINs
6. To study the possible targeted areas of distribution of LLINs

Introduction

People often get malaria through the bites of infected female Anopheles mosquitoes. Malaria is still widespread in tropical and subtropical nations while being rare in temperate areas. Over 400,000 individuals die from malaria each year, infecting close to 290 million people worldwide. India accounts for 3% of the global malaria burden, per the

WMR 2019. Orissa region in India is the state that contributes the most to malaria. Despite having a population of 36.7 million (3.5%), the state of Orissa is responsible for 25% of the 1.5–2 million recorded cases of malaria each year, 39.5% of *P. falciparum* malaria, and 30% of malaria-related fatalities in India. One of the most effective ways to avoid malaria is to sleep beneath an LLIN because they provide a chemical and physical barrier for mosquitoes. In addition to being prevented from biting someone sleeping beneath an LLIN by the netting, mosquitoes that attempt to do so are additionally killed by the pesticide covering. Because they are made with netting that incorporates an insecticide that is authorised by the WHO, LLINs are far more effective than conventional mosquito nets.

Malaria

What is Malaria?

A potentially fatal illness called malaria is transmitted to people by certain kinds of mosquitoes. Tropical nations are where it is primarily found. It may be avoided and treated. A parasite is to blame for the infection, which cannot pass from one person to another. The symptoms might be minor or fatal. Fever, shivers, and headaches are considered mild symptoms. Fatigue, disorientation, convulsions, and breathing difficulties are among the serious symptoms. The risk of severe illness is higher among newborns, kids under 5, pregnant women, travellers, and individuals with HIV or AIDS.

People often get malaria through the bites of infected female *Anopheles* mosquitoes. The initial signs of malaria may be difficult to identify since they may be mild and comparable to those of many feverish disorders. If *P. falciparum* malaria is not treated, it can lead to severe sickness and death within twenty-four hours. The two most dangerous *Plasmodium* parasite species—*Plasmodium falciparum* and *P. vivax*—are among the five which trigger malaria in humans. The most common and lethal malaria parasite on the continent of Africa is *P. falciparum*. The most common malaria parasite beyond sub-Saharan Africa is *P. vivax*. *P. malariae*, *P. ovale*, and *P. knowlesi* are the additional types of malaria that may infect people.

An uninfected mosquito starts the cycle of mosquito transmission. When a mosquito bites someone who has malaria, it contracts the disease. Another individual may acquire malaria parasites if this mosquito attacks them in the future. Once within the body, the parasite moves to the liver, where some kinds can lay dormant for up to a year. Red blood cells become infected when the parasites exit the liver after reaching maturity. People often start to exhibit signs of malaria around this time. At this stage of the malaria cycle, an uninfected mosquito that bites a person will get infected with the parasites that cause malaria and may pass them on to other persons it bites. Red blood cells are affected by the parasites responsible for malaria, thus people can also get the disease by coming into contact with contaminated blood, which includes: Mothers and unborn children; blood transfusions; and the sharing of needles that are utilised to inject drugs.

Most fatalities from malaria are caused by one or more severe complications. Brain swelling or injury might result from blood cells with parasites within that obstruct tiny blood arteries to the brain (cerebral malaria). Seizures and comas might result from cerebral malaria. In addition to harming organs like the kidneys and liver, malaria can also rupture the lymphatic system. Any one of these ailments has the potential to be fatal. Additionally, malaria may lead to anaemia, which is a condition in which there are insufficient red blood cells to provide enough oxygen to the tissues of the body. Last but not least, quinine, a popular drug used to treat malaria, can also result in low blood sugar levels (hypoglycemia), as can severe forms of the disease. A coma or death may arise from extremely low blood sugar.

Prevalence of Malaria in the World

Malaria is still widespread in tropical and subtropical nations while being rare in temperate areas. Over 400,000 individuals die from malaria each year, infecting close to 290 million people worldwide. The number of malaria cases increased from 245 million in 2020 to 247 million in 2021, according to the most recent World Malaria Report. With six other diseases (diarrhoea, HIV/AIDS, tuberculosis, measles, hepatitis B, and pneumonia), malaria contributes to 85% of the overall impact of infectious illnesses on the world's population. Arguably the most serious public health

issue in the globe is malaria. In many underdeveloped nations, it is a major source of sickness and mortality, with small children and expectant mothers being the most vulnerable populations.

Over the two pandemic peak years (2020–2021), COVID-related setbacks resulted in an additional thirteen million cases of malaria and 63 Thousand malaria-related fatalities. An estimated 619,000 people died from malaria in 2021, which is still 51,000 (9%) more than in 2019 before the epidemic hit but six thousand (1%) fewer than in 2020. Although at a slower rate than in 2020, the number of malaria cases increased in 2021. In 2021, there were reportedly 247 million instances, up from 232 million in 2019 and 245 million in 2020. Without adding the COVID-19 pandemic, an estimated 268 million individuals in 37 countries with high malaria incidence need aid. Malaria rates increased in each of these nations beyond what the COVID-19 epidemic alone could account for. These humanitarian crises were mostly caused by conflicts, starvation, and flooding, which were occasionally made worse by disease epidemics.

The prevalence of malaria in the world is still overwhelmingly heavy in the WHO African Region. Approximately 95 per cent of the total cases of malaria and 96% of all malaria fatalities occurred in the Region in 2021. A little more than 80% of the malaria-related fatalities in the region have been triggered in children below the age of five. The majority of malaria infections and deaths—234 million cases and 593,000 fatalities—are expected to occur in Sub-Saharan Africa (SSA) in 2021. All 16 of the nations with the highest rates of malaria cases are in SSA. Nigeria accounts for 26.6% and 31.3%, respectively, of all malaria cases and fatalities worldwide. The expected number of malaria-related fatalities in SSA (593,000) decreased marginally from 2020 (599,000). Malaria poses a disproportionate danger to young children, especially African children with poor access to healthcare: 76% (or 470,000) of the malaria-related fatalities in 2021 were in children below the age of five. A child dies from this illness almost every minute.

The predicted amount of money needed to combat malaria in 2021 was \$3.5 billion, slightly more than in 2020. The predicted \$7.3 billion in investments required to continue on the path to eradication, however, was well below what was made in 2021. It is becoming increasingly difficult for malaria programmes to finance goods and services due to cost-increasing factors such as global inflation, COVID-19 supply chain issues, and the Ukraine conflict.

Socio-Economic Impact of Malaria

Many of the most prosperous nations today historically had high rates of malaria, but over the past few decades, it has been eradicated in those nations. Currently, malaria is very common in several of the world's poorest nations. This is partially a result of the disease's difficulty being combatted due to inadequate funds, yet there is also an adverse consequence. The sickness reduces the economy's production. According to Okorosobo et al. (2011), the "malaria penalty" to GDP in Nigeria and Chad might be as high as 9%. According to Azemar and Desbordes (2009), if malaria and HIV hadn't existed, foreign direct investments in the average sub-Saharan African nation may have increased by a third. Malaria is responsible for little over half of this.

Prevalence of Malaria in India

Nine anopheline vectors spread malaria in India under various geo-ecological conditions. Although the WHO South East Asia Regional Office estimates 15 million illnesses and 20,000 fatalities, there are only around 2 million confirmed infections and 1,000 reported deaths per year. 77% of all malaria cases in Southeast Asia are caused by India. Both *Plasmodium falciparum* and *P. vivax* cases have been described as having multi-organ involvement or dysfunction. The majority of the cost of malaria is taken by economically active generations.

A retrospective investigation of the impact of malaria revealed that 1.86 million years of life adjusted for disability were lost as a result of malaria. According to a cost-benefit study, the National Malaria Control Programme receives a generous reward of 19.7 Rs for every Rupee invested. Malaria is endemic in the states where ethnic tribes are present, especially *P. falciparum*, which has a rising drug resistance. Anaemia, abortions, poor birth weight babies, stillbirths, and maternal mortality are just a few of the serious effects of severe malaria during pregnancy.

India accounts for 3% of the global malaria burden, per the WMR 2019. India has made achieved tremendous progress in the past years in minimising malaria incidence. In the Southeastern Asian Region of WHO, of ~1.4 billion people living in eleven nations (6% of the world's area), approximately 1.2 billion individuals are susceptible to the danger of malaria, the majority of whom live in India. But only two and a half million of the world's malaria cases originated in Southeast Asia. Of this, India alone provided 76% of the overall cases. Taking into consideration clinical episodes, it is currently projected with the assistance of epidemiologic models and geographical and demographic information that Plasmodium falciparum forecasts beyond Africa, particularly in Southeast Asia, are 200 per cent greater than those stated by the World Health Organization (118.94 million of the worldwide estimates of five hundred fifteen million cases).

One of India's most malarious states is Gujarat, namely the Surat area. There were several factors that affected the epidemiology of malaria in the Surat district, including: (i) a high risk of malaria; (ii) diverse eco-systems; (iii) tribal, urban, coastal, and migrant populations; (v) irrigated and industrial areas; and (vi) the presence of triple-resistant vector species (resistant to DDT, benzene hexa-chloride (BHC), and malathion).

A nation of 330 million people was expected to have 75 million cases of malaria in 1947, the year India gained independence. The number of cases of malaria drastically decreased to barely 100,000 in 1964, marking a great victory on the front of extermination during the eradication period in the late 1950s and early 1960s. Malaria, however, made a reappearance after a trend reversal. The number of malaria cases had reached 6.4 million by 1976. P. falciparum continues to increase, and in the past few years, its fraction has progressively increased to over 50%. In general, males carry a heavier burden than women across all age categories. In contrast to the Indo-Gangatic fields where the situation was the opposite, children in Assam, Arunachal Pradesh, and Rajasthan possessed malaria at a greater rate than elders did.

In India, there are three different levels of government-funded healthcare: the primary level, which includes a network of primary health centres and sub-centers in rural regions, urban health centres, and urban health centres or dispensaries in the towns that are run by local governments and corporations; the secondary level, which includes district hospitals; and the tertiary level, which includes medical schools and hospitals. An organised National Vector Borne Disease Control Programme (NVBDCP) divides the costs of eradicating malaria, filariasis, Japanese encephalitis, leishmaniasis, and dengue/Dengue Hemorrhagic Fever in India and offers scientific and operational guidance to state-level governments.

Multifunctional workers at the local level help with the implementation of NVBDCP through the primary care system. The three main pillars of the NVBDCP's current malaria control approach are early identification and comprehensive treatment, selective vector control, and behavioural change communication. The Intensified Malaria Control Project (IMCP), which is funded by the World Bank, has begun operations in India. With the help of the World Bank, the Enhanced Malaria Control Project (EMCP) was running in 181 specific districts of the nation throughout the 1990s.

A malariometric indicator to express malaria cases per 1,000 people is the annual parasite incidence (API). According to NVBDCP incidence statistics, the API in the majority of India was less than 2, while areas with 2 to 5 API were dispersed, and regions with > 5 API were dispersed in the northeastern regions of Rajasthan, Gujarat, Karnataka, Goa, Southern Madhya Pradesh, Chhattisgarh, Jharkhand, and Orissa. In various regions of India, there are varied ratios of P. vivax and P. falciparum. Although P. falciparum infections are primarily found in the indo-gangatic plains and northern mountainous states, they are also present in the northwest region of India and southern Tamil Nadu state; in forested areas home to ethnic tribes, the ratio of P. falciparum infections is 30–90%; and in the remainder of areas, it is anywhere from 10 to 30 per cent.

Orissa region in India is the state that contributes the most to malaria. Despite having a population of 36.7 million (3.5%), the state of Orissa is responsible for 25% of the 1.5–2 million recorded cases of malaria each year, 39.5% of

P. falciparum malaria, and 30% of malaria-related fatalities in India. Similar to this, micro to highly prevalent malaria conditions exist in the other states populated by ethnic communities mostly in forest habitats, with a majority of *P. falciparum* to a degree of ninety per cent or perhaps more.

Prevalence of Malaria in Maharashtra

Malaria deaths in the state have made a jump to almost 80% in 2022, the increase is almost forefold to the pre-pandemic year of 2019. The state health administration declared malaria a notifiable condition on December 21, 2021. Malaria is a parasite-caused sickness that is transmitted by the bite of contaminated, female *Anopheles* mosquitoes. Dr. Kailas Baviskar, the state Department of family welfare's deputy director of health services, said they have been surveying communities to find new cases so they can eradicate malaria by 2030.

The deaths are mainly from Chandrapur, Gadchiroli and Gondia districts which have sizeable tribal populations. Almost 50% of the deaths are believed to be children under 15 from tribal regions. On the other hand, five regions, specifically Latur, Osmanabad, Nanded, Parbhani and Hingoli have reported 0 instances of Malaria, while 16 districts such as Bhandara, Ratnagiri, Dhule, Nandurbar, Wardha, Ahmednagar, Kolhapur, Nashik, Jalgaon, Washim, Sangli, Beed, Solapur, Aurangabad, Jalna and Yavatmal have disclosed 1-10 cases. Malaria cases recorded in Maharashtra so far this year (14,606) have dropped but deaths have increased to a concerning amount.

In Mumbai, The BMC recorded 659 cases of malaria and 215 incidents of dengue in September 2022. 3,371 instances of malaria and 646 occurrences of dengue fever have been documented so far this year. At Nanavati Hospital's senior consultant for internal medicine, Dr Rahul Tambe, stated, "I've seen five to six dengue patients a day over the past week. They don't all require admission. It takes patients seven to eight days to recover." The rainy weather with its intermittent rain is increasing dengue and malaria infections. According to the health division of the Mumbai Municipal Corporation (BMC), the city recorded 120 instances of malaria and 78 cases of dengue from October 1 to October 9 2022.

Possible Solutions to Malaria

By preventing insect bites and using medications, malaria can be avoided. By avoiding bites from mosquitoes with the use of mosquito nets, insect repellents (including DEET, IR3535, or Icaridin), coils, vaporizers, protective gear, and window screens, it is feasible to reduce the risk of contracting malaria.

Due to its great efficacy in avoiding infection and lowering disease transmission, vector management is a crucial part of malaria prevention and control methods. ITNs (insecticide-treated nets) and IRS (indoor residual spraying) are the two main therapies. *Anopheles* mosquitoes are becoming more resistant to pesticides, which poses a danger to progress in the fight against malaria worldwide. According to the most recent World Malaria Report, additional risks to ITNs include inadequate access, the loss of nets as a result of daily stress outpacing replacement, and changing mosquito behaviour.

Similar to the pre-pandemic year of 2019, deliveries of insecticide-treated bed nets continued in 2021. A total of 128 million (or 75%) of the 171 million bed nets treated with insecticides that were supposed to be distributed in 2021 were actually delivered; the rest were scheduled for 2023. In sub-Saharan Africa, 68% of homes have at least one ITN by 2021, up from 5% in 2000. 53 nations started indoor residual spraying (IRS) initiatives in 2021 to fight malaria. Even while IRS is universally acknowledged to be very successful, its relatively expensive cost continues to limit its capacity to be scaled up.

Over the past ten years, there has been a significant rise in the use of intermittent preventive treatment during pregnancy (IPTp). In order to lessen the impact of malaria during pregnancy, 35 African nations have implemented national IPTp programmes. From around 200,000 in 2012 to almost 45 million in 2021, the average number of children treated every cycle of Seasonal Malaria Chemoprevention (SMC) climbed substantially. An extra 11.6 million kids received treatment with SMC per cycle in 2021. Nigeria was responsible for 92% of this rise.

Insecticide-Treated Bed Nets (ITNs)

What are ITNs?

Since treating cotton nets is not affordable and has short-lived results, it is advised to treat synthetic nets (nylon and polyester) with insecticide. If used properly, insecticides used in nets to repel mosquitoes are safe for humans. A tingling feeling on the skin might result from direct skin contact with the insecticide on a still-wet net. Even for young children, this is not dangerous. The netting may smell like a pesticide after treatment. This won't last more than a couple of days and won't damage those who sleep with a net.

As mosquitoes attack at night, sleeping behind a bed net lowers the chance of man-vector interaction and is a useful preventative technique. However, most mosquito nets only offer a minimal physical barrier and level of protection as mosquitoes remain capable of biting through the mesh or entering it if it is used improperly. In addition to lowering mortality, ITN administration appears to have additional advantages, such as decreased anaemia (an impact magnitude higher than what we have observed with deworming). Additionally, Bleakley (2010) argues that lessening the detrimental effects of malaria may have a long-lasting effect on children's development and, consequently, on their capacity to be productive and effective throughout their lives.

The primary conclusions of Lengeler 2004's meta-analysis of 22 studies and its revision in Pryce et al. 2018 are as follows: In children under the age of 5, there is a statistically significant seventeen per cent reduction in the risk of general death, according to Pryce et al. (2018) The review author attributed the lesser or comparable-sized impacts observed in two studies that tried to assess plasmodium-specific mortality in Lengeler 2004 to the difficulties of linking death to malaria. decreases in the incidence of parasitic malaria, simple clinical experiences of malaria, and other indicators of infections caused by malaria with statistically significant severity. In individual studies, effects on nutrition-related metrics (weight-for-age, weight-for-height, average mid-upper arm circumference, but not height-for-age) were often statistically significant; however, they were not pooled into an overall analysis.

A significant potential benefit of ITNs on productivity was discovered by Fink and Masiye (2015), who randomly allocated five hundred and sixteen farmers in Zambia to groups that received subsidised ITNs, groups that obtained free ITNs, or a control group. They discovered that free ITNs raised the mean annual harvest value for an agricultural producer by \$76, or twelve percent of the group's average yearly harvest worth at baseline. The validity of the trial is seriously jeopardised by the baseline disparity in the outcome of interest amongst the group receiving treatment and control group. On the other hand, it has been suggested that LLINs may not only lessen the immediate impact of malaria but may also limit possibilities for people to build defences, making them more vulnerable to the disease in the long run.

Because they are flammable, bed nets might be a fire risk. In an area of Benin, Egrot et al. 2014 conducted interviews with residents regarding bed net-related fires and looked for previous research on the topic. The survey discovered cases of fires connected to bed nets in various nations. The survey uncovered scant information regarding the incidence of fires connected to bed nets. The admissions for bed net-related burns to a major referral hospital in Kampala, Uganda, were evaluated by Kalanzi et al. in 2014. From 2008 to 2011, the survey discovered 45 individuals who were brought to the burns centre with burns caused by bed nets. Of the 45 patients, 15 passed away. If many burn patients choose not to seek medical attention, hospital records may understate the real frequency of bed-net-related burns. According to the limited information available, bed net-related burns do not appear to be a significant issue in comparison to the number of individuals who use nets.

How are ITNs made?

The size, form, colour, material, and/or pesticide treatment status of nets might vary. The majority of nets are constructed from polyester, polyethene, or polypropylene. Pyrroles and pyrethroids are the only pesticide classes that have been authorised for use on ITNs. These pesticides are poisonous to insects and ultimately kill them, but there is

evidence that they offer relatively little health risk to people and other animals. In the past, nets required retreating every six to twelve months, or possibly occasionally if the nets are washed. Retreating nets is as easy as soaking them in a solution of water and pesticide and letting them dry in the shade.

One of the main obstacles to the widespread adoption of ITNs in countries with endemic diseases was the requirement for periodic retreatment. In addition, the majority of African nations had relatively low rates of retreatment due to the insecticide's higher price and lack of awareness of its significance.

Nets for mosquitoes, pesticides, a basin, a measuring cup, rubber gloves, and soap make up the essential tools to treat the net. Before treatment, the net has to be cleaned or laundered. It is best to treat the nets outside in the shade. When administering care indoors, an area with windows open is preferred. A basin and gloves being used first-hand are also necessary. Protective gloves are essential to treat these nets. The net material determines how much water is required. The quantity of water needed for one artificial net (nylon, polyester), regardless of its size and form, is 12 litres (if the net is particularly large, additional water may be necessary). Food, beverages, or medications are not permitted to be placed in the measurement container. The type of pesticide used will determine how much is required to treat a net. Typically, 10 to 15 ml of pesticide are needed to treat just one net. The remaining pesticide has to be kept in its original packaging, out of reach of kids, and in a dark place. Using gloves, the water and insecticide must be mixed in a basin.

An individual must never treat more than one net at once. The net must be placed in the water and insecticide-filled basin. The net should be soaked for a sufficient amount of time to fully permeate it. The nets are then removed and squeezed lightly to enable the extra liquid to drain back. On sheets of plastic, the net can dry completely in the shade. The net may then be strung up to complete its shaded drying process. Curtains may be treated with any remaining solution of water and pesticide after all accessible nets have been treated.

The pesticide is removed from the ITNs by washing. The nets can be washed as rarely as possible, gently, and in cold water with soap. Washing or rinsing treated nets near sources of drinking water must be avoided. Toilets or a hole far from homes, shelters for animals, water for consumption sources, rivers, lakes, and waterways to dispose of water used for washing and cleaning. After being washed three times, nets need to retreat one more; washing should be done at least once a year, ideally prior to the season of rainfall. In regions where mosquitoes are a year-round problem, nets may need to be treated twice per year.

The Distribution of ITNs

ITNs have been the subject of significant discussion over whether they should be given away for free or sold, with some believing that purchasing them (even at heavily discounted prices) may increase the probability that they will reach users. Evidence suggests that imposing a charge has dramatically decreased product demand without increasing utilisation rates in a proportional manner (and has had no impact on programme expenses).

It is still quite difficult to gather the necessary finances to buy these nets. WHO currently suggests that LLINs be given away without charge after significant discussion. LLIN purchases are supported by several nations through multilateral and bilateral donors as well as initiatives like the President's Malaria Initiative and the Global Fund against HIV/AIDS, Tuberculosis, and Malaria. Through organisations like the CDC Foundation External or Malaria No More External, individual donations of mosquito nets can be made.

One excellent study assessed how user fees affected online purchases and internet usage. Increased pricing (from \$0 to \$0.75, the rate at which they were initially sold), according to a programme in Kenya that distributed nets to maternity clinics, lowered demand by around 75% but were unrelated to greater rates of use. According to D'Alessandro et al. 1995, people in The Gambia who received free mosquito nets in year one were subsequently had to pay for pesticides to retreat them in the second year, which resulted in a large drop in coverage and an increase in infant mortality. According to Noor et al. 2007, a programme in Kenya started supplying nets at discounted costs in

2002. At 25%, net coverage rates were still incredibly low, therefore in the year 2004, Kenya supplied even more nets that were significantly subsidised. The programme started giving away nets for free in 2006, increasing net coverage to seventy-nine per cent during that year and the next.

In light of the argument made above that ITNs offer protective advantages at the community level, expanding coverage in communities might turn out to be advantageous to everybody, beyond ITN users. This provides a further justification for free ITN distribution.

Long-Lasting Insecticidal Nets (LLINs)

What are LLINs?

One of the most effective ways to avoid malaria is to sleep beneath an LLIN because they provide a chemical and physical barrier for mosquitoes. In addition to being prevented from biting someone sleeping beneath an LLIN by the netting, mosquitoes that attempt to do so are additionally killed by the pesticide covering. Because they are made with netting that incorporates an insecticide that is authorised by the WHO, LLINs are far more effective than conventional mosquito nets. The nets may be utilised for a maximum of three years or Twenty washes as a result of this treatment, which also extends the duration of the insecticide impact.

LLINs in society provide several advantages to both users and non-users, including Personal safety is provided to net users, whereas indirect protection is advantageous for both users and non-users. Due to greater mosquito death rates and a smaller human infectious reservoir, there are fewer mosquitoes overall and a lesser percentage of them are pathogenic. The Long Lasting Impregnated Bednets (LLINs) or Insecticide Treated Bednets (ITNs) offer greater and more effective defence by eliminating and repelling mosquitoes. Cockroaches, bedbugs, houseflies, fleas, and other pesky insects are likewise killed by ITNs and LLINs or kept at bay.

LLINs are mosquito nets that contain the pesticide woven into the fabric, preventing it from being washed away after as many as 20 times. These nets are often more successful than standard ITNs since they apply insecticide in a more efficient and high-quality manner. The LLIN is also more affordable (because it may be used for three to five years) than handing out regular bed nets and spraying them with pesticides at least twice a year. Because of this, traditional ITNs are only a sensible solution in regions where no less than fifty per cent of people currently sleep beneath a net.

How are LLINs made and stored?

The way the nets are used and stored will also affect how long they last. Users are advised, for instance, to wash LLINs as infrequently as possible (no more than five times per year), lay them out to air out in the shade, patch any minor holes, and knot the net to store them during the day.

Polyester, cotton, cotton-synthetic blends, nylon, polyethylene, or polypropylene are the materials used to make nets. There are several LLIN variants in terms of net size, colour, mesh, form, packing, and labelling choices. According to UNICEF, a typical LLIN has the following measurements: (length) 190 x (width) 180 x (height) 150 cm; 100 deniers. Since 2010, UNICEF has purchased three standard sizes of LLIN in the following dimensions: two rectangular nets measuring (L)190 x (W)180 x (H)150 cm and (L)180 x (W)160 x (H)150 cm; and one conical net measuring (H)220 x (C)1050 cm. All of these LLINs must be at least 100 deniers.

Due to their reduced weight and softer construction, countries prefer LLINs made of polyester over those made of polyethylene. As a result of this desire, LLINs manufactured of polyester now make up almost 90% of UNICEF's purchases. Only four of the ten companies that received LTAs from UNICEF, however, make LLINs from polyester. Uneven country usage of UNICEF LTA allocations jeopardises the diversity and security of the LLIN supply. To provide a more comprehensive and balanced supply security, UNICEF aims to close the disparity between polyester and polyethylene nets and to encourage a larger use of polyethylene LLINs.

Both the individual LLINs and the LLIN bundles are securely packaged in plastic bags. However, it is crucial to make certain that warehouses are spotless, well-ventilated, and illuminated, and that the LLINs do not have exposure to direct sunlight. To make sure the warehouse is free of rats, insects, and termites, it should be periodically cleaned and checked. In particular, during the rainy season, it must be assured that the storage facility is free from water seepage or penetration through the walls, roof, doors, and windows. Additionally, it should be made sure that the staff is educated to utilise the fire extinguishers and that they are readily available and accessible. Stocks will be kept away from electrical outlets and electrical connections and appliances that are fire resistant will be installed.

The volume of LLINs rather than their weight should be the main issue while storing them. There must be sufficient capacity for storage at all levels because of the extremely massive quantities involved. In practice, 4 bales/m³ is a good working estimate because, in principle, 5.8 bales of polyester LLIN fill a volume of 1 m³. 6 bales/m³ is the maximum storage density for polyethylene LLINs, meaning that a 600 m³ warehouse could hold 3,600 bales or 144,000 LLIN. It is frequently possible to hire storage space, but the cost of renting must be compared to the potentially greater expense of delayed delivery.

The cartons are placed no higher than 2.5 m in steel racks or slotted angles, at least 10 cm from the ground, and 30 cm from the neighbouring stacks and walls. A good storage system should allow for simple mobility of employees by providing corridors between the stacks. 'First in, first out' should be the guiding principle for stock management. The bales have to be piled so as to form equal heaps, each of which is designated. The stock ledgers should be updated with the current stock levels, and the files should be maintained securely.

Impact of LLINs on the World

According to studies, LLIN usage decreased the overall prevalence of malaria by 50% in sub-Saharan Africa, which is home to more than 90% of all cases worldwide. With the acquisition of 53,000 nets in 2000, UNICEF made its first LLIN purchase to aid in the avoidance and elimination of malaria in countries where the illness is a problem. Since then, this number has greatly increased, albeit yearly statistics change based on requests from nations where malaria is widespread. UNICEF has distributed over 275 million mosquito nets since 2012.

Early research experimentally compared the burden of malaria in users and non-users can be used to make conclusions. These studies tend to demonstrate instinctively that the burden declines in the groups using nets, while others are parallel, but lesser reductions are frequently reported in non-user cohorts. More recently, Killeen made the case that individual safety only accounts for a small portion of the overall impact by using models. The Gambia study, which found that malaria incidence was greater among those who were not users residing in village groups of persons using nets than amongst villages lacking nets, is frequently used as support against a community impact.

Long-lasting insecticidal nets (LLINs) are known to be efficient at preventing malaria, but achieving and maintaining high levels of ownership and use are highly challenging. In order to stop the spread of malaria, about 40,000 LLINs were delivered in the 80 villages of the Keshkal sub-district in Chhattisgarh, India, in 2014. One year after mass distribution, the research evaluated LLIN coverage, access, usage patterns, and important factors affecting net use. With an overall of 15,003 people present in the houses on the evening before the poll, 2970 households were questioned. Nearly 98% of homes had a minimum of one LLIN, and 59.4% of those polled said they had used one the night before. From 41 to 94% of LLINs were used across the research clusters. Approximately 89 per cent of all the LLINs were discovered to be in excellent physical condition—they lacked holes. Nevertheless, the relationship of households with no less than one LLIN per two people was just 39 per cent.

The research clusters did not have appropriate LLIN coverage, making it challenging for all family members to utilise an LLIN. The majority of LLIN usage among children under the age of five, differed between clusters. To have an epidemiological effect on this measure at the community level, health education initiatives and spreading awareness about the advantages of sleeping under LLINs are required. These groups at high risk include pregnant women and children under the age of five. A general desire to utilise nets when they're accessible is indicated by the relatively

high net utilisation despite the limited availability of LLINs. The limited coverage at the home level is the greatest obstacle to the expanded usage of nets.

Second Generation LLINs

According to Lama Ramzi Suleiman, Contracts Manager at the UNICEF Supply Division's Health Technology Centre, proper maintenance and storing soon could not be sufficient to ensure the functionality of any of the present LLINs. "Since we've been using these nets for approximately 20 years, Anopheles mosquitoes have begun exhibiting pyrethroid [insecticide] resistance. We must keep looking at substitute drugs" she said.

As a result, UNICEF has begun distributing the second generation of LLINs that, in addition to using an insecticide, also employ an oil known as piperonyl butoxide (PBO) to block the mosquitoes' natural defence system. The toxic nature of the pyrethroid kills the mosquito if its biological defence is compromised.

Why aren't enough LLINs being distributed in India

LLINs should be made available in more ITN target populations' locations. In general, even if some residents of a village have traditional bed nets, there should be enough LLINs given to satisfy the entirety of the community's population. Over the next five to ten years, it is anticipated that LLINs would replace other malaria vector control measures as the primary strategy in high-risk locations. According to national criteria, long-lasting insecticidal net (LLIN) acquisition volumes might fluctuate significantly from year to year. Typically, governments buy new and replacement LLINs every two to three years for widespread distribution operations. The supply of aggregates overall is constant. In contrast to the estimated worldwide LLIN deliveries of 250 million in 2019—more than half of the indicated needs—UNICEF believes that the entire annual global LLIN manufacturing capacity is 400 million nets.

The number of LLINs needed and delivered each year is greatly impacted by, among other things, the replenishment cycles of big nations with high malaria endemicity. Over the course of ten years, the total number of LLIN deliveries worldwide has steadily climbed, reaching over 250 million in the years 2017 and 2019, however, this number can range between 160 and 200 million nets annually from 2013 to 2018. Eighty to ninety per cent of LLINs are shipped to nations in SSA, or sub-Saharan Africa. With 6% of the world's deliveries, India is the largest recipient nation outside of SSA. In endemic nations, the state sector accounts for 90% of demand, with the private sector's share only making up 1% of this amount.

The kinds of bed nets that can be distributed rely on the brands that have been authorised in India and the availability of supplies. The projected lifespans of the various types of nets delivered annually and any unique requirements will be communicated to the states by NVBDCP. It may be presumed that a typical household comprises five individuals (2 adults and 3 youngsters), barring any facts to the contrary. Thus, a single LLIN could potentially cover 2.5 people on average. As a result, for a particular village, the required number of LLINs is often equal to either the entire population divided by 2.5 or the total number of households times by 2. It's recommended to add twenty per cent because some towns could have several large families that require more nets.

Sometimes, people may claim that the amount of nets determined by this plan is insufficient because every member of the house sleeps separately. They must be informed that such variances cannot be taken into consideration by the public sector and that these households could purchase supplementary LLINs or bednets from the marketplace. In general, a sufficient amount of LLINs must be propagated to a designated village in just one operation. If LLINs are not available in sufficient quantities, it is possible to consider distributing one per home annually over a time frame of two years. The date of LLIN distribution is not as important as the timing of IRS or net re-treatment. Distribution, though, could be best done prior to the beginning of rainfall for practical reasons. LLINs should be distributed to particular groups, such as children attending tribal schools as well as hostels, in addition to designated high-risk communities with the goal of covering the whole population.

The Cost-Effectiveness of LLINs

Unless they are priced more than USD 1.5 over the price of normal nets, long-lasting bed nets (LLINs) are more cost-effective if they have identical physical longevity as standard bed nets (3 years). In order to avoid the less expensive net (of a comparable type) from becoming more cost-effective, each year of lifetime growth might be coupled with a price rise of USD 1 or more. This is since a longer lifespan results in fewer expenses for delivery. Resupply net distribution improves the number of under-5 fatalities avoided by 5-14% at the cost of USD 17–25 per additional person covered every year, or USD 1080–1610 for each additional under-5 death avoided. Resupply net distribution is done alongside the renewal of all nets every 3–4 years.

The World Health Organization's advice to only distribute LLINs is supported by study findings, which also provide information on the price ranges over which this advice will no longer be valid. If programme planners are ready to spend USD 1600 for each under-5 fatality avoided, putting money into replenishment is cost-effective. Programme planners ought to be ready to pay higher prices for nets that have an extended physical lifespan.

How to best use limited resources for malaria management in order to optimise social and economic gains is a critical topic for policymakers. The overall expenses of ITNs are higher compared to those of in-house residual spraying (IRS), which also shows up in the greater price per capita (Rs. 56 against Rs. 51), according to our comparison of ITNs and in-house residual spraying (IRS). Although 74% of the cost of all insecticides was attributable to IRS, the price of nets for mosquitoes had a significant role in this. Both strategies worked well to cut down on malaria. Although IRS and ITNs both work well to combat malaria, ITNs tend to be more effective and efficient. With regard to the expected fluctuation of important factors like staff, net and pesticide cost, and effect measurement, this finding is strong. Because these results were obtained in a region with minimal malaria mortality, they are very significant. The results, however, likely understate the real cost-effectiveness (CE) of both strategies in comparison to Indian practices.

In aid of malaria control and elimination activities that encompass malaria prevention, diagnosis, treatment, and surveillance, the total worldwide money provided to malaria control initiatives averages around USD 2.8 billion a year, varying between USD 2.5 billion and 3.1 billion.²³ While foreign donors and the Global Fund provide the majority of financing, governments of endemic countries provide an estimated 28% of the overall budget (USD 900 million). An estimated USD 400–500 million is spent per year on purchasing LLINs, excluding the expenses of transportation and secondary distribution, according to an average LLIN price of USD 2.00 per unit. The Global Fund received around 56% of this expenditure, and the President's Malaria Initiative (PMI) of the United States received 20%. The remainder was provided by the World Bank, UNICEF, the Against Malaria Foundation (AMF),²⁴ the Canadian International Development Agency (CIDA), the Department for International Development (DFID) of the United Kingdom (UK), UNITAID, and private sales.

Review of Literature

“Physical Durability of Two Types of Long-Lasting Insecticidal Nets (LLINs) Three Years after a Mass LLIN Distribution Campaign in Mozambique, 2008–2011” - Am J Trop Med Hyg, February 2015: In this study, the researchers concluded that the majority of LLINs propagated by means of a mass campaign in 2008 have been kept in spite of the damage that began early in the LLINs' lives, even though other measurements of LLIN durability, like insecticidal efficiency and insecticide levels, are still pending on these same LLINs. In this rural Mozambique location, we discovered that PermaNet2.0 had fewer and more compact holes than Olyset. The Mozambique NMCP may find this information useful in determining how well the two LLIN brands perform in terms of physical durability for upcoming LLIN purchases for widespread campaign distribution. Their research was restricted to both LLIN brands Olyset and PermaNet 2.0 which were given out during a widespread campaign in 2008; additional LLIN brands may have different results in similar or dissimilar circumstances. Consequently, even in comparable environments, our results might not be extended to different LLIN brands. Further investigation is required to ascertain how an LLIN's damage, regardless of brand, impacts the device's capacity to stop and lessen transmission. additional data on

performance with regard to of structural durability will support these important adjustments when national malaria control programmes undertake additional field tests of LLINs durability.

“Efficacy of pyriproxyfen-pyrethroid long-lasting insecticidal nets (LLINs) and chlorfenapyr-pyrethroid LLINs compared with pyrethroid-only LLINs for malaria control in Benin: a cluster-randomised, superiority trial” - Manfred Accrombessi, PhD; Jackie Cook, PhD; Edouard Dangbenon, MSc; Boulais Yovogan, MSc; Hilaire Akpovi, MD; Arthur Sovi, PhD et al, January 24, 2023: Through this study, researchers could understand that in a region containing pyrethroid-resistant mosquitoes, chlorfenapyr-pyrethroid LLINs provide more malaria protection than pyrethroid-only LLINs over the course of two years. Protection was equivalent for pyrethroid-only and pyriproxyfen-pyrethroid LLINs. These results offer essential second-trial data that will help the WHO formulate guidelines for these new LLIN classifications. The significance of chlorfenapyr as an LLIN therapy for preventing malaria in regions with pyrethroid-resistant vectors is supported by this study. To manage resistance successfully over the long run, however, a variety of novel active components are needed. novel developments, such as pyriproxyfen, also require additional investigation in order to develop efficient vector control methods.

“Design, implementation and evaluation of a national campaign to distribute nine million free LLINs to children under five years of age in Tanzania” - Kimberly Bonner, Alex Mwita, Peter D McElroy, Susan Omari, Ally Mzava, Christian Lengeler, Naomi Kaspar, Rose Nathan, Joyce Ngegba, Romanus Mtung'e & Nick Brown, 31 March 2011: Through this study, researchers concluded that a nationwide LLIN distribution plan that involved full participation from local government bodies helped prevent the healthcare system from becoming overburdened. The price of distribution per net was equivalent to that of other public health initiatives. ITN ownership and use grew dramatically for the intended beneficiaries, especially among rural communities. ITN ownership as well as utilisation will improve in 2010–2011 as a result of the planned universal LLIN deployment and additional behavioural modification communication.

“Durability of long-lasting insecticidal nets (LLINs) in Ethiopia” - Honelgn Nahusenay Hiruy, Seth R. Irish, Semira Abdelmenan, Yonas Wuletaw, Ayele Zewde, Adugna Woyessa, Mebrahtom Haile, Sheleme Chibsa, Lena Lorenz, Alemayehu Worku, Josh Yukich, Yemane Berhane & Joseph Keating, 26 March 2023: Due to significant attrition rates and a quick loss of physical integrity, the LLIN survival period was less than the predicted three years. To guarantee that LLINs offer an adequate level of defence against malaria transmission, national malaria programmes may think about buying more robust LLINs, teaching communities on how to minimise LLIN damage, and changing the present three-year distribution timetable for LLINs. While this article advances knowledge of parameters influencing functional survival, more investigation is required to identify the causes of LLINs' fast rate of attrition and lack of structural integrity in field environments.

“Evaluation of Long-lasting insecticidal nets (LLINs) for malaria control in an endemic area in Brazil” - Ana Cristina da Silva Ferreira Lima, Allan Kardec Ribeiro Galardo, Josiane Nogueira Müller, Ana Paula Sales de Andrade Corrêa, Kaio Augusto Nabas Ribeiro, Guilherme Abbad Silveira, Andrea Valladão Hijjar, Luiz Guilherme Soares da Roch Bauzer & José Bento Pereira Lima, 12 May 2023: Compared to the LLIN treated with permethrin, the LLIN coated with alpha-cypermethrin was more effective. The findings show that proper usage of mosquito nets—and therefore, population protection—needs to be backed up by health promotion initiatives. For this vector control method to be effective, several measures are thought to be crucial. To effectively support the proper application of this technology, more studies that take into account the monitoring of mosquito net deployment are required.

“Efficacy of Pyrethroid–Pyriproxyfen and Pyrethroid–Chlorfenapyr Long-Lasting Insecticidal Nets (LLINs) for the Control of Non-Anopheles Mosquitoes: Secondary Analysis from a Cluster Randomised Controlled Trial (cRCT)” - Constantin J. Adoha, Arthur So, Boulais Yovogan, Bruno Akinro, Manfred Accrombessi, Edouard Dangbénon, Esdras M. Odjo, Hermann Watson Sagbohan, Casimir Dossou Kpanou, Gil G. Padonou,

Louisa A. Messenger, Clément Agbangla, Corine Ngufor, Jackie Cook, Natacha Protopopoff, and Martin C. Akogbéto, 27 April 2023: Chlorfenapyr and pyriproxyfen, two innovative insecticides used in mosquito nets to suppress Anopheles mosquitoes, may not be effective against Culex species and Mansonia species. For the purpose of effectively controlling the growth of Culex spp. and Mansonia spp., more laboratory tests are required to establish the dosage of these insecticides utilised on mosquito nets. However, the decrease in density following net dispersion over all three arms would indicate that pyrethroids (alpha-cypermethrin) are still efficient against these species. For the management of these mosquito species in places where they are exophagic or attack equally indoors and outside, outdoor control measures may also be taken into consideration.

“Long-lasting insecticidal nets (LLINs) use among household members for protection against mosquito bite in Mogadishu districts” - Ahmed Aweis, Abdinur A. Salad, Fathi A. Araye, Abdifatah M. Ahmed, Osman A. Wehlie, Ali Abdirahman Osman, Isaiah Gumbe Akuku, March 16, 2023: Because not enough households in the research area owned LLINs, it was difficult for households to use them. As a result, the universal protection goal of making sure no less than ninety per cent of households possess an LLIN in these areas has not been met; if this fails to be monitored, it could undermine the advancements achieved in malaria control measures. However, thanks in great part to freshly purchased nets, the objective of guaranteeing that at least 80% utilise at least one LLIN per two individuals was reached. Despite inadequate ownership and availability, the limited use of LLIN demonstrates a population-level willingness to use them. The study has also shown that barriers to LLIN use include large households, older LLINs, the poor physical integrity of the nets, ignorance of the causes of malaria or its preventative measures, household heads who are not partnered, as well as misconceptions about the residents' relatively low susceptibility to malaria infection. Due to the enormous number of households lacking LLINs, facility-based uninterrupted dissemination and mass distribution campaigns will likely continue to be important, particularly for government and partner organisation programmes. However, in order to maintain coverage and replace worn-out nets, efforts to increase willingness to pay for LLINs must be stepped up. Frequent sample surveys need to be conducted to gauge net use in Mogadishu areas because the availability of freshly acquired nets was a driving factor in the utilisation of the nets.

“Effectiveness of three-year-old piperonyl butoxide and pyrethroid-treated long-lasting insecticidal nets (LLINs) versus pyrethroid-only LLINs against malaria infection: results of a cluster randomised trial in Tanzania” - Natacha Protopopoff, Jacklin F. Mosha, Louisa A. Messenger, Eliud Lukole, Jacques D. Charwood, Alexandra Wright, Enock Kessy, Alphaxard Manjurano, Franklin W. Mosha, Immo Kleinschmidt, Mark Rowland, July 07, 2022: After three years of use, PBO-LLINs no longer offered community protection against malaria infection compared to std-LLINs due to low net consumption. Children who continued to sleep under PBO-LLINs had a reduced risk of infection than children who slept under a standard-LLIN, but the incidence remained too high. For this kind of LLIN to have the greatest impact, it is critical that net dissemination frequencies and effective lifetime be in alignment.

“Malaria control initiatives that have the potential to be game-changers in India's quest for malaria elimination” - Manju Rahi and Amit Sharma, May 28, 2022: The researchers could conclude that India confronts a number of obstacles and hurdles on its path to eradicating malaria by 2030, despite the fact that the country's malaria load has been steadily declining. The difficulties include the lack of a platform for the digital integration of data, the incomplete paper-based aggregated surveillance, the absence of private sector participation, and the requirement for more accurate diagnostic tools. The removal of P. vivax malaria is further complicated by poor primaquine compliance and the presence of G 6 PD deficiency. Malaria medication and pesticide resistance continue to pose a serious threat to the entire planet. Additionally, the effectiveness of existing vector control techniques is decreased by outdoor malaria transmission and vector behavioural changes. An obstacle to the successful implementation of the lessons learned and the evidence produced by other organisations operating in this sector is the lack of cooperation and synergy between the national malaria programme as well as other participants in the field. We have put out a number of ideas

and proposals that may prove to be game-changers in India's fight against malaria and may propel India closer to malaria eradication.

“Impact of long-lasting insecticidal nets on resting and feeding behaviour of *Anopheles fluviatilis* and *Anopheles culicifacies* (Diptera: Culicidae), the vectors of malaria in East- Central India” - S. S. Sahu, K. Gunasekaran, A. N. Shriram, D. K. Panigrahi, Mohammed Mustafa Baig, N. Krishnamoorthy, A. Mathivanan, B Vijaya Kumar, Manju Rahi, Ashwani Kumar, 3 May 2023: LLINs were found to be extremely effective in decreasing the population density of *An. fluviatilis*, causing a change in its resting habits from human homes to cattle sheds, and changing its feeding habits from humans to animals. They were also found to change the composition of their sibling species, causing a greater abundance of species 'T' than 'S' and almost eliminating the infection rate. LLIN use had no effect on *An. culicifacies* with regard to any of the aforementioned factors. In all of the LLIN-distributed districts in east-central India, there was a noticeable decrease in the number of malaria cases. The community must continue to utilise LLINs in light of the behavioural changes seen in *An. fluviatilis*, the primary malaria vector.

“Equity in long-lasting insecticidal nets and indoor residual spraying for malaria prevention in a rural South Central Ethiopia” - Alemayehu Hailu, corresponding author Bernt Lindtjørn, Wakgari Deressa, Taye Gari, Eskindir Loha, and Bjarne Robberstad, 2016: While homes were evenly sprayed, LLIN coverage was low and much more likely to belong to wealthy households. Based on data from continuous monitoring, periodic replenishment of LLINs should be implemented after the present mass gratuitous distribution of LLINs.

“Free distribution of insecticidal bed nets improves possession and preferential use by households and is equitable: findings from two cross-sectional surveys in thirteen malaria endemic districts of Bangladesh” - Syed M Ahmed, Shamim Hossain, Mohammad M Kabir, and Sanjit Roy, 2011: During the study period, there has been a significant improvement in the possession and use of insecticidal bed nets, particularly among both of the most susceptible populations (under-five children and pregnant women). This improvement includes a narrowing of the gaps between the deficit and non-deficit households as well as the high and low endemic districts.

Research Methodology:

The methodology of research is a means to describe how a researcher plans to conduct their investigation. It is a rational, systematic approach to a study topic. A methodological framework explains how a researcher will execute the study in order to get accurate, legitimate data to achieve the objectives they have established. It includes the data they will gather, where they will get it, how they will get it, and how they will analyse it.

A methodology offers the study credibility and yields reliable scientific results. Additionally, it presents a thorough strategy that aids in keeping researchers on the course, facilitating a simple, efficient, and manageable approach. The reader may comprehend the strategy and procedures utilised to arrive at results by understanding the researcher's methodology.

Types of Research Methodology

1. Descriptive Research

A population, scenario, or phenomenon is intended to be correctly and methodically described through descriptive study. What, where, when, and how inquiries can be answered, but why questions cannot. A descriptive research strategy can study one or more variables using a wide range of research techniques. When the goal of the study is to discover traits, frequencies, trends, and classifications, descriptive research is the most effective option. When little is understood about the subject or issue, it is beneficial. Understanding how, when, and where something occurs is necessary before you can investigate why it occurs.

2. Exploratory Research

Exploratory research is a technical approach that looks at research issues that haven't been thoroughly examined before. Exploratory research frequently has a qualitative primary focus. Nevertheless, research with a sizable sample

size that is exploratory in nature might also be quantitative. Due to its adaptable and open-ended character, it is also frequently referred to as interpretative research or a theoretically grounded method. When a particular issue needs to be investigated for the first time or when gathering data is difficult for any other reason, exploratory research is frequently performed. If you wish to investigate a broad concept or a particular subject, but there is no prior information or paradigm that allows you to do so, you can employ this sort of research.

Statistical Tools Adopted:

In this paper, with the help of different graphs and chart presentations, the data was evaluated.

Sampling Technique:

A general questionnaire consisting of 18 questions was prepared with the objective of collecting data on the most important attributes for analysis.

Hypothesis

The hypothesis proposed here is as mentioned below.

H0 - Long-lasting insecticidal nets do not help reduce the prevalence of Malaria in a region.

H1 - Long-lasting insecticidal nets help reduce the prevalence of Malaria in a region.

Data Types and Sources:

1. Primary Data

The term "primary data" refers to information that has been collected directly by the researcher. The primary data is gathered in accordance with the goals outlined by the study. A small proportion of the population is chosen as a sample for the purpose of gathering primary data, and experiments and surveys are conducted on this sample to provide the desired findings. Research tools such as questionnaires, in-person interviews, behavioural observations, one-on-one talks, online and offline surveys, etcetera. are used to gather the main data.

2. Secondary Data

Secondary data is information that was gathered earlier by another individual. Journals, government databases, UN databases, databases offered by the analytics firm, financial data supplied by the companies, etc. are examples of sources from which one may obtain accurate data.

Population:

Group of maximum people having knowledge of malaria and long-lasting insecticidal nets to which the findings are generalised.

Sampling Frame:

For performing non-profitability sampling randomly, a list of different people belonging to various professions was generated from a selected area.

Sample Size:

Sample size of 70 respondents was selected for the meaningful study.

Study Area:

The study is conducted throughout the city of Mumbai, India and Gujarat, India. Mumbai being the finance capital, is expected to have knowledge about the several economic factors affecting the city. Mumbai and Gujarat are both regions with a large number of cases of Malaria.

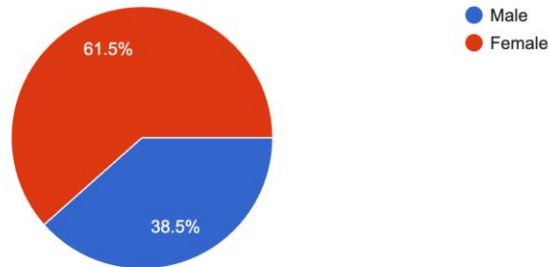
Limitations:

1. The respondents lack of knowledge to the questions in the questionnaire.
2. The research method of a questionnaire relies on self-reporting, which can lead to concerns of the accuracy and validity of the data.
3. Social desirability bias may be present when respondents were answering questions on the questionnaire.
4. The questionnaire does not provide in-depth insights into participants thoughts, feelings and experiences.
5. The sampling technique used was snowball sampling, this can lead to lack of representativeness in the sample that may make it difficult to generalize the findings.

Data Analysis and Presentation

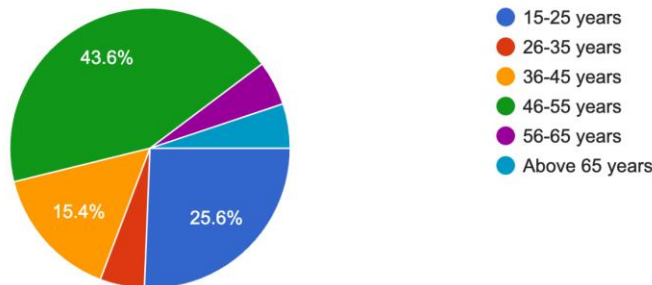
I CONDUCTED A SURVEY: QUESTIONNAIRE METHOD AND RESULTS WERE AS FOLLOWS:
THERE WERE 39 RESPONSES TO THE COMPULSORY QUESTIONS ASKED BELOW:

What is your gender?
39 responses



61.5% of the people who filled this form were primarily females whereas, 38.5% were males.

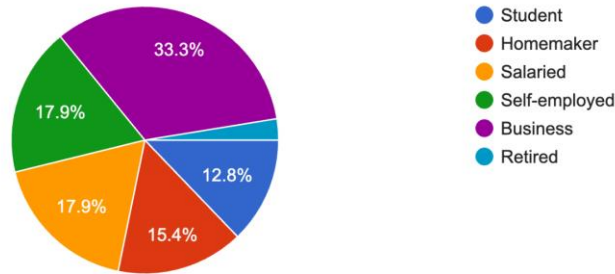
What is your age?
39 responses



The majority of people who completed this survey were between the ages of 46 and 55 years old, with 25.6% being those younger and falling in the age bracket of 15-25 years. Only 15.4% of individuals were in the age group of 36-45 years old.

What is your profession?

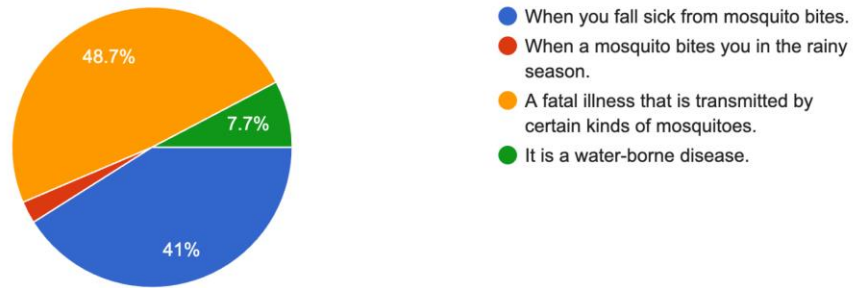
39 responses



Individuals who responded to this survey had a variety of professions from the majority being part of a business (33.3), self-employed and salaried (17.9% each), and a part of homemakers (15.4%).

According to you, What is Malaria?

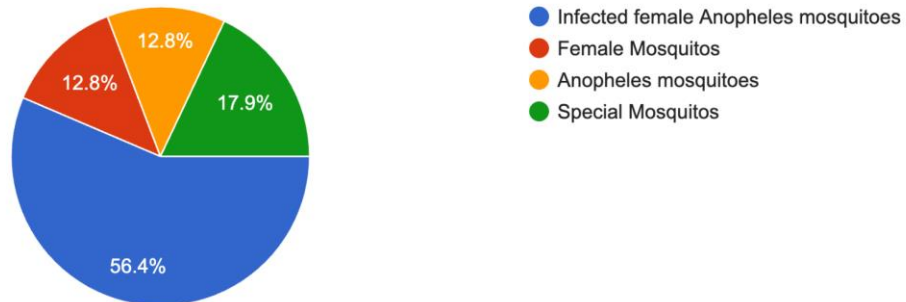
39 responses



48.7% of people surveyed believed that Malaria is a fatal illness that is transmitted by certain kinds of mosquitos. On the other hand, a large group of people (41%) believed that Malaria is when you fall sick from mosquito bites.

What do you think transmits Malaria?

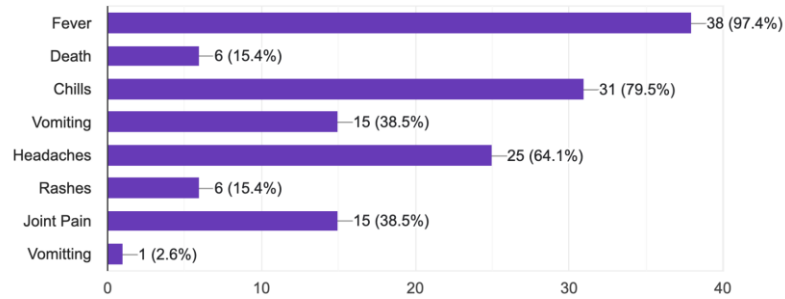
39 responses



The majority of people (56.4%) believed that infected female Anopheles mosquitoes transmitted Malaria. However, several individuals (17.9%) also believed that special mosquitos transmit malaria.

What are the symptoms of Malaria?

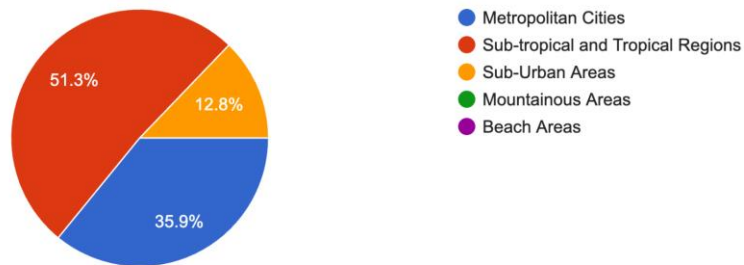
39 responses



The majority of survey takers selected fever as a symptom of malaria (97.4%) and a large group of people also selected chills as a symptom (79.5%). However, only one person believed vomiting to be a symptom of Malaria.

In your opinion, where is Malaria most found?

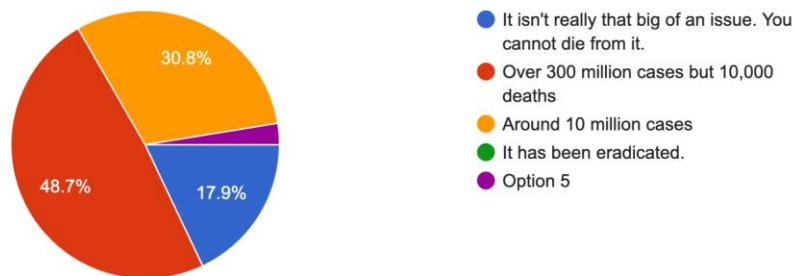
39 responses



Around half (51.3%) of the participants think that Malaria is most found in sub-tropical and tropical regions with many believing that it is most found in metropolitan cities (35.9%).

What do you think is the prevalence of Malaria in the world today?

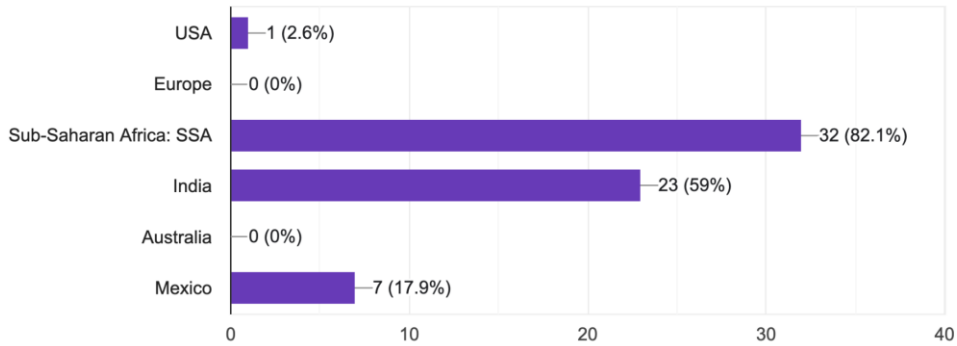
39 responses



Almost half (48.7%) of the survey takers believed that over 300 million cases of Malaria are there in the world today, as well as 10,000 deaths. A large group of people (30.8%) in fact believe that there are around only 10 million cases of Malaria in the world today.

According to you, in what parts of the world is Malaria most present in?

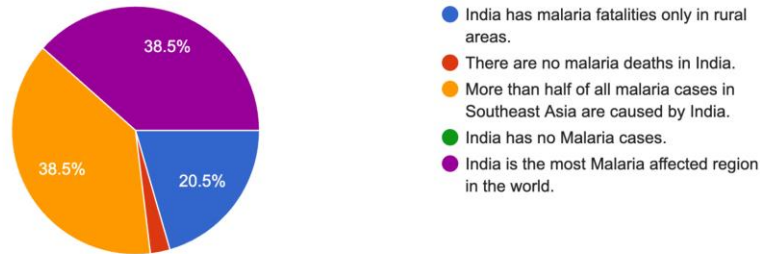
39 responses



According to the participants, Malaria is most present in the Sub-Saharan Africa region (82.1%) and in India (59%). No individual believes that Malaria is the most present in Europe or Australia.

In your opinion, what is the prevalence of Malaria in India?

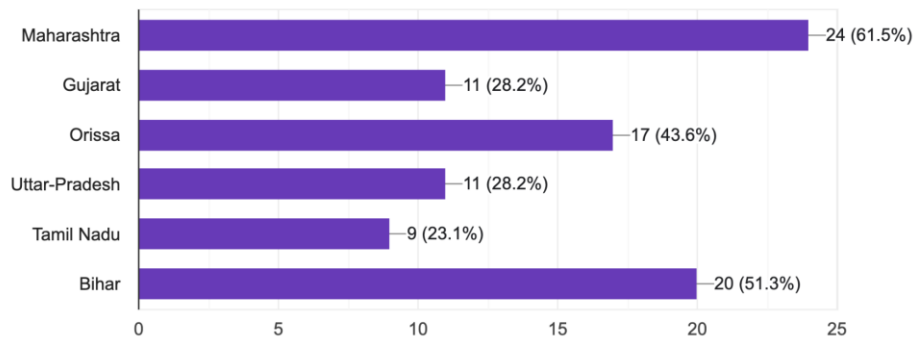
39 responses



The same number of survey takers believe that India is the most affected region in the world and that more than half of all malaria cases in Southeast Asia are caused by India (38.5%). However, 20.5% of test takers believe that India has malaria fatalities only in rural areas.

From your point of view, what regions in India are the most affected by the Malaria disease?

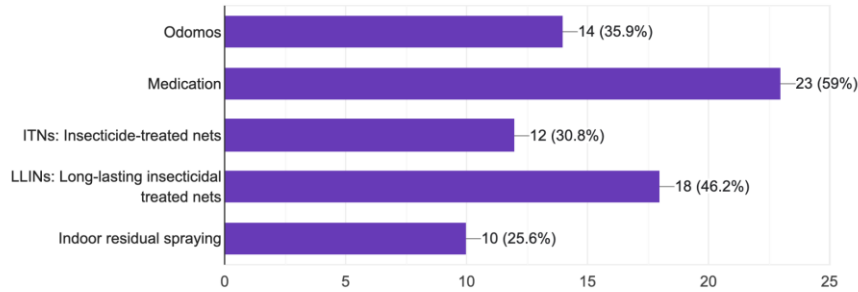
39 responses



61.5% of individuals believe that Maharashtra is the most affected by the Malaria disease in India. And 51.3% think that Bihar is the most affected region with only 23.1% of individuals believing that Tamil Nadu is most affected by this disease.

What are the Possible Solutions to Malaria that you are aware of?

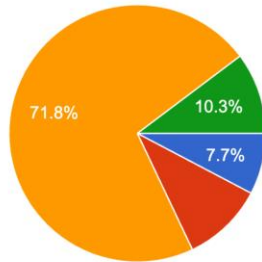
39 responses



Most people are aware of the solution of medication against Malaria (59%), as well as 46.2% being aware of LLINs.

What do you think ITNs/LLINs are?

39 responses

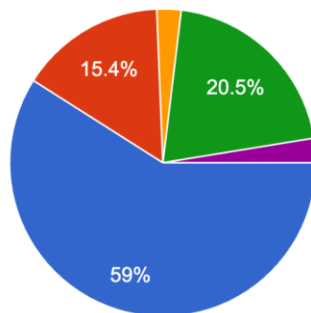


- Forms of vector management solutions.
- Cotton bed nets that serve as a physical barrier from insects.
- Nets with a physical and chemical barrier from insects.
- Nets that only kill mosquitos that try to pass through.

71.8% of participants think that LLINs/ITNs are nets with a physical and chemical barrier from insects. However, 10.3% of people believe that these nets only kill mosquitos that try to pass through.

What do you believe to be the impact of the usage of LLINs?

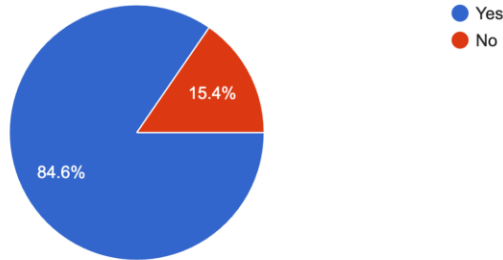
39 responses



- LLIN usage decreased the overall prevalence of malaria by 50% in sub-Saharan Africa.
- UNICEF has distributed over 275 million mosquito nets since 2012.
- UNICEF declared that the nets are a failed solution.
- They are not affordable, and thus fail to act as an effective solution where they are used.
- UNICEF declared that they are a failed solution.

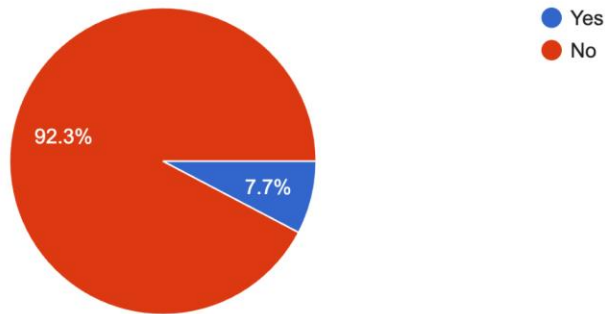
59% of individuals believed that LLIN usage decreased the overall prevalence of Malaria by 50% in the SSA. On the other hand, 20.5% of participants believe that they are not affordable and thus fail to act as an effective solution where they are in need.

Have you had/known someone who has had malaria?
39 responses



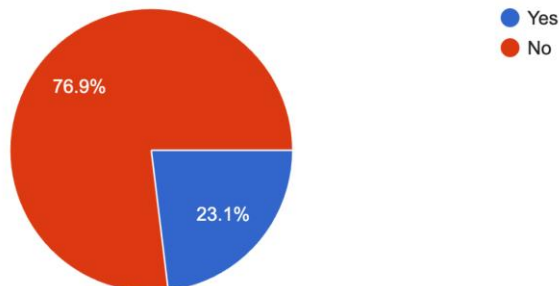
84.6% of test takers had/know someone who has had malaria. 15.4% did not have or know someone with Malaria.

Have you used/known someone that has used an ITN or a LLIN?
39 responses



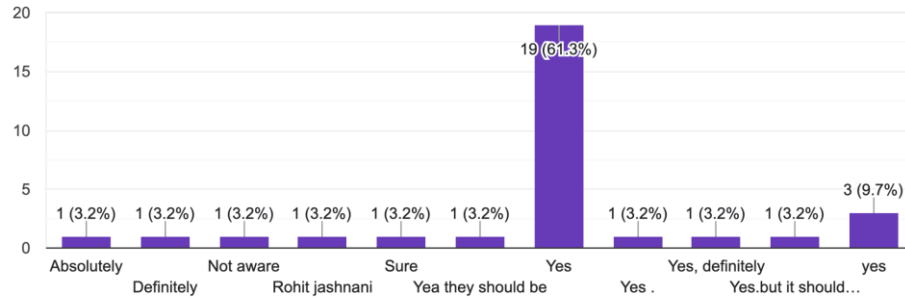
92.3% of participants did not use or know someone who used an ITN or a LLIN. Only 7.7% of participants did own a net themselves or knew someone who did.

Did you know about ITNs/LLINs before this form?
39 responses



The majority of participants, 76.9%, did not know about ITNs/LLINs before this survey. Only 23.1% of participants did know about this solution.

If LLINs have been proven to be an effective solution in eradicating Malaria and its economic consequences, do you think they should be provided to areas in need in India?
31 responses



Almost all participants believe that LLINs should be provided to areas in need in India, around 93.6%.

CONCLUSION AND SUGGESTIONS

Despite governmental efforts to eradicate Malaria, India still imposes a large part of the global Malaria burden. Nevertheless, cases have begun to decrease, but not fast enough. Long-lasting insecticidal nets have been proven to be an effective and durable solution to combat Malaria and eventually eliminate the epidemic. The nets are both a physical and chemical barrier against the mosquitoes, killing them once and for all, reducing the population of the infected insects. There are a high number of people suffering, beyond what is reported and this must be accounted for and battled against.

There are second-generation LLINs that show even more promise and advancement towards eradicating Malaria. However, the issue is that not enough nets are being supplied to the regions in need in India. These mosquitoes do not only attack in rural areas but in cities as well, nevertheless, the nets are just not made affordable to those in lower-income brackets. Due to the low supply, prices rise, and these nets are not being utilised to their best capability. There is high demand for this solution, and for good reason. Even after supplying, individuals must be educated on how to best use the net for the longest amount of time to make sure it is being used to its full potential.

It is necessary to implement an agenda to manufacture these nets at a high quantity that is in demand, provide them to those in need at lower costs, and educate these citizens on the best way to utilise these nets to achieve the maximum effectiveness. Through this process, the long-lasting insecticidal nets will reduce the cases and deaths of Malaria, all over India, at a high rate. Consequently, one day this will be an opportunity to eradicate the risk of Malaria from the country.

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Appendix:

Questionnaire

Q1. What is your gender? *

- Male
- Female
- Other

Q2. What is your age? *

- 15-25 years
- 26-35 years
- 36-45 years
- 46-55 years
- 56-65 years
- Above 65 years

Q3. What is your profession? *

- Student
- Homemaker
- Salaried
- Self-employed
- Business
- Retired
- Other

Q4. According to you, what is Malaria? *

- When you fall sick from mosquito bites.
- When a mosquito bites you in the rainy season.
- A fatal illness that is transmitted by certain kinds of mosquitoes.
- It is a water-borne disease.

Q5. What do you think transmits Malaria? *

- Infected female Anopheles mosquitoes
- Female Mosquitos
- Anopheles mosquitoes
- Special Mosquitos

Q6. What are the symptoms of Malaria? *

- Fever
- Death
- Chills
- Vomiting
- Headaches
- Rashes
- Joint Pain

Q7. In your opinion, where is Malaria most found? *

- Metropolitan Cities
- Sub-tropical and Tropical Regions
- Sub-Urban Areas
- Mountainous Areas
- Beach Areas

Q8. What do you think is the prevalence of Malaria in the world today? *

- It isn't really that big of an issue. You cannot die from it.
- Over 300 million cases but 10,000 deaths
- Around 10 million cases
- It has been eradicated.

Q9. According to you, in what parts of the world is Malaria most present in? *

- USA
- Europe
- Sub-Saharan Africa: SSA
- India
- Australia
- Mexico

Q10. In your opinion, what is the prevalence of Malaria in India? *

- India has malaria fatalities only in rural areas.
- There are no malaria deaths in India.
- More than half of all malaria cases in Southeast Asia are caused by India.
- India has no Malaria cases.
- India is the most Malaria affected region in the world.

Q11. From your point of view, what regions in India are the most affected by the Malaria disease? *

- Maharashtra
- Gujarat
- Orissa
- Uttar-Pradesh

- Tamil Nadu
- Bihar

Q12. What are the Possible Solutions to Malaria that you are aware of? *

- Odomos
- Medication
- ITNs: Insecticide-treated nets
- LLINs: Long-lasting insecticidal treated nets
- Indoor residual spraying

Q13. What do you think ITNs/LLINs are? *

- Forms of vector management solutions.
- Cotton bed nets that serve as a physical barrier from insects.
- Nets with a physical and chemical barrier from insects.
- Nets that only kill mosquitos that try to pass through.

Q14. What do you believe to be the impact of the usage of LLINs? *

- LLIN usage decreased the overall prevalence of malaria by 50% in sub-Saharan Africa
- UNICEF has distributed over 275 million mosquito nets since 2012.
- UNICEF declared that the nets are a failed solution.
- They are not affordable, and thus fail to act as an effective solution where they are in need.

Q15. Have you had/known someone who has had malaria? *

- Yes
- No

Q16. Have you used/known someone that has used an ITN or a LLIN? *

- Yes
- No

Q17. Did you know about ITNs/LLINs before this form? *

- Yes
- No

Q18. If LLINs have been proven to be an effective solution in eradicating Malaria and its economic consequences, do you think they should be provided to areas in need in India?
