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Problem Created Owing to Insects in Carrying Vector Borne Diseases and Combined Vector Control Approach

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Abstract

Vectors are living organisms that serve as vehicles to transmit a pathogen (a disease-causing agent like a virus or parasite) from a host to a human or to an animal or both, and vector-borne diseases are infectious diseases or illness transmitted through insects. This article combines practical information from successful vector control programs, including early use of chemicals and recent research into a vital resource for all involving in combating insect's vector borne diseases. Diseases transmitted by insects are continuing to have a major impact on human populations. Malaria, dengue, onchocerciasis, sleeping sickness and leishmaniasis all adversely affect humans. Malaria and dengue are one of the most important causes of adults and children mortalities, and reduce economic development in many countries, with agricultural productivity often greatly reduced, as many vectors are active in the wet season that is favourable for crop production. Vector control is crucial to reduce the extent to which drugs are needed to treat the diseases, as the parasite can become resistant, or the drugs are often too expensive for those living in rural and urban areas that are most affected by these diseases. In contrast to expenditure and effort on consultation, diagnostic, medicine and vaccine development, relatively little attention has been given to vector control in the past. Vector control is encouraging where insects control has been consistently applied in the past and the results have been dramatic especially with early efforts by sprayings inside surfaces of houses with insecticides. As a result, integrated vector management (IVM) is a process for managing vector populations in such a way as to reduce or interrupt transmission of disease. Characteristic features of IVM include methods based on knowledge of factors influencing local vector biology, disease transmission and morbidity, use of a range of interventions often in combination and synergistically, collaboration within the health sector and with other public and private sectors that impact on vectors, engagement with local communities and other stakeholders, and a public health regulatory and legislative framework. It covers the main chemical methods of vector control, including the use of indoor residual spraying, space treatments, use of treated bed nets and larviciding, but also stresses on the importance of drainage schemes and improvement of houses to prevent access of indoor vectors, and techniques that have largely been responsible for reducing the risk of vector borne diseases.

Keywords

Vector Control, Situation Analysis, Preventative Measure, Disease Management, Insect

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1. Introduction

Arthropods of medical importance include insects (class Insecta) and arachnids (class Arachnida). Of the arachnids, only mites and ticks (order Acarina) are vectors of diseases. Of the insects, five groups are of medical importance: true flies (order Diptera), true bugs (order Heteroptera, or

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Hemiptera), lice (order Anoplura), fleas (order Siphonaptera) and cockroaches (order Dictyoptera). Mosquitos and ticks the mainly blood-feeding arthropods are the main culprits; mosquitos can be vectors of malaria or dengue, and ticks can be vectors of lyme disease. This article provides an essential guide for physicians, public health officials, and pest control professionals on insects of medical importance and the health conditions they cause, and presents current recommendations for management and treatment of vectors (Olsen, 1998; Matthews, 2011).

2. Problem of Insects

Medically important insects are problematic in imposing diseases threat and serious losses in finance to treat the vector and diseases (Vreysen et al., 2000; Reiter, 2001; Emerson et al., 2001).

2.1. Hemiptera True Bugs Reduviidae

Assassin bugs or kissing bugs in the genera Triatoma and Rhodnius transmit a protozoan pathogen *Trypanosoma cruzi* that causes chagas disease in few areas of the world.

2.2. Phthiraptera Lice Pediculidae

Human lice *Pediculus humanus* and *P. capitus* spread *Borellia recurrentis*, which is a spirochaete pathogen and causes epidemic relapsing fever. They also carry the rickettsial pathogens that cause epidemic typhus *Rickettsia prowazeki* and trench fever *R. quintana*.

2.3. Diptera Flies Simuliidae

Black flies spread *Onchocerca volvulus*, which is a parasitic roundworm and onchoceriasis, and the disease caused by infestation of these worms may cause blindness in peoples.

2.4. Psychodidae Flies

Sand flies in the genus *Phlebotomus* are vectors of a bacterium *Bartonella bacilliformis* that causes carrion's disease (oroyo fever). In certain parts of world, they also spread a viral agent that causes sand fly fever (pappataci fever) as well as protozoan pathogens *Leishmania* spp., which cause leishmaniasis.

2.5. Ceratopogonidae

Punkies are the vectors of parasitic roundworms in several genera, including Acanthoc heilonema, Dipetalonema, Mansonella, and Onchocerca.

2.6. Culicidae

Mosquitoes in the genus Anopheles are the principle vectors of malaria, which is a disease caused by protozoa in the genus Plasmodium. The *Aedes aegypti* is the main vector of the viruses that cause yellow fever. Other viruses, which are the causal agents of various types of encephalitis, are also carried by Aedes spp., mosquitoes. The *Wuchereria bancrofti* and *Brugia malayi* that are parasitic roundworms cause filariasis, and are usually spread by mosquitoes in the genera Culex, Mansonia, and Anopheles. Dengue fever is among the most widespread vector-borne infectious diseases. The primary vector of dengue is the *A. aegypti* mosquito that is prevalent in the tropics and sub-tropics and is closely associated with human habitats. The power to identify the origin of new introductions of invasive vectors of human disease relies heavily on the availability of a panel of reference populations. The work demonstrates the importance of generating extensive reference databases of genetically fingerprinted human-disease vector populations to aid in public health efforts to prevent the introduction and spread of vector-borne diseases (Lounibos, 2002).

2.7. Tabanidae

Horse flies and deer flies may transmit the bacterial pathogens of tularemia *Pasteurella tularensis* and anthrax *Bacillus anthracis*, as well as a parasitic roundworm *Loa loa* that causes loiasis in few tropical areas.

2.8. Chloropidae

Eye gnats in the genus Hippelates can carry the spirochaete pathogen *Treponema pertenue* that causes yaws and may also spread conjunctivitis (pink eye).

2.9. Muscidae, Calliphoridae, Sarcophagidae

House flies of family Muscidae, blow flies family Calliphoridae, and flesh flies family Sarcophagidae often live among filth and garbage. They can carry the pathogens for dysentery (*Shigella dysentariae*), typhoid fever (*Eberthella typhosa*), and cholera (*Vibrio comma*) on their feet and mouthparts.

2.10. Glossidae

Tsetse flies in the genus Glossina transmit the protozoan pathogens *Trypanosoma gambiense* and *T. rhodesiense* that cause African sleeping sickness.

2.11. Blattidae

Cockroaches carry disease-causing organisms typically gastroenteritis as they forage, and their excrement and cast skins also contain a number of allergens causing responses such as watery eyes, skin rashes, congestion of nasal passages and asthma.

3. Problem of Vector-Borne Disease

Vector-borne diseases account for 17 percent of the estimated global burden of all infectious diseases. They have a significant negative impact on human and animal health, along with huge economic implications due to reduced human capacity and extra strain on health services. Some of the biggest threats today faced by mankind and one of the most important causes of adults and children mortalities are included here. Malaria has the biggest impact on human health. Despite a much percent reduction in malaria mortality rates due to improved control measures, malaria still kills one child almost every minute. Dengue fever incidences have grown dramatically around the world in recent decades. The World Health Organization (WHO) estimates that there may be 50-100 million dengue infections worldwide every year. River blindness, also known as onchocerciasis, is a parasitic infection spread by the bites of small black flies that breed in rapidly flowing rivers. It is one of the leading causes of preventable blindness in the world and endemic to 36 countries in Africa and Latin America. Chagas disease is spread by infected bugs and about 7 million to 8 million peoples are estimated to be infected worldwide, mostly in Latin America. This disease starts with swelling of the eyelids, fever and fatigue, but can lead to malnutrition, cardiac disorders and even heart failure. Sleeping sickness occurs in 36 sub-Saharan Africa countries where tsetse flies transmit the disease to humans. In cattle, the disease called Nagana, kills millions of cattle a year (Fish, 2001; Gubler, 2001; Lounibos, 2002; Sutherst, 2004; Rochon et al., 2005).

Insecticide resistance is an increasing problem in many insect vectors of certain diseases. The knowledge of the basic mechanisms underlying resistance to commonly used insecticides is well established. Molecular techniques have recently been allowed to start and dissect most of these mechanisms at the DNA level. The next major challenge will be to use this molecular understanding of resistance to develop novel strategies with which people can truly manage resistance. State of the art information on resistance in insect vectors of disease can be critically reviewed in this context globally (Hemingway and Ranson, 2000). Consequently, integrated vector management (IVM) is a process for managing vector populations in such a way as to reduce or interrupt transmission of disease.

4. Prominence of Vector Control

As the impacts of disease and pathogen are devastating on humans, the need to control the vectors in which they are carried is prioritized around the world. Vector control in many third world areas can have tremendous impacts as it increases mortality rates, especially among infants. Because of the high movement of the population, disease spread is also a greater issue in these areas. Given the dramatic impact, vector-borne diseases can have serious consequences on humans, and vector control must play a vitally important role in public health and livestock management programs. Without these interventions, dangerous diseases would proliferate unchecked, and with the increased movement of populations and livestock, the global spread of disease is a growing concern. Vector control is crucial to reduce the incidence of infection from diseases; this is especially important for those for which there is currently no effective cure or preventive medical measures available, such as dengue, west Nile and chikungunya viruses. Even for vector-borne diseases for which effective and targeted medical treatment exists, such as malaria, issues such as cost, delivery, correct diagnosis, drug resistance and other challenges make disease control incomplete through the use of medical drugs alone as an unrealistic alternative to disease prevention without vector control (Ranson, et al., 2011; Van den Berg et al., 2011; Thomas et al., 2012).

5. Methods of Vector Control

Vector control involves using preventive methods to eradicate or control vector populations in order to limit the transmission and spread of diseases. All these measures are important elements for an integrated approach to control the spread of vector borne diseases. The choice of the most appropriate method to use depends on the disease pattern and behavior of the vector. Methods of vector control can be categorized broadly into 2 broad categories like situational analysis and preventative measures (Curtis, 2000; Patz et al., 2002; 2005).

5.1. Situational Analysis

Globally, Integrated Vector Management is acknowledged as an important decision-making process to manage diseases, vectors and reduce reliance on chemical controls. For an effective implementation of IVM, the following holistic approaches must be taken:-

5.1.1. Local Determinants of Disease

For describing the local determinants of the disease, the providing of the following data is needed in the target are:-

5.1.2. Epidemiological Data

It is to describe what are the disease prevalence and incidence rates in the area, the number or kind of repeated episodes of disease per household and per person, the entomological human biting rates or inoculation rates, the status of other vector-borne diseases prevalent in the area that will be reduced by interventions, which proactive efforts will be made for optimal planning to maximize impact on prevalent vector borne diseases, what is the disease stratification, and does the country have up to date information on different diseases levels in different areas (high, moderate, low or none).

5.1.3. Vector Related Data

It needs what are the main vectors in the area, which species of vectors are prevalent, what is the status of insecticide resistance in vectors, the status of drug resistance in parasites, the seasonality of their occurrence, the local densities and fluctuations of the vectors, are dry season refuge areas known, is their biting and resting occurring mainly indoors or outdoors or is this unknown, and does biting occur partly in the early evening before peoples sleep or exclusively at night or is this unknown.

5.2. Demographic Data

It prerequisites what is the profile of disease cases in the community, the larger community statistical description, has a community-based physical mapping of the local population and disease characteristics, who are the local stakeholders that should be involved in that mapping exercise, where do vulnerable human groups live in relation to vector hot spots, what human behaviours are relevant to vector biting habits (for example adult and children sleeping patterns, use of bed nets), do vectors bite early evening or later when most peoples are in bed, which human populations live close, what is the nature and quality of community access to diagnostic and treatment services, how accurate is diagnosis (rapid diagnostic testing and microscopy), and how effective is the medication the peoples receive.

5.3. Environmental Determinants of Disease

Its fundamentals include what are the relevant meteorological data, the local land use (including nomadic land use), the local ecosystems, the seasonal pattern of local water use and spatial distribution of local water, which ecosystems are mostly associated with disease transmission (rural-agricultural, urban, riverine, coastal), and what are the breeding habitats and sites.

5.4. Technological Factors

Its essentials include policy environment (policies of government, regional administration or local government have direct or indirect impact), institutional arrangements and capacities (institutional arrangements are in place for operationalizing the policy instruments), what capacities or human resources are available for planning, implementation, evaluation), political environment (the political agendas of various stakeholder groups with respect to disease control in the community), and in what way do these different political agendas align or oppose each other.

5.5. Information Gaps

What information is available and what is not available, and what gaps need to be covered by the plan.

5.6. Preventative Measures

A sustainable and long-term IVM approach can improve living conditions and at the same time the development in vast stretches of vector borne disease endemic areas (Ownson et al., 2005; Weber et al., 2013), wherein the strategy includes the following:

5.6.1. Important Entomological Information

Vector related data focus on what are major vector species identified and which molecular forms are available, what are the biting and resting behaviors of vector, what are the breeding habitats and sites, is the biting, feeding and resting behaviors of the major vector species known, is it known that vectors mainly but not always feed indoors or outdoors, what is the situation in the country, and what is the vector resistance status including resistance mechanisms and potential for cross resistance.

5.6.2. Mechanical Control Methods

It is the house improvement including screening of eaves, improved sanitation, use of long sleeved shirts, bed nets (avoid human-net contact), insect screens and use of traps.

5.6.3. Habitat Control

It includes removing or reducing areas where vectors can easily breed and can help to limit population growth, for example, stagnant water removal, destruction of old tires and cans which serve as mosquito breeding environments, and good management of used water can reduce areas of excessive vector incidence. Removing or reducing the number of places where the vector can breed helps to limit populations from growing excessively, for example, by removing stagnant water, removing old tires and empty bottles which serve as mosquito breeding habitats and through good management of used water.

5.6.4. Reducing Contact with Vectors

The limiting exposure to insects or animals that are known as disease vectors can reduce infection risks significantly, for example, bed nets, window screens on homes, or protective clothing can help to reduce the likelihood contact with vectors. To be effective, this requires education and promotion of methods among the population to raise the awareness of vector threats. The reducing of risk exposure to insects or animals that are vectors of diseases can limit the hazard of pathogen infection, for example, using bed nets, adding window screens to homes, or wearing protective clothing can help to reduce the likelihood of humans coming into contact with vectors. Healthy housing screens on doors, on windows or to close gaps between walls and roofs of houses or huts can be installed by families to reduce human and vector contacts. An important component of exposure reduction is also the promotion of health education and raising awareness of risks.

5.6.5. Biological Control

The use of predators (natural enemies of the vectors), bacterial toxins or botanical compounds can help to control vector populations, for example, using fishes that eat mosquito larvae or the introduction of sterilized male insects in order to reduce the breeding rate of insects are methods to control vectors and reduce the risk of infection. Most efficient larvivorous fishes for mosquito control are guppy and poecilia, use of natural vector predators, and materials such as bacterial toxins or botanical compounds can help to control vector populations.

5.6.6. Larval Source Management

Larval source management is the management of aquatic habitats (water bodies) that are potential larval habitats for mosquitoes in order to prevent the completion of immature development. The types of larval source management are habitat modification- a permanent alteration to the environment e.g., land reclamation, and habitat manipulation- a recurrent activity e.g., flushing of streams. Chemical control with insecticides, larvicides and repellents are used to control vectors, for example, larvicides can be used in mosquito breeding zones, insecticides can be applied to house walls (indoor residual spraying), bed nets treated with insecticide and use of personal skin repellents can reduce the risk of insect bites and thus pathogenic infection.

5.6.7. Environmental Management Methods

Ecosystem compatible environment modifications are clearing of stagnant water, breeding sites physically destroyed or modified and removal of vegetation from near house, while environment manipulation include irrigation management and removal of trash It further relates what is the relevant meteorological data, climate data (confounding data), rainfall data and temperature data. This also relates to provide what is the local land use and local land use mapped, and the seasonal pattern of local water use and spatial distribution of local water.

5.7. Chemical Control of Vectors

Chemical control of vectors is often the only method that can reduce vector populations in a disease epidemic, but with vectors developing resistance to insecticides, there is increasing awareness that a single control method is often insufficient and also that chemical control must be integrated where possible with other control measures. Chemical control of vectors using pesticides is a key element in the fight against vector-borne diseases. When used properly and as a part of Integrated Vector Management (IVM) framework, pesticides can effectively and safely control disease-transmitting vectors populations and prevent potential outbreaks. In many situations the use of pesticides is the most cost-effective method available (Sarwar, 2015 a; 2015 b; 2015 c; 2015 d; 2015 e). Methods include as stated the following:-

5.7.1. Avoiding Risk of Insects

For avoiding the risk of insect's biting or contamination, insecticides are incorporated in or coated onto textile materials such as mosquito nets or other treated materials such as clothing, curtains, tarpaulins and tents. Long-lasting insecticidal nets provide personal protection and can also protect communities, if the coverage with nets is high enough.

5.7.2. Dealing Immature Populations

Limiting the growth of populations at early stages like eggs, larvae and pupae, and larvicides have been used worldwide in vector control programs to reduce populations by treating breeding grounds.

5.7.3. Dealing Adult Populations

Indoor residual spraying and outdoor space spraying are used to control the adult stages of the vector insect. Indoor residual spraying is the most effective way to rapidly reduce vector's density and can be effective for up to several months depending on the product used.

5.7.4. Use of Biopesticides

Biopesticides are certain types of pesticides which are derived from animals, plants, bacteria and certain minerals. Biopesticides include naturally occurring substances that control pests (biochemical pesticides), microorganisms that control pests (microbial pesticides) and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants). Recently many biopesticides agents have been found promising under field and laboratory conditions including the fungal spores, metabolites, proteins, toxins and enzymes that have shown significant efficacies against adults and developmental stages of mosquitoes (Sarwar, 2015 f; 2015 g; 2015 h).

5.8. Industry

Industry might continue to make significant investment in research and development to find new and innovative products for vector control, including developing advanced long-lasting insecticidal net technology, introducing new long-lasting insecticidal sprays for indoor residual house spraying, and finding completely new insecticides and pesticide products to combat insecticide resistance which is a growing and major threat to vector control programs.

6. Essential Guide for Physicians and Professionals Workers in Public Health

Without a competent workforce, a public health agency is as useless as a new hospital with no health care workers. The task of ensuring that this workforce is prepared with skills and knowledge to face both identified and emerging public health challenges is immense. The physicians and professionals are public health nurses dedicated to community health promotion, including the prevention of vector-borne diseases. Public health is needed everywhere and it is a part of the infrastructure that keeps our communities safe and healthy. The physicians and professionals should inform the public about an epidemiological outbreak investigation in the community; diagnose and investigate health problems and health hazards in the community; link peoples to need personal health services and assure the provision of health care when otherwise unavailable; inform, educate and empower peoples about health issues; enforce laws and regulations that protect health and ensure safety; develop policies and plans that support individual and community health efforts; mobilize community partnerships to identify and solve health problems; and conduct research for new insights and innovative solutions to health problems. The theme of preventing the vector-borne diseases is the most powerful element in implementation of essential public health services. Through prevention, countless injuries, illnesses and even chronic diseases can be avoided; lives can be saved; health care cost can be contained; and individuals, their families and their communities can benefit from the population-based reach of the essential public health services (Mays et al., 2001; Kennedy and Moore, 2001; 2015 i; 2015 j; 2015 k).

7. Conclusion

Integrated Vector Management (IVM) is defined by the WHO as the rational choice of vector control method for optimum use of resources. This may include combining interventions such as using various pesticides in parallel and in combination with non-chemical methods to provide a comprehensive response to the vector control problem. However, it may also refer to pesticide uses alone as is the case with indoor residual spraying, and where pesticide use combined with training and monitoring forms in the integrated approach. It is an essential tool, not only for medical entomologists and those directly involved in government health departments, but also for all those who provide the skills and management needed to operate successful area-wide vector management programs such as libraries in all universities and research establishments. The use of pesticides for vector control is done through the integrated vector management framework to ensure that pesticides are used responsibly and in the most effective manner in combination with other methods when appropriate. The integration of vaccination programs with appropriate currently-used or new vector control methods has the potential to eliminate insects of health concern as a public wellbeing problem.

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