Indoor Residual House Spraying (IRS)
The Basics

(Photographer – Francois Maartens (MRC-SA), Namaacha, southern Mozambique, 2000)

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Introduction and Background to Indoor Residual Spraying (IRS)

Malaria is one of the oldest diseases known to mankind. Descriptions of "deadly fevers", a classic symptom of the disease can be found in the ancient Chinese, Indian and Egyptian manuscripts dating back to 5000-6000 B.C. References are also made in the Vedic writings of 1600 B.C in India, but Hypocrites was the first to describe the manifestations of the disease and relate them to a time, 2500 years ago.

In 1897, Dr. Ronald Ross discovered malaria cysts in the stomach wall of the Anopholine mosquito that fed on a malaria patient. The following year, Giovanni Babtista Grassi, an Italian scientist established that malaria was transmitted by the Anopheles mosquito. This discovery was significant and the transmission of the "deadly fever" or malaria was known for the first time. These discoveries would change the way malaria was controlled and the malaria vector mosquitoes breeding sites were targeted to prevent malaria infections.

Drainage of stagnant water to destroy the breeding sites of the highly effective Anopheles malaria vector proved to be reasonably effective in Europe. In 1928, the Greek government began major drainage programs to address the malaria problem in the county. Marshy plains and even lakes were drained in an effort to control malaria transmission by drying up possible breeding sites of the mosquitoes

The first trials of IRS to target the adult malaria vector took place in South Africa in 1932. The results were so encouraging that the IRS vector control method spread across the globe. IRS became the backbone of international malaria control and the method was extensively and successfully used in the malaria eradication campaigns between 1955 and 1970. The publishing of the book "Silent Spring" by Rachel Carson in the 1960's caused an interventional outcry against the use of DDT in the agricultural sector but international pressure could soon be felt on IRS in occupational health.

Today, malaria has a devastating effect on economic development throughout the world and continues to impair the world's poorest developing countries. Malaria is a serious public health problem in more than 90 countries and affects 40% of the world's population. Mortality due to malaria is estimated to be over one million deaths each year that equates to 3000 child deaths per day or one child every 30 seconds.

Questions and Answers

What is malaria?

Malaria is an infectious disease caused by the parasitic infection of red blood cells by a protozoan, which is transmitted by the bite of an infected female malaria vector mosquito.

What does malaria mean?

The name malaria is a Latin word meaning bad air; the early Romans associated the deadly fever with swamps and the bad smell that came from the swamps.

What is a malaria vector?

A malaria vector is specific mosquito specie that has the ability to carry the malaria parasite and then spread the parasite to humans.

The epidemiological definition of a malaria vector is: "*An organism that does not cause disease itself but which spreads infection by conveying pathogens from one host to another.*"

Are mosquitoes born with malaria?

No mosquitoes are born with the malaria parasite; a malaria vector needs to bite a malaria infected person before they can transmit the disease to other humans. The percentage of malaria infected people in a population and the density of malaria vectors determines your risk of contracting the disease.

What is mosquito density and how is it measured?

Mosquito density refers to the abundance of mosquitoes, specifically malaria vector mosquitoes in an area. Mosquito density can be determined in the following ways.

Window traps - A window trap is a device that is installed in a window that catches all mosquitoes that enter and exit houses.

Knock down – A sheet is placed over the floor and furniture in a house. Pyrethrum is then sprayed in the house to kill all insects. After spraying, the sheet is then examined and the mosquitoes are identified and counted. By analyzing the mosquitoes, the mosquito density and mosquito specie composition can be determined.

Do all mosquitoes have the ability to transmit malaria?

There are over 3000 different mosquito species in the world and only 40 are malaria vectors. Mosquito species have diverse behavioral characteristic and it is important to understand their feeding preference and resting patterns so that the most effective and appropriate malaria control intervention can be selected. Some mosquito species feed primarily on animals (zoophilic) and others seek out humans for their blood meal (anthropophilic). Some species live (exophilic) and bite outdoors (exophagic) while others fly into houses (endophilic) and feed indoors (endophagic).

What is IRS?

Indoor residual house spraying (IRS) is a malaria control intervention targeted at the malaria vector mosquito. Trained spray operators equipped with hand held pumps, spray the inside surface of the walls with a residual insecticide. The insecticide then dries and forms a crystalline deposit on the sprayed surface.

Why IRS?

IRS is a proven effective World Health Organisation-recommended malaria control intervention. The main aim of IRS is to kill and/or repel the malaria mosquito from houses so that the mosquitoes cannot bite and transmit malaria to the inhabitants. Human vector contact is thus prevented causing a break in the malaria transmission cycle.

How does it work?

The insecticides used in IRS effects the malaria vector mosquitoes in several ways. When a house is sprayed mosquitoes are repelled and deterred from entering and biting.

The **deterrent** or **spatial repellency** effect deters and repels mosquitoes from entering sprayed houses. The **excito-repellent effect** causes discomfort to mosquitoes that do enter houses and that come into contact with the sprayed surface causing the mosquitoes to either die or to exit before biting. **Toxicity** of a residual insecticide kills mosquitoes on contact thus reducing the mosquito population and mosquito density in an area. By reducing the lifespan of the malaria vectors malaria transmission is interrupted by reducing human, vector contact.

Where do you spray?

The answer is in the name: indoor residual house spraying takes place indoors, residual insecticide is applied on the inside walls of houses. There are a number of reasons why insecticide is applied indoors only.

1. The application of residual insecticide indoors maximizes the protection to the inhabitants, preventing or repelling mosquitoes from entering houses and killing mosquitoes that do enter and come into contact with the sprayed surfaces.

2. Many malaria vectors bite and rest indoors, IRS targets these malaria vectors by applying insecticide against the walls.
3. The residual effect of the insecticide is prolonged when it is applied on the inside walls of houses because it is kept in a relatively cool and dry environment and out of direct sunlight that decreases the repellency and toxicity of insecticide.
4. By applying insecticide indoors it is kept out of the physical environment eliminating possible negative environmental contamination.

(Photographer – Francois Maartens (MRC-SA), Mbazwana, KwaZulu-Natal 2002)

When do you spray?

The timing of spraying operations varies according to your geographical location. Climatic factors such as rainfall and temperature dictate to a large degree when the malaria season starts and ends and thus when spraying commences and stops. In equatorial regions malaria transmission is year round and in other area malaria transmission is seasonal.

How often do you spray?

The frequency of spraying depends on the insecticide used in IRS due to varying degrees of efficacy (effectiveness) and it depends on the surface the insecticide is sprayed on. Typically the walls of houses in rural areas in Africa are made from either mud or reed. In urban and semi urban areas walls are predominantly made from brick or plastered cement. Some insecticides remain effective for up to a year and others can remain

effective between three and six months. If an insecticide is effective for a year, IRS will take place once a year and if an insecticide is effective for three or six months then two to three spray rounds a year is required for effective malaria control. The frequency of spraying has a direct influence on the cost of the malaria control program.

What do you spray with?

Insecticides are used in IRS malaria control interventions. All insecticide used in IRS malaria control originates from the agricultural sector and can be divided into the following groups:

Organophosphates
Carbamates
Pyrethroids
Organochlorines

Several factors need to be considered before an insecticide is selected for IRS such as vector susceptibility (vulnerability), residual effect (how long the insecticide is effective), repellency, availability, cost and safety.

What is rotational spraying?

Rotational IRS spraying is a very effective measure to control the buildup and development of mosquito insecticide resistance. Malaria control programs would alternate the different insecticides used in IRS to minimize exposure that mosquitoes have to the insecticides used in IRS programs. By alternating insecticides on an annual or bi-annual basis insecticide resistance can be prevented and managed if and when it develops in the mosquito population.

Do the communities approve of IRS?

IRS malaria control is popular amongst communities; it is common to find very high malaria parasite prevalence (30% to 90%) amongst communities before malaria control is introduced into an area. Once a house is spayed there are notably fewer mosquitoes that enter a house and therefore greatly reduced malaria transmission. Acceptance rates amongst communities are high once the importance of IRS is experienced, realized and explained. Information, education and communication (IEC) is however needed on an ongoing basis to sustain high levels of IRS acceptance.

Are communities educated?

Before IRS spraying starts a knowledge, attitude and practice (KAP) survey should be conducted to asses the communities' knowledge on malaria. Once this is determined a focused education campaign should be launched to educate the local community on malaria and the importance of IRS. IEC and KAP are a vital part of malaria control. Communication between the health authorities and the communities are important and

constant feedback should be given to the communities as malaria control progresses. It is vital to involve community leaders and it improves the trust and communication between the malaria control program and the communities.

Who are the spray operators?

The most successful IRS malaria control programs make use of local men and woman and is revered to as community based praying. By recruiting local men and woman, communities take ownership of the malaria control intervention in their area. Work is created and all the men and woman that are recruited as spray operators are familiar to the local community reducing refusals when houses are sprayed.

What does IRS spray training involve?

Spray training is a two week process where men and woman are recruited out of the community and thoroughly trained in the following aspects.

Personal protection equipment
Correct application rate of insecticide
Mixing of insecticide
Pump maintenance
Storage of insecticide
Documenting spray coverage
Communication with the community and home owners

After two weeks of intensive training a practical exam is undertaken. Unsuccessful candidates are re trained and successful candidates are deployed back into their communities.

Is IRS safe?

Spray operators are equipped with a full overall, respiration mask, full facial visor, safety gloves and boots. Direct contact with the insecticide is minimized by the use of the above mentioned personal protection equipment and therefore it is safe.

IRS is also safe for the inhabitants of sprayed houses. For a specified period after spraying, usually not longer than a few hours, residents should not enter houses. The insecticides used in IRS are approved by the World Health Organisation and small amount of insecticide used is entirely safe for residents. Any discussion of safety must balance the real threat to health and well-being from deadly mosquitoes, which kill over one million people from malaria annually, with any threat from insecticides. Any rational balancing of these risks would conclude that the insecticides are safe and should be used to save lives.

What is spray coverage?

Spray coverage refers to the percentage houses sprayed in an area. The ideal situation would be to spray every single house; however, spray coverage's of 80% is seen as the gold standard for effective IRS malaria control.

How is spray coverage measured?

Once a house is sprayed, a copy of a spray card is left with the home owner indicating when and by whom the house was sprayed. After each day, the vector control manager will collect these spray cards from the spray operators and the information will be captured into a database. A record is then kept of each sprayed house and the spray coverage can be calculated after each spray round. Field supervisors can monitor and evaluate the spray progress by looking at the spray cards left in houses to determine if, when and by whom the house was sprayed.

Why is spray coverage important?

IRS is targeted at the malaria vector to break the human-vector contact. The higher the spray coverage of an area the more people are protected from the malaria vector thus breaking the malaria transmission cycle. The combined repellency effect of sprayed houses in an area disrupts the collective resting and feeding patterns of the mosquito population in the sprayed areas.

Why don't we do IRS everywhere?

Mosquito species have different characteristics with varying biting and resting habits and therefore the malaria control intervention is selected accordingly. If a malaria vector is endophilic (resting indoors) IRS is the most appropriate malaria control intervention. If a malaria vector is exophilic (resting outdoors but feeding and also resting indoors) IRS with insecticides that have good airborne effect can be successfully used. In areas where a malaria vector is exophilic and/or exophagic, (resting and feeding outdoors), other control methods such as exterior space spraying (for emergency control), environmental manipulation, drainages and vegetation clearing around houses should be considered.

Why the negative publicity?

Many successful IRS programs were victims of the international outcry against DDT use in the agricultural sector in the 1960s. The word DDT invokes emotional and sometimes irrational reactions and the negative publicity received many years ago still cloud perceptions today. Some people are ignorant and confuse and associate malaria IRS with DDT and more specifically agricultural aerial crop spraying.

There has been reluctance from the World Health Organisation and donors to fund IRS for many years. The negative press combined with the fact that successful IRS requires

substantial investment into the supporting public health systems has discouraged investment into this highly effective malaria control intervention.

Historically, tons of DDT was used in the physical environment as can be seen below.

FIGURE 18.—Stearman biplane applying DDT to control anophelines over Stuttgart, Ark., Army Air Base.

Currently, the application rate for DDT in malaria IRS is 2 grams per m^2 inside a house against a wall.

The first trials of residual house spraying took place in South Africa in 1932. Pyrethrum was the preferred insecticide for many years due to its toxicity but the discovery of the insecticidal properties of DDT by Paul Muller in 1939 had an unparalleled impact on malaria control worldwide.

The first IRS using DDT took place in 1942 in American and British army camps and soon after the first civilian IRS using DDT took place in Italy in 1944. The result was so encouraging that the World Health Organisation adopted the principal of malaria eradication in 1955. A global campaign was launched to eradicate malaria and excellent successes were achieved between 1955 and 1970. Europe saw the eradication of endemic malaria in Romania, Yugoslavia, the Netherlands, Italy, Bulgaria, Spain, Portugal, Poland and Hungary while North America, Australia, the former USSR, and some parts of Asia achieved similar successes in their respective countries.

Farmers were so impressed with DDT's success that they began using the insecticide on crops to kill pests. The widespread use of DDT fostered environmental pressure throughout the world. "Silent Spring" by Rachel Carson in 1962, caused an emotional

public reaction and marked the beginning of several environmentalist movements against the use of DDT.

DDT was banned in the agricultural sector in the United States in 1973 and soon after most other environmentalist groups turned their attention towards creating international pressure against the use of DDT in other sectors. Although the initial pressure was against the usage of DDT in the agricultural sector, opposition spread to the occupational health application of DDT in malaria control.

The effect of the ban on DDT in malaria control could clearly be seen with malaria emerging stronger than ever. In Sri Lanka, the number of malaria cases dropped from 2.8 million in 1948 to 17 in 1963 after DDT was used in residual house spraying. After spraying with DDT was stopped in 1964, the malaria cases began to rise again and reached 2.5 million in 1969. The same phenomenon could be seen in many other tropical and impoverished countries around the world.

The United Nations Environmental Programme is working towards global elimination of DDT together with other persistent organic pollutants, known as POPS. The Stockholm Convention came into force on 17 May 2004 after it was ratified by 50 countries. It has been hailed by environmentalists as a public health treaty, to protect public health from both DDT and malaria. Although DDT is banned for agricultural usage, it is exempted in the POPS treaty for disease vector control. Countries that have requested to do so are allowed to continue using DDT against malaria, until effective and affordable alternatives are available.

DDT is still being successfully used today in malaria control programs due to its cost per unit weight, its durability as a residual insecticide and its excellent repellency. DDT's long lasting residual effect on walls allows low income countries to apply the insecticide once a year compared to two spray rounds with other, more expensive insecticides like pyrethroids and organophosphates.

Some African countries that fund their own malaria control such as South Africa, Namibia, Botswana and Swaziland have weathered international opinion and maintained extremely successful IRS programs for several decades. Successful IRS malaria control by these countries has started to sway international attention back towards IRS. Funding for malaria control has increased substantially over the past few years with increasing interest by African countries to use IRS.

The DDT debate rages on with some first world countries that have used DDT in the past calling for the global elimination and banning of DDT use, while the impoverished third world countries that are ravaged by malaria are calling for the controlled use of DDT in public health.