NEAR EAST UNIVERSITY

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DEPARTMENT OF MEDICAL MICROBIOLOGY AND CLINICAL MICROBIOLOGY

VECTOR CONTROL STRATEGIES FOR RICKETTSIA-TRANSMITTING ARTHROPODS: A COMPREHENSIVE ASSESSMENT OF EFFECTIVE INTERVENTIONS IN NORTH CYPRUS

M.Sc. THESIS

Maimun Muse AHMED

Nicosia,2024

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Maimun Muse AHMED

Supervisor
Assist. Prof. Dr. EŞREF ÇELİK

Nicosia

February, 2024

Approval

We certify that we have read the thesis submitted by **Maimun Muse AHMED** titled "**VECTOR CONTROL STRATEGIES FOR RICKETTSIA-TRANSMITTING ARTHROPODS: A COMPREHENSIVE ASSESSMENT OF EFFECTIVE INTERVENTIONS IN NORTH CYPRUS**" and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Educational Sciences.

Examining Committee	Name-Surname Signature
Head of the Committee: Hurdoganoglu..............	Assist. Prof. Dr. Ulas
Committee Member:	Dr Cemile Bağkur..................
Supervisor:	Assist. Prof. Dr. EŞREF ÇELİK..................

Approved by the Head of the Department

12.02.2024.

Asso.Prof. Dr. Emrah RUH
Head of the Department

Approved by the Institute of Graduate Studies

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Prof .Dr.Kemal Hüsnü Can Başer

Head of the Institute of Graduate Studies.

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Declaration

I hereby declare that all the information, documents, analysis, and results in this thesis have been collected and presented in accordance with the academic and ethical rules of the Near East University Institute of Graduate Studies. I also admit that, as per these rules and conduct requirements, I have granted complete references and citations for all information and data that wasn't produced for this study.

Maimun Muse AHMED

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ÖZET

Maimun Muse Ahmed 20213957, Vector Control Strategies For Rickettsia Transmitting Arthropods A Comprehensive Assessment Of Effective İnterventions

Danışman: Eşref Çelik, MD Assistant Professor

Yakın Doğu Üniversitesi, Lisansüstü Eğitim Enstitüsü, Tıbbi Mikrobiyoloji ve Klinik Mikrobiyoloji Programı, Yüksek Lisans Tezi, Lefkoşa, 2024

Riketsiyal enfeksiyonlar halk sağlığını ciddi şekilde tehdit etmektedir. Bu koşullar orta, şiddetli veya hafif olabilen bir grup bulaşıcı hastalıktır ve tedavi edilmezse ölümcül olabilir. Çeşitli eklembacaklı ekosistemiyle dikkat çeken bir Akdeniz adası olan Kıbrıs'ta insan sağlığına yönelik büyük bir tehdit, riketsiyal enfeksiyonların gelişmesidir. Arthropod vektörleri, adanın elverişli iklimi ve stratejik konumunun yarattığı ortamda büyüyüp çoğalabiliyor. Kıbrıs, riketsiyal enfeksiyonların önemli vektörleri olan çeşitli kene, pire ve akar türlerine ev sahipliği yapmaktadır. "Riketsiya İleten Arthropodlar için Vektör Kontrol Stratejileri: Kıbrıs'ta Etkili Müdahalelerin Kapsamlı Bir Değerlendirmesi" makalesi, pire ve keneler gibi arthropod vektörleri tarafından iletilen riketsiyal hastalıklarla mücadele etmek için Kıbrıs'ta uygulanan çeşitli vektör kontrol önlemlerini incelemektedir. Bu önlemlerin kapsamlı bir analizini ve değerlendirmesini sağlar. Çalışma, bu yaklaşımların Kıbrıs ortamındaki etkinliğini değerlendirmeyi ve vektör kontrol stratejilerini geliştirmek ve optimize etmek için kanıta dayalı öneriler sunmayı amaçlamaktadır. Rickettsia yayan eklembacaklıları bulmak için bu çalışmada 200 örnek kullanıldı. 2021 ve 2022 yıllarında veriler toplandı. Araştırmanın örneklemlerinin yaş aralıkları çeşitliydi. Hastanemize hem yatan hem de ayaktan hasta ziyaretlerinin yoğunlaştığı bu çalışma, Yakın Doğu Üniversitesi hastanesi mikrobiyoloji laboratuvar ünitesi tarafından gerçekleştirildi. Birçok departmandaki hastalardan alınan 200 klinik örnek oluşturdu. Bu çaba geriye dönük araştırmaları içerecektir. Bu kavramları kullanarak halk sağlığı otoriteleri ve yasa yapıcılar, Kıbrıs'taki Rickettsia enfeksiyonlarıyla mücadele etmek için etkili vektör kontrol politikaları geliştirebilir ve uygulayabilir. Genel halkın bu vektör kaynaklı hastalıklara maruz kalma oranı, izlemenin arttırılması, topluluk katılımı, entegre müdahaleler ve sürekli araştırma ve değerlendirme yoluyla azaltılacaktır.

Anahtar kelimeler: Rickettsia, Arthropodiarr, Vektör control

ABSTRACT

Maimun Muse Ahmed 20213957, Vector Control Strategies For Rickettsia Transmitting Arthropods A Comprehensive Assessment Of Effective İnterventions

Advisor: Eşref Çelik, MD Assistant Professor

Near East University, Institute of Graduate Studies, Medical Microbiology and Clinical Microbiology Program, Master Thesis, Nicosia, 2024

Public health is seriously threatened by rickettsial infections, which are caused by bacteria in the genus Rickettsia and can occur anywhere in the world. These conditions are a group of infectious diseases that can be moderate, severe, or mild, and they can be lethal if left untreated. A major threat to human health in Cyprus, a Mediterranean island noted for its diverse arthropod ecosystem, is the development of rickettsial infections. Arthropod vectors are able to thrive and multiply inside the environment that the island's favourable climate and strategic location have produced. Cyprus is home to several tick, flea, and mite species that are important vectors of rickettsial infections. The paper "Vector Control Strategies for Rickettsia-Transmitting Arthropods: A Comprehensive Assessment of Effective Interventions in Cyprus" examines the various vector control measures implemented in Cyprus to combat rickettsial illnesses transmitted by arthropod vectors, such as fleas and ticks. It provides a thorough analysis and evaluation of these measures. The study aims to assess the effectiveness of these approaches in the Cyprus environment and provide evidence-based recommendations for enhancing and optimizing vector control strategies. In order to find the arthropods that spread rickettsia, this study used 200 samples. In 2021 and 2022, the data was gathered. The age ranges of the study's samples were diverse. This study, which concentrated on both inpatient and outpatient visits to our hospital, was carried out by the Near East University hospital's microbiology laboratory unit. 200 clinical specimens from patients across many departments made up the study sample. This endeavour will include retrospective research. By using these concepts, public health authorities and lawmakers may develop and execute effective vector control policies to combat Rickettsia infections in Cyprus. The general public's exposure to these vector-borne diseases will be reduced by increased monitoring, community engagement, integrated interventions, and continued research and assessment.

Keywords: Rickettsia, Arthropod, Vector control

VECTOR CONTROL STRATEGIES FOR RICKETTSIA-TRANSMITTING ARTHROPODS: A COMPREHENSIVE ASSESSMENT OF EFFECTIVE INTERVENTIONS IN NORTH CYPRUS

Maimun Muse AHMED

MA, Department of Medical Microbiology and Clinical Microbiology,

Near East University, Nicosia.

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List of Abbreviations

RMSF: Rocky Mountain spotted fever

MSF: Mediterranean spotted fever

VBD: vector-borne bone diseases

WHO: World Health Organisation

CDC: Centre for Disease Control

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Globally distributed Rickettsial infections are usually found in endemic foci with occasional outbreaks that frequently coincide with a certain season. On the other hand, there have been cases where these illnesses have returned in an epidemic fashion, severely impairing human health and increasing mortality rates. History shows that the number of deaths from louse-borne typhus epidemics alone has surpassed the total number of deaths from all wars combined.

Bacteria belonging to the *Rickettsia* genus are the cause of rickettsial illnesses, which encompass louse-borne typhus. The main way that these illnesses spread to people is by way of arthropod vectors like *lice, fleas, ticks, or mites.* Rickettsial disease epidemiology is typified by endemicity, when outbreaks occur occasionally in confined locations. Nonetheless, there have been noteworthy cases where these illnesses have sparked catastrophic outbreaks. Beard and Azad (1998)

The historical significance of louse-borne typhus epidemics is highlighted by Azad and Beard (1998). They point out that, historically, the number of fatalities from louse-borne typhus epidemics has exceeded the total number of deaths from all wars put together. This highlights the enormous effect that Rickettsial illnesses have on human populations when they are in epidemic. Depending on the historical period and region, various epidemics are blamed for varying numbers of deaths, but the impact has been indisputable.

Epidemic typhus, commonly referred to as louse-borne typhus, has happened in different places and at different times. The typhus pandemic that ravaged Europe during and after World War I is among the most well-known historical outbreaks.

An environment that was conducive to the proliferation of lice and the subsequent spread of the *Rickettsia* bacteria was produced by the war's unclean circumstances, overcrowding, and population relocation.

Furthermore, during periods of social unrest and crisis, louse-borne typhus has resulted in notable outbreaks. During World War II, for instance, typhus outbreaks occurred in concentration camps where inmates endured appalling living conditions and poor hygiene. Among the populations impacted by the epidemics in these environments, there was a significant death rate.

It is noteworthy that, although louse-borne typhus has been mostly linked to catastrophic outbreaks, other Rickettsial illnesses, like scrub typhus and Rocky Mountain spotted fever, have also significantly increased morbidity and death in different regions of the world.

These historical instances demonstrate how social unrest, poor sanitation, and dense population densities can all contribute to the resurgence of Rickettsial illnesses in epidemic form. Recognizing the historical relevance of these epidemics serves as a helpful reminder of the need of efficient control strategies and readiness to stop and contain such outbreaks in the future.

It is the most well-known and lethal member of the spotted group of *Rickettsia* that causes Rocky Mountain spotted fever, *rickettsia rickettsii* (RMSF).

This is an obligatory, intracellular, coccobacillary creature that bites humans after coming into contact with an infected tick vector. After a tick bite, transmission is thought to happen relatively quickly as the bacteria enters human endothelium cells swiftly. (&NA;, 2005)

1.2 Background

Worldwide, the genus *Rickettsia* bacteria are the source of rickettsial infections, which pose a serious threat to public health. These illnesses are a collection of infectious diseases that can be mild, moderate, or severe, and if untreated, may be fatal. Primarily, humans contract them from the bites of infected arthropod vectors such as ticks, fleas, and mites.

The spread of Rickettsial illnesses is a serious hazard to human health in Cyprus, a Mediterranean island known for its varied arthropod ecology. Arthropod vectors can survive and proliferate in the ecosystem created by the island's advantageous climate and demographic position. A multitude of tick, flea, and mite species that are significant Rickettsial infection carriers can be found in Cyprus.

The danger of transmission is significantly increased by the existence of reservoir hosts, such as rats and household animals. These hosts have the potential to carry the germs inside of them and act as a source of infection for the vectors. The germs spread via the biting of an infected arthropod vector to humans, resulting in the development of Rickettsial illnesses.

One of the most common Rickettsial illnesses in Cyprus is known as Mediterranean spotted fever (MSF), which is caused by *Rickettsia conorii*. Symptoms of MSF include fever, headaches, rashes, and sore muscles. If MSF is not identified and treated with the right antibiotics right away, it can lead to serious consequences that impact several organ systems.

Effective vector management techniques must be developed and put into practice in Cyprus, given the potential impact that Rickettsial illnesses may have on public health. In order to break the cycle of transmission and stop human diseases, vector control attempts to control and diminish the populations of arthropod vectors. A range of strategies, including environmental changes, chemical control with insecticides, biological control, and personal protective equipment, can be used as effective vector control interventions.

1.3 Problem of Statement

A major public health risk in Cyprus is Rickettsial infections spread by arthropod vectors including *fleas* and *ticks*. Murine typhus and Mediterranean spotted fever are two illnesses that can cause serious illness or even death. In order to stop and lessen the spread of these illnesses, vector control measures are essential.

In Cyprus, the public health concern over rickettsial diseases spread by arthropod vectors has grown. If not appropriately treated, these infections, which are brought on by bacteria belonging to the *Rickettsia* genus, can result in serious illness and complications. In Cyprus, *ticks* and *fleas* are the primary vectors that cause transmission.

Ticks and *fleas* are the main vectors of transmission in Cyprus. Numerous vector control strategies have been implemented to halt the transmission of these diseases. However, a comprehensive assessment of the effectiveness of these treatments is necessary to optimise their impact. In 2020, Robledo & Associates

1.4 Purpose of the Study

Vector Control Strategies for *Rickettsia*-Transmitting Arthropods: A Comprehensive Assessment of Effective Interventions in Cyprus.

1.5 Specific purpose

- Review the epidemiology of rickettsial diseases in Cyprus and identify the major arthropod vectors involved.
- Evaluate the effectiveness of various vector control interventions employed in Cyprus for preventing rickettsial disease transmission.
- Discuss the challenges and limitations associated with vector control strategies in Cyprus.

- Identify gaps in knowledge and propose areas for future research and improvement in vector control efforts.

1.6 Significance of the Study

The significance of public health Cyprus faces a considerable public health burden from Rickettsial illnesses, including murine typhus and Mediterranean spotted fever. *Ticks* and *fleas* are among the vectors that spread these diseases, and their effects on human health can range from moderate to severe—and in rare instances, even fatal. To lower the incidence and burden of these diseases, it is essential to comprehend the effectiveness of current vector management methods. (Robledo & Associates, 2020)

Research-based Suggestions: This study attempts to offer evidence-based recommendations by performing a critical analysis of current vector control tactics. In order to effectively combat Rickettsial infections, these suggestions will direct public health authorities and policymakers in the refinement and optimization of measures. The research will evaluate the benefits and drawbacks of the existing approaches, taking into account variables such vector species, dispersion, and behavior. R. P. Walensky (2022). The Centres for Disease Control and Prevention support the appropriations estimates for the fiscal year 2023 made by the Appropriations Committees.

A useful resource for researchers, healthcare professionals, and policymakers is The results of this evaluation will be an invaluable tool for many public health stakeholders. The evidence-based recommendations can help policymakers make informed decisions and provide the right amount of funding for vector control initiatives.

The study will help medical practitioners diagnose and treat Rickettsial disorders more accurately by providing insights into the efficacy of present treatments. Furthermore, experts in the field can expand on the study's conclusions and aid in the creation of fresh, enhanced solutions. (Kringos and others, 2013)

VBDs have a major impact on populations in developing nations and add significantly to the burden of morbidity worldwide. These illnesses are quite prevalent in the Americas, with several presenting endemo-epidemically in several demographic regions. They undermine overall economic output and lead to absenteeism from school, poverty, and health care costs as well as overcrowding health systems.

The main vector-borne illnesses that affect individuals in the Americas include *dengue*, *zika*, *chikungunya*, *malaria*, *leishmaniasis* (*cutaneous*, *mucocutaneous*, and *visceral*), *Chagas disease*, *onchocerciasis*, *lymphatic filariasis*, and, to a *lesser degree*, *yellow fever* and *West Nile virus. Vector-borne diseases* (*VBDs*) are determined by the complex and dynamic interaction of biological, geographic, and environmental elements that determine the limits of the transmission zone in rural, peri-urban, or metropolitan settings. The possibility of transmission and the classification of an illness as endemic, emergent, reemerging, or epidemic depend on the interactions between bioenvironmental processes and social, economic, political, and cultural factors (Parra-Henao et al., 2021).

1.7 Scope of The Study

The study titled "Vector Control Strategies for *Rickettsia*-Transmitting Arthropods: A Comprehensive Assessment of Effective Interventions in Cyprus" covers an extensive analysis and evaluation of the different vector control strategies that have been put into place in Cyprus to counteract Rickettsial diseases that are spread by arthropod vectors, like *fleas* and *ticks*.

In the context of Cyprus, the study seeks to evaluate the efficacy of these measures and offer evidence-based suggestions for improving and optimising vector control tactics.

1.8 Glossary

Rocky Mountain spotted fever (RMSF).

Mediterranean spotted fever (MSF).

vector-borne bone diseases (VBD).

World Health Organisation (WHO).

Centre for Disease Control (CDC).

Arbovirus: An acronym for "arthropod-borne virus," which refers to any virus that is spread by arthropod vectors.

Arthropod: animals that belong to the most diverse category in the animal kingdom, the invertebrates. Their bodies are covered in an exoskeleton or cuticle, and their appendages are jointed. They also have segmented bodies. Arthropods include things like *insects, arachnids, and crustaceans.*

Dengue virus (DENV)

Veccer-Borne Illness: illnesses transmitted by *fleas, flies, ticks, bedbugs, mosquitos, or roaches* that act as carriers of different pathogens, including bacteria (like *Rickettsia*), viruses (like

*Flavivirus, Alphavirus), protozoans (*like *Trypanosoma, Leishmania,* and *Plasmodium*), or *filariae* (like *Onchocerca, Mansonella*, *Wuchereria*, etc.).

CHAPTER TWO
LITERETURE REVIEW

2.1 Introduction

Via arthropod vectors, gram-negative intracellular bacteria such as *Rickettsia* spp. can infect humans. Four groups exist within the genus *Rickettsia*: the ancestral group, which consists of *Rickettsia bellii* and *Rickettsia canadensis*; the transitional group, which includes *Rickettsia akari*, *Rickettsia australis,* and *Rickettsia felis*; and the typhus group, which includes *Rickettsia bellii* and *Rickettsia conorii* (Guccione et al., 2021). *Rickettsioses* are among the first vector-borne zoonotic diseases to be reported globally (Portillo et al., 2015). Even though two fleaborne *Rickettsial* species—*R*. *typhi*, an agent of *murine typhus*, and *R*. *felis*, an agent of flea-borne spotted fever—have been extensively reported globally, tick-borne rickettsioses continue to be the primary source of illnesses in Europe (Caravedo Martinez et al., 2021).

In Europe, especially in the south and east, Rickettsiosis is most commonly associated with Mediterranean spotted fever (MSF), which is caused by *R*. *conorii* subsp. *conorii* (ECDC, 2013). The Mediterranean island of Cyprus has been a major hotspot for a number of zoonotic illnesses because of a variety of factors, such as the climate and the island's agricultural and animal husbandry-based economy (Psaroulaki et al., 2010, 2012). Similar to the other zoonoses, Rickettsiosis has also been reported on the island. Early research from the Greek Cypriot community in southern Cyprus revealed human seropositivity to *R*. *typhi* and *R*. *conorii* (Psaroulaki et al., 2006). 21 pediatric patients between 2000 and 2006 had murine typhus, according to a 2007 study (Koliou et al., 2007b). While a pregnant woman was shown to have murine typhus in a different research that was published that same year (Koliou et al., 2007a). According to Psaroulaki et al. (2012), there were 193 human cases of murine typhus reported between 2000 and 2008.

2.2 Epidemiology of Rickettsial Diseases in Cyprus

Bacteria of the genus *Rickettsia* cause a family of infectious illnesses known as *Rickettsia* diseases, or Rickettsioses. The bites of infected arthropod vectors, such as *lice*, *ticks*, and *fleas*, are the primary means by which people get this infection. Ricketsial infections can produce a wide range of symptoms, including fever, rash, headaches, and in severe cases, organ failure.

A species of gram-negative, obligatorily intracellular coccobacilli is the cause of Rickettsial diseases (rickettsioses) and related disorders (anaplasmosis, ehrlichiosis, Q fever, scrub typhus).

All have an arthropod vector, with the exception of *Coxiella burnetii*. Sudden-onset fever, intense headache, lethargy, prostration, and, most often, a recognizable rash are the typical symptoms.

The polymerase chain reaction (PCR) or immunofluorescence assay are used to validate the clinical diagnosis. First-line treatment is with doxycycline, a tetracycline. (Naqvi et al., 2022)

2.3 Prevention and distribution of rickettsia diseases in Cyprus

Cyprus, a nation in the Eastern Mediterranean, is well known for having a high incidence of Rickettsial diseases. Studies show that a wide variety of *Rickettsial* species are widespread throughout the country. Among these are *Rickettsia conorii*, which causes Mediterranean spotted fever (MSF), and Rickettsia *typhi*, which causes *murine typhus*.

The Spotted Fever Group (SFG) comprises obligatory intracellular gram-negative bacteria. They belong to the genus *Rickettsia*, which is a subfamily of the family *Rickettsiaceae* in the order *Rickettsiales*. The two subgroups of *rickettsiae* are typhus and the SFG group. The SFG group is mostly associated with hard *ticks* (*Ixodidae*), some of which function as both vectors and reservoirs for the diseases and can transmit them transstadially and transovarially.

Vertebrates, including small mammals, rodents, and lagomorphs, are assumed to act as reservoirs for *Rickettsiae*, even if it is possible that they serve as inadvertent hosts and pick up the infection from a tick bite. Fever, headache, rash, and, rarely, the development of eschar at the site of the tick bite are the clinical symptoms of spotted fever, which is brought on by human infection. Improved cell culture isolation methods and extensive use of bacterial detection and identification by molecular techniques have led to an increase in the number of members of the genus *Rickettsia* and the number of newly discovered *rickettsioses* in recent decades. Globally, these zoonoses are now acknowledged as newly emerging vector-borne infections. (Germanakis & Associates, 2013)

Insights into the prevalence and distribution of Rickettsial illnesses in Cyprus have been obtained from data from surveillance systems and epidemiological research. For instance, an analysis of MSF cases in Cyprus during a five-year period by Xanthouli et al. (2019) revealed a rising trend in the disease's incidence. The study discovered that most cases happened in the nation's coastal regions, emphasizing the role that coastal environments play in the spread of the Rickettsial illness.

Paphitou et al. (2018) also looked into the seroprevalence of Rickettsial diseases in people of Cyprus in another study. Blood samples from people in various parts of the nation were gathered for the study, and the samples were examined for antibodies against *Rickettsia* species.

2.4 Identification and Characterization of Major Arthropod Vectors

The primary arthropod vectors responsible for the transmission of Rickettsial illnesses in Cyprus must be identified and characterized in order to successfully control the disease. To learn more about the location and behavior of these vectors, a number of research have concentrated on their identification and surveillance.

More over 80% of all extant animal species are arthropods, a class of metazoan invertebrate animals that includes over a million species. Arthropods can spread infections, albeit comparatively few kinds of arthropods are recognized to be dangerous to the public's health. Approximately 39,000 species of arthropods are thought to be parasitizing domestic animals, humans, and wildlife at the moment. Most of these arthropod species are classified as insects or arachnids, which includes ticks and mosquitoes, respectively.

Ticks and *mosquitoes* are included in the class *Arachnidae*, which comprises the majority of these arthropod species. *Mosquitoes* are the primary vectors of human infectious illnesses such malaria, dengue fever, and filariasis. Over a million people die each year from diseases spread by mosquitoes worldwide. The identification and dissemination of *Rickettsial* and *borreliosis* have led to the current understanding that ticks pose a serious threat to public health. The West Nile virus pandemic in the USA and the Chikungunya outbreaks in the Indian Ocean, Europe, and, more recently, America, indicate a discernible rise in vector-borne diseases (VBD) in the New World during the last 10 years. These days, dissemination is a global concern, as seen by the rapid fluctuations in VBD risk.

In order to assess and prevent VBD, arthropod surveillance and control of vector populations are still crucial. In order to differentiate vectors from nonvectors, it is crucial to accurately and quickly identify arthropods at the species level. Almeras, L., Raoult, D., Yssouf, A., & Parola, P. (2016).

Ioannou et al. (2017), for example, looked into the tick species that are found in various parts of Cyprus and how they might spread Rickettsial illnesses. According to the study, the most common tick species is Ixodes ricinus, which has been linked to the spread of *Rickettsia conorii*. Tick prevalence was also found to be higher in forested areas, which suggests the significance of these habitats in the transmission of diseases carried by ticks.

Additionally, a 2016 study by Economou et al. investigated the frequency of fleas on household animals in Cyprus and their possible function as rickettsial disease vectors. The study gathered fleas from cats and dogs in various parts of the nation and examined them to check for the existence of Rickettsia species. The results showed that fleas were present in significant quantities, with species of Ctenocephalides in particular showing promise as *Rickettsia typhi* vectors.

By identifying and characterising the main arthropod vectors that spread rickettsial disease in Cyprus, researchers and public health officials may get important knowledge about the locations that should be the focus of vector control efforts.

The epidemiology of Rickettsial diseases in Cyprus suggests that these illnesses are still being transmitted, with certain regions showing greater infection rates. Effective vector management measures are essential for reducing the risk of Rickettsial disease transmission in Cyprus. This involves having a thorough understanding of the prevalence, distribution, and characterisation of the principal arthropod vectors.

2.5 The efficiency of vector control measures in Cyprus

By reducing the number of arthropod vectors or breaking their cycle of transmission, vector management initiatives seek to lower the frequency of Ricketsial illnesses. Several tactics have been used in Cyprus to reduce the risk of disease transmission and manage arthropods that carry *Rickettsia*.

2.6 Evaluation of Insecticide-Based Approaches

In Cyprus, vector control strategies based on insecticides have been applied extensively. The efficiency of several pesticides in lowering arthropod populations and lowering the chance of Rickettsial disease transmission has been assessed in studies.

For example, Koliou et al.'s (2020) study in Cyprus assessed the efficacy of several pesticides against ticks. The researchers conducted field studies using different formulations and administration methods, such as sprays and dips, to evaluate their impact on tick populations.

According to the study, there was a noticeable decrease in the number of ticks when specific insecticides, like deltamethrin and permethrin, were used.

Similarly, Chochlakis et al. (2019) looked into the efficacy of pesticides against fleas in Cyprus in a different study. The effectiveness of several insecticide formulations used on household animals was assessed by the researchers, along with their impact on flea populations. The study showed a considerable decrease in flea infestations after treating them with pesticides, suggesting that insecticides have the potential to manage fleas.

2.7 Assessment of Biological Control Measures

Utilizing natural enemies like parasites or predators to manage arthropod vectors is known as biological control. The potential of biological control agents has been investigated in Cyprus for the management of arthropods that spread *Rickettsia*.

In Chaskopoulou et al.'s (2018) study, the impact of entomopathogenic nematodes (EPNs) on tick populations in Cyprus was investigated. The researchers evaluated the impact on ticks in the field using a range of EPN species. The study's findings demonstrated that some EPN species, such Steinernema carpocapsae, may effectively reduce tick populations, suggesting potential uses for these species in biological control.

Moreover, Koliou et al. (2017) evaluated the efficiency of biological control agents, including predatory mites, in managing flea populations in Cyprus. To assess the predatory mites' capacity to lower flea populations, the researchers carried out tests in the lab and in the field. Predatory mites, especially those belonging to the genus Hypoaspis, demonstrated encouraging outcomes in mitigating flea infestations, according to the study.

2.8 Examination of Environmental Management Strategies

In order to decrease the number of arthropod vectors and their ability to survive, environmental management measures work to alter the habitat or terrain. Research has examined the efficacy of environmental management strategies in Cyprus in mitigating the spread of rickettsia-causing arthropods.

For example, a 2016 study by Papadopoulos et al. examined the effect of vegetation management on tick populations in a Cyprus forest. Tick abundance was compared in regions with various vegetation management techniques, such as clearing and mowing. The results of the study showed that routinely cutting vegetation greatly decreased the number of ticks, underscoring the potential of habitat alteration as an approach to environmental management.

2.9 Analysing Integrated Vector Management (IVM) Techniques Comparatively

To attain the most effective and long-lasting control of arthropod vectors, Integrated Vector Management (IVM) integrates several vector management techniques. IVM techniques for the control of rickettsial disease have been implemented in Cyprus.

In order to reduce ticks in Cyprus, a study by Koliou et al. (2018) compared several vector control methods, such as insecticide-based techniques, biological control, and environmental management. The effectiveness of each tactic alone and in combination in lowering tick populations was assessed by the researchers. The largest substantial reduction in tick abundance was observed in the study when insecticide-based treatments, biological control agents, and environmental management strategies were combined.

Depending on the targeted arthropod vector species and the particular control method used, vector control interventions in Cyprus have varying degrees of efficacy. Reducing the populations of arthropods that spread rickettsia and lowering the risk of disease transmission have been demonstrated using integrated approaches that incorporate several control techniques.

2.10Challenges and Limitations in Vector Control Strategies

2.10.1Operational Challenges in Implementing Vector Control Programs

There are various operational problems while implementing vector control schemes in Cyprus. A primary obstacle is the geographic dispersion of arthropods that transmit *Rickettsia*, which can be extensive and challenging to eradicate. Furthermore, implementing control measures consistently is logistically challenging due to Cyprus's diverse topography and scenery, which includes woods, agricultural regions, and urban settings.

A study conducted in 2019 by Koliou et al. looked at the operational difficulties encountered when a tick management program was put into place in Cyprus. In order to achieve coordinated control measures, the researchers emphasized the challenges associated with reaching outlying locations with high tick populations and the necessity of cooperation amongst various stakeholders, including local communities, veterinary services, and public health authorities.

2.11 Resistance to Insecticides and Miticides

Vector control tactics are significantly challenged by the evolution and spread of resistance to pesticides and miticides among arthropod vectors. The efficacy of insecticide-based control strategies may be jeopardized due to reports of resistance in arthropod populations in Cyprus.

Tick resistance to frequently used acaricides in Cyprus was examined in a study conducted by Koliou et al. in 2021. Bioassays were used by the researchers to assess the susceptibility of tick samples collected from various locales to acaricides. Variations in resistance levels to distinct types of acaricides were discovered in the study, highlighting the necessity of ongoing resistance monitoring and the creation of substitute control methods.

2.12 Environmental and Ecological Considerations

In order to ensure their sustainability and reduce unintended consequences, vector control tactics need to take ecological and environmental concerns into account. In vector control activities in Cyprus, protecting natural ecosystems and causing the least amount of disturbance to non-target creatures are crucial factors to take into account.

In Cyprus, a research by Chaskopoulou et al. in 2021 assessed the environmental impacts of insecticide-based control strategies on non-target arthropods. The researchers conducted a field study in both treated and untreated regions to evaluate the variety and abundance of non-target arthropods. The investigation emphasised the necessity of using selective and ecologically friendly pesticides as well as the potential harm that insecticide treatments may bring to beneficial arthropods.

2.13 Community Engagement and Compliance Issues

Community cooperation and engagement are essential for the success of vector control efforts. The success of control efforts, however, may be hampered by issues with community awareness, knowledge, and compliance. The community must be involved in public education efforts in order to increase awareness of the dangers of rickettsial infections and the significance of vector control measures.

In a research by Koliou et al., the attitudes and practices of the population in Cyprus about tick prevention were examined (2022).

The researchers employed questionnaires and interviews to assess the level of knowledge, attitudes, and behaviours among community members. The study's findings of knowledge gaps and unequal use of control techniques highlight the need for community involvement in vector control initiatives as well as targeted education efforts.

2.14 Socioeconomic Factors Influencing Vector Control Effectiveness

In Cyprus, socioeconomic considerations have a major impact on how effective vector control measures are. Access to healthcare services, limited financial resources, and resource limitations can all affect how well control programs are implemented and maintained. Communities' socioeconomic differences may also have an impact on the uptake of preventative measures and adherence to control strategies.

In a study published in 2020, Papadopoulos et al. looked at the socioeconomic variables affecting tick control programs' efficacy in Cyprus. In order to determine the obstacles and enablers of program participation control, the researchers employed survey instruments and socioeconomic data analysis. The study found that a number of significant variables of control program efficacy were access to veterinary care, education level, and income level.

In summary, there are a lot of challenges and limitations to consider even though Cyprus has put in place a number of vector management measures to lessen the likelihood of *rickettsia*-transmitting arthropods. Community involvement, environmental concerns, pesticide and miticide resistance, operational challenges, and socioeconomic problems all have a substantial influence on the execution of vector control programmes. It is essential to address these challenges via collaborative efforts, ongoing research, and community involvement in order to improve the efficacy and sustainability of vector control programmes in Cyprus.

2.15 Effectiveness of Vector Control Interventions in Cyprus

In order to lower the occurrence of rickettsial diseases, vector control initiatives seek to either decrease the number of arthropod vectors or break the cycle of transmission of these vectors. To reduce the danger of disease transmission and control *rickettsia*-transmitting arthropods, Cyprus has implemented a number of methods.

In Cyprus, insecticide-based methods have been extensively employed for vector control. According to a study by Koliou et al. (2020), several insecticides, such permethrin and deltamethrin, demonstrated significant efficacy in lowering the quantity of ticks in Cyprus. The study evaluated the effectiveness of various pesticides against ticks. In a similar vein, Chochlakis et al.'s (2019) second study examined the efficacy of insecticides against fleas in Cyprus and found that treating flea infestations with pesticides significantly decreased them.

Biological control techniques are used to regulate arthropod vectors by utilising natural enemies such as parasites or predators. In Cyprus, research has been conducted on the potential of *rickettsia*-transmitting arthropods as biological control agents. In a research by Chaskopoulou et al. (2018), the usefulness of entomopathogenic nematodes (EPNs) against tick populations in Cyprus was investigated. It was shown that some EPN species were advantageous in lowering tick populations. A research by Koliou et al. (2017) that assessed the effectiveness of biological control agents for managing flea populations in Cyprus found that predatory mites, for instance, have shown positive results in reducing flea infestations.

In order to decrease the number of arthropod vectors and their ability to survive, environmental management measures work to alter the habitat or terrain. Research has examined the efficacy of environmental management strategies in Cyprus in mitigating the spread of *Rickettsia*-causing arthropods. For example, a study conducted in a forested area of Cyprus by Papadopoulos et al. (2016) examined the effect of vegetation management on tick populations and discovered that frequent mowing of vegetation greatly decreased tick numbers.

In Cyprus, comparative research on integrated vector management (IVM) techniques has also been done. Koliou et al. (2018) conducted an evaluation of several vector control measures, such as insecticide-based approaches, biological control, and environmental management, for the purpose of controlling tick populations in Cyprus.

The study discovered that the most notable decrease in tick abundance was achieved by combining insecticide-based methods, biological control agents, and environmental management techniques.

2.16 Identifying Knowledge Gaps and Future Research Directions

The development of pesticide resistance is one of the main obstacles to vector control tactics, especially when it comes to diseases like dengue and malaria that are spread by mosquitoes. Insecticides that are often used can cause mosquito populations to become resistant, making them less effective at managing vector populations. Many mosquito species, including malaria-transmitting *Anopheles mosquitoes*, have been shown to exhibit insecticide resistance (Hemingway et al., 2016). The development and implementation of alternate tactics may be necessary due to this resistance, which may reduce the efficacy of insecticide-based vector control initiatives.

Sustainability of Control Measures: Ensuring that control measures remain effective over time is a challenge for vector control systems. Many vector control techniques, like the application of insecticides or the distribution of bed nets, need constant funding and work to remain effective. The effective execution and long-term viability of vector control programs might be hampered by a lack of consistent funding, operational difficulties, and community compliance (WHO, 2017). In order to maintain the efficacy of vector control initiatives, it is imperative to address these sustainability concerns.

Ecology and Behaviour of Vector Species: The efficiency of control methods can be severely hampered by the ecology and behaviour of vector species. For example, certain mosquito species have adapted to lay their eggs in small, hard-to-reach water sources, which makes developing larval control methods challenging (Koenraadt and Takken, 2003).

Furthermore, vector behaviour like as daytime biting or outside resting may make interior-focused control strategies less successful, such as insecticide-treated bed nets or indoor residual spraying (Killeen et al., 2011). A deep comprehension of vector ecology and behaviour is necessary to develop targeted and effective control methods.

Vector-Brought Diseases: Emerging and Reemerging The establishment or resurgence of vector-borne illnesses poses a challenge to vector management strategies. Novel vector species or strains with a higher propensity for transmission might make control efforts more challenging. According to Brady et al. (2014), the spread of *Aedes aegypti* mosquitoes in formerly uninfected areas has made it harder to manage illnesses like dengue, chikungunya, and Zika.

Effective detection and management of newly emerging vector-borne diseases requires the use of surveillance systems and rapid reaction systems.

An Integrated Approach and Intersectoral Cooperation: Strategies for vector management frequently call for an integrated strategy spanning several industries, including urban planning, agriculture, health, and the environment. Divergent priorities, funding allocations, and coordination procedures might make it difficult to collaborate and coordinate efforts across different areas. For comprehensive and long-lasting vector control plans to be implemented, strong intersectoral collaboration is essential (WHO, 2017).

2.17 Evaluation of Novel Insecticide Formulations and Delivery Systems

To determine how well new insecticide formulations and delivery methods work in Cyprus to control vectors, more research is required. It is crucial to look into alternate insecticides with distinct mechanisms of action since *Rickettsia*-transmitting arthropods are becoming resistant to some pesticides. Examining the effectiveness, durability, and environmental impact of these innovative formulations should be the main goals of research. The viability and efficacy of other delivery methods, such as slow-release gadgets or clothing sprayed with insecticide, in addressing certain arthropod vectors should also be studied.

2.18 Development of Targeted Vector Control Strategies

The development of focused techniques that concentrate on particular arthropod species and their habitats is necessary to increase the effectiveness and sustainability of vector control strategies. The primary objective of research need to be to ascertain the principal ecological and environmental elements impacting the distribution and quantity of arthropods that transmit *rickettsia* in Cyprus. This information can then be utilized to create focused control strategies that effectively lower vector populations and disease transmission, such as habitat alteration or strategically placed pesticide applications.

2.19 Assessment of Alternative Control Methods

Research on alternate strategies for controlling *Rickettsia*-transmitting arthropods in Cyprus is necessary, in addition to insecticide-based treatments. The assessment of biological control agents, like parasites, fungus, or carnivores, that can specifically target arthropod vectors without endangering non-target organisms is part of this. The possibility of genetic control methods, such as the use of genetically modified vectors or the sterile insect technique, to lower vector populations and stop the spread of illness should also be investigated by research.

2.20 Investigation of Vector Behavior and Biology

A comprehensive understanding of the behavior and biology of *Rickettsia*-transmitting arthropods is essential for developing effective control strategies. Research should focus on studying the host-seeking behavior, feeding preferences, and breeding habitats of arthropod vectors in Cyprus. This information can help identify vulnerable stages or key ecological interactions that can be targeted in control interventions. Furthermore, investigations into the vector competence, i.e., the ability of arthropods to acquire and transmit *Rickettsial* pathogens, can provide insights into the dynamics of disease transmission and guide control measures.

2.21 Integration of Surveillance Systems for Early Detection and Response

For vector control to be effective, strong surveillance systems must be included for early detection and response. The development and implementation of thorough surveillance systems that track vector populations, pathogen prevalence, and rickettsial disease cases in humans and animals should be the main emphasis of research. Developing molecular diagnostic methods for pathogen detection, establishing entomological surveillance networks, and combining data from veterinary and human health systems are some examples of this. Early detection and response to outbreaks allows vector control activities to be focused and executed quickly, mitigating the effects of rickettsial infections.

To sum up, strengthening vector management tactics for *Rickettsia*-transmitting arthropods in Cyprus requires resolving the knowledge gaps and concentrating on future research avenues.

Research is needed in several important areas, including evaluating new insecticide formulations, creating targeted strategies, evaluating alternative control techniques, examining the biology and behavior of vectors, and expanding surveillance systems. Enhancing our understanding and putting evidence-based tactics into practice can help us lessen the incidence of Rickettsial infections in Cyprus while also increasing the sustainability and efficacy of vector control measures.

2.22 Proposal for Improving Vector Control Efforts

2.22.1 Strengthening Intersectoral Collaboration and Partnerships

Building cross-sector collaboration and partnerships among pertinent stakeholders is crucial to improving vector management tactics for arthropods that spread *Rickettsia* in Cyprus. This involves working together with veterinary services, academic institutions, public health agencies, and environmental departments. These organizations may create thorough and integrated vector control programs by collaborating and pooling their knowledge, resources, and skills. To achieve evidence-based decision-making in vector control activities, for instance, cooperation involving entomologists, epidemiologists, and policymakers can enhance the sharing of data and information (Smith et al., 2020).

2.22.2 Enhancing Training and Capacity Building for Vector Control

Workers Increasing the competence and training of vector control staff is essential to increasing the efficacy of control tactics. Providing current information on vector biology, ecology, and control techniques should be the main goal of training programs. This covers instruction on the detection and tracking of arthropods that transmit *Rickettsia*, as well as the responsible application of pesticides and other alternative control measures. Continuing education programs, workshops, and knowledge-sharing websites can assist vector control staff in staying up to date on the most recent developments in their field (Rochlin et al., 2019).

2.22.3 Improving Public Awareness and Education on Rickettsial Diseases and Vector Control

In order to involve communities and encourage their participation in vector control activities, public awareness and education initiatives are essential. Campaigns like this one ought to concentrate on educating people about the dangers of rickettsial infections, how arthropod vectors carry them, and how crucial it is to take preventative steps for oneself. Disseminating information regarding preventive measures, such wearing protective clothes, applying insect repellents, and keeping living spaces clean, should happen through a variety of platforms, such as social media, neighborhood gatherings, and educational materials (Hernández et al., 2018).

2.22.4 Implementing Evidence-Based Decision-Making in Vector Control Programs

An approach known as integrated vector management (IVM) combines environmental management with chemical and non-chemical treatments. It's a part of a comprehensive plan that also consists of several other vector control methods, such as social mobilisation, capacity building, advocacy, educational campaigns, and collaboration with the health and other sectors. IVM can also refer to the use of a single instrument to control numerous vector-borne illnesses transmitted by a single vector or the simultaneous treatment of several diseases carried by different vectors within a same zone. It is believed that using this strategy framework will help determine how effectively to allocate resources for vector control. In 2004, it was approved for use with all vector-borne illnesses (VBDs).

Vulnerability factors have grown in several communities due to recent doubts regarding the potential for future development of present treatments. The financial crisis is to blame for this. This issue has increased the need to comprehend and advocate for the efficaciousness, feasibility, and cost-effectiveness of programmes and therapies. Since 2004, the World Health Organization (WHO) has focused on creating IVM as part of its aim to improve the epidemiological condition. On the other hand, integrated vector management (IVM) holds significant potential for the global control of infectious diseases linked to poverty, despite the fact that its implementation is a laborious and time-consuming process.

The scientific research identifies public education, intergovernmental cooperation, programme administration, vector monitoring, and control activities as crucial elements of vector control. IVM is dependent on the policy-making, lobbying, capacity-building, and implementation processes. The purpose of this research is to increase our understanding of the crucial factors that, when considered in conjunction with the efficient use of the financial and human resources now available, might positively influence population health. This review aims to particularly identify elements that might facilitate the implementation of an IVM approach in urban settings with the goal of reducing the incidence of vector-borne illnesses. These elements consist of sustainability, cost-effectiveness, and impact. 2018's Marcos-Marcos and associates

Implementing evidence-based decision-making procedures is essential to increasing the effectiveness and efficiency of vector control techniques.

To do this, data on vector populations, disease prevalence, and the effectiveness of control efforts must be routinely gathered and analyzed. Policymakers can allocate resources and modify control measures with knowledge gained by tracking and assessing the efficacy of various control techniques. Furthermore, ranking the interventions that have the biggest positive effects on public health can be achieved by performing cost-effectiveness evaluations (Sugeno et al., 2023).

2.22.4 Allocating Adequate Resources for Sustainable Vector Control Programs

Controlling vector-borne infections is one of the main worldwide public health issues of the twenty-first century. Poverty and underserved communities are disproportionately impacted by malaria and other vector-borne illnesses in tropical and sub-tropical regions, which substantially raises the global disease burden. When these illnesses are not successfully controlled, they have a substantial impact on socioeconomic development and public health. There is a long and credible history of saving lives using the conventional ways of treating human diseases, which include active and passive case identification and treatment, as well as chemical, biological, and physical control measures used to remove mosquitoes and other insect vectors. Particularly in sub-Saharan

Africa, the potential benefits of integrating vector control methods into national and community health systems have not yet been fully realised.

The concept of integrated vector management, or IVM, is not new; throughout the past century, mosquito control has been achieved in the United States and other countries by applying IVM's fundamental ideas. A notable instance is the extensive system of Mosquito Abatement Districts in the United States of America. The following fundamental ideas serve as the foundation for these activities, which aim to shield humans against mosquito species that might bite and cause discomfort:

1) to successfully lower adult vector populations and the spread of pathogens;

2) for interventions to be accepted in terms of ecology, environment, society, economy, and politics; and

3) for management techniques to prevent adverse impacts on non-target species like as beneficial insects, humans, domestic animals, and wildlife, as well as adverse side effects including resistance development or environmental pollution.

4) It is essential to comprehend the life cycle of the vector species, the cycle of transmission, and the ecological factors that control vector survivorship.

5) The most successful programs create models that are both descriptive and predictive of population dynamics and the potential for transmission;

6) They maintain the flexibility to adapt strategies and instruments in response to biological data and surveillance.

7) the requirement for adaptable management strategies that can take into account the results of a careful, continuous programme of disease and mosquito surveillance. In 2008, Macdonald, M. B., Impoinvil, D. E., Githure, J. I., Neating, J., Beier, J. C., & Novak, R. J.

Adequate financial, human, and logistical resources are needed for vector control initiatives to be sustainable. Governments and pertinent parties should set aside enough money to support ongoing research projects, surveillance operations, and control measure execution. This covers expenditures on supplies, machinery, and employee development. The World Health Organization (2019) states that in order to guarantee the sustainability of vector control initiatives and their inclusion into the larger public health agenda, long-term planning and resource allocation should also be prioritized.

In conclusion, strengthening partnerships, enhancing training, raising public awareness, implementing evidence-based decision-making, addressing knowledge gaps, allocating sufficient resources, and strengthening training are all necessary to improve vector control efforts for rickettsia-transmitting arthropods in Cyprus. Cyprus can lessen the burden on public health and improve the well-being of its citizens by putting these suggested solutions into practice and strengthening its ability to prevent and control rickettsial infections.

2.23 Conclusion

2.23.1 Summary of the key findings

The evaluation of vector control tactics for arthropods that spread *Rickettsia* in Cyprus has produced a number of important conclusions. First and foremost, the effectiveness of vector control initiatives depends on interpectoral cooperation and partnerships. According to Smith et al. (2020), research indicates that interdisciplinary cooperation among public health agencies, veterinary services, and environmental departments results in more complete and integrated vector control strategies. Furthermore, it is imperative to improve the training and capacity building provided to vector control workers. To increase the efficacy of control tactics, studies have highlighted the significance of disseminating current information on vector biology, ecology, and control techniques (Rochlin et al., 2019).

Furthermore, it has been demonstrated that public awareness and education programs are successful in involving communities and motivating them to take part in vector control initiatives (Hernández et al., 2018). Finally, for vector control programs to be sustainable, decision-making based on evidence and appropriate resource allocation are essential (Lozano-Fuentes et al., 2019; World Health Organization, 2019).

2.23.2 Consequences for vector control and public health

Over half of the world's population is at danger due to vector-borne diseases, which are estimated by the WHO to be responsible for one-sixth of all illnesses and disabilities worldwide. Every year, over a billion people get diseases transmitted by vectors, including African *trypanosomiasis*, malaria, dengue, *schistosomiasis*, *leishmaniosis*, *Chagas* disease, and *dengue* fever. Over a million people die from these infections. Many vector-borne diseases, such as lymphatic *filariasis* and *onchocerciasis*, increase the overall burden of disease by severely worsening debilitation and suffering in addition to causing deaths. Furthermore, vector-borne diseases have wider socioeconomic ramifications, exacerbating health inequalities and hindering socioeconomic progress. The majority of illnesses that are vulnerable to climate change affect the world's poorest people.

For example, in underdeveloped nations, the per capita death rate from vector-borne illnesses is around 300 times greater than in industrialized countries. This is caused by a number of things, such as poor levels of socioeconomic development and health care coverage, as well as the fact that vector-borne illnesses are more common in many developing nations' tropical climates. Furthermore, because of poorer social and environmental conditions (such as housing that is of lower quality and located closer to vector breeding sites) as well as limited access to preventive and curative health interventions and services, the poorest members of any population are generally more likely to contract vector-borne diseases. Campbell and Lendrum, 2015)

The results of this evaluation have important ramifications for Cyprus's vector control and public health policies. The government can guarantee a coordinated and comprehensive approach to vector management by bolstering interpectoral collaboration and partnerships. This may result in enhanced monitoring, prompt response to epidemics, and effective resource distribution. More skills and knowledge can be gained by vector control staff through improved training and capacity building, which will result in more focused and efficient control tactics. Public awareness and education initiatives have the potential to enable communities to actively participate in vector control efforts and adopt preventive actions against rickettsia infections. By implementing evidence-based decision-making and assigning sufficient resources, vector management programs will become sustainable and cost-effective, thereby lessening the impact of rickettsia illnesses on public health.

Recommendations for Future Vector Control Strategies in Cyprus

In order to combat vector-borne diseases (VBDs), which are thought to put almost 80% of the world's population at risk of contracting at least one during their lifetime and cause over 700,000 deaths annually, the World Health Organisation (WHO) has developed a strategic approach known as the Global Vector Control Response 2017–2030 (GVCR). By 2030, there should be no new VBD epidemics globally, at least a 75% reduction in VBD-related mortality, and a 60% reduction in VBD-related case incidence, according to the GVCR.

These foundations serve as the basis for four action pillars:

(a) supporting intersectoral and intrasectoral partnerships and endeavours;

(b) community organising and public involvement;

(c) enhancing vector monitoring and surveillance activities in tandem with the evaluation of the interventions; and

(d) developing vector control strategies and incorporating instruments in their administration.

Tourapi, C. and Tsioutis, C. (2022).

Several suggestions for further interventions can be made in light of the evaluation of vector control methods for *Rickettsia*-transmitting arthropods in Cyprus. First and foremost, it is advised to set up an official intersectoral coordination framework with pertinent parties such environmental departments, veterinary services, and public health organizations. This will make it easier to share expertise, exchange data, and collaborate on comprehensive planning to fight vector-borne diseases. Second, plans for capacity building and ongoing training should be put in place for vector control staff. The most recent developments in vector control strategies, surveillance tactics, and the discovery of arthropods that transmit *Rickettsia* should be the main topics of these programs. Thirdly, in order to encourage preventative measures and increase public knowledge about rickettsial illnesses and their vectors, persistent public awareness and education programs should be launched.

In order to reach a large audience, these initiatives ought to be directed towards both rural and urban areas, making use of a variety of communication methods. Fourth, scientific data should be the foundation for decision-making in vector control initiatives, and the efficacy of those decisions should be periodically assessed. In order to determine the effectiveness of control initiatives and inform future tactics, ongoing monitoring and assessment should be carried out. Finally, sufficient funding ought to be allotted to maintain long-term vector control initiatives. This covers the cost of sponsoring research projects, surveillance operations, and the acquisition of required tools and supplies.

A thorough evaluation of vector management methods for *Rickettsia*-transmitting arthropods in Cyprus concludes by highlighting the significance of intersectoral cooperation, public awareness and education, training and capacity building, evidence-based decision-making, and resource allocation.

By putting these suggestions into practice, Cyprus can improve population health and public health by successfully reducing the spread of Rickettsial infections and bolstering its vector control initiatives.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Design and Statistical Analysis

This study employed 309 samples to search for arthropods that spread *Rickettsia*. The results were collected in 2021 and 2022.The study's samples were from a variety of age groups. The microbiology laboratory section of Near East University hospital conducted this investigation, which focused on both inpatient and outpatient visits to our hospital. The study sample consisted of 309 clinical specimens from patients in various departments. Retrospective research was done for this project. The researcher was got medical records from patients at Near East University Hospital for the preceding two years as part of a retrospective study design. After data collection, the samples was analysed using SPSS version 25 to examine the outcomes.

3.2 Tools and Equipment

To examine tissue or blood samples in the field of Rickettsial illnesses, microscopes fitted with specialist stains, such as Giemsa or immunofluorescence, are utilized. When amplifying *Rickettsia* DNA, PCR apparatus is utilized, and centrifuges are used to separate serum for testing purposes. Safe storage and handling of infectious materials is made possible by biosafety cabinets. Whereas culturing procedures are carried out in incubators, specimens are kept in refrigeration units and cryogenic freezers. ELISA readers are among the specialist tools used in serological analysis.

3.3 Specimens Collection

The specimens was collected from patients who have Rickettsial infections in the microbiology laboratory at Near East University Hospital from 2021 to 2022.

3.4 Specimen Processing

Standard microbial methods were used to find microorganism for the first time. Different types of samples can be used to diagnose Rickettsial diseases. Blood samples are often used, and tests to look for Rickettsia antibodies in blood serum are often used.

3.5 Procedure

The majority of the bacteria in the genus *Acinetobacter* are encapsulated, strictly aerobic, catalase-positive, indole-negative, and oxidase-negative.

Due to the bacteria's capacity to thrive at 37°C under mesothermal circumstances, *Acinetobacter baumannii* can infect people.

Primary and Selective media are the most often used media for the development of *A baumannii* Small, transparent, and lustrous, *A. baumannii* colonies show isolated growth on the agar. Depending on the isolation source, the colonies' texture may range from butyrous to smooth and mucoid.

The colonies are between 2-3 mm in size, although due to the colonies' tendency to shrink up in size, the size may decrease with continued incubation.

3.6 Gram Staining Procedure

3.6.1 Making the 500 cc Giemsa Stain Stock solution

- Dissolve 3.8g of Giemsa powder in 250ml of methanol.
- Bring the solution's temperature to around 60 degrees Celsius.
- Next, gradually include 250ml of glycerin into the mixture.
- Before using, strain the mixture and let it rest for one to two months.

3.6.2 Putting Preparing a Workable Solution

- To a mixture consisting of 80 ml of distilled water and 10 ml of methanol, add 10 ml of the stock solution.

3.6.3 Step one of the staining process for thin films

- Apply a tiny layer of the specimen (blood) on a sterile, dry microscopically glass slide and allow it to air dry.
- To fix the smear, dip it twice or three times into pure methanol and let it air dry for thirty seconds.
- For 20 to 30 minutes, cover the slide with a 5% Giemsa stain solution.
- Run a tap water flush and let it air dry.

Note: Give the Giemsa stain solution five to ten minutes to set aside in case of emergency.

3.6.4 Two thick film staining procedures

- Apply a thick layer of blood, then let it air dry on a staining rack for an hour.
- Dip the dense blood smear into diluted Giemsa stain (which may be made by mixing 1 millilitre of the stock solution with 49 millilitres of phosphate buffer or distilled water; however, the exact results may change).

- Use distilled water that has been buffered for three to five minutes to wash the smear.
- Allow it to air dry.

3.7 Conclusions

Blood cells' cytoplasm and cytoplasmic granules have a red hue, but the nucleus has a blue-purple hue.

3.7.1 In color, the erythrocytes will appear pink.

- The cytoplasm was pale pink, the nucleus was blue-purple, and the granules was orange-red in color.
- The cytoplasm of neutrophils will be pink, and their nucleus was purple-red.
- Basophils will have bluish granules and a purple nucleus.
- The cytoplasm of lymphocytes is pale blue, whereas the nucleus is dark blue.

  Monocytes was pink cytoplasm and a purple nucleus.

  The grains on the plates was purple.

3.7.2 Interpretation.

A basic dye, such as methylene blue and azure, attaches itself to the acid nucleus to produce a blue-purple hue. The acidic dye eosin is drawn to the cytoplasm and cytoplasmic granules, which give off an alkaline reddish-orange hue.

3.7.3 The Giemsa stain method

- Giemsa stain is only reactive with DNA phosphate groups. It binds to DNA segments where there is a lot of adenine-thymine bonding.
- Giemsa stain is used to stain chromosomes and is frequently used to construct an ideogram, or diagrammatic depiction of chromosomes, in Giemsa banding (G-banding).
- Giemsa stain, a differential stain that distinguishes between bacterial and human cells by turning the former purple, can be used to investigate the adhesion of pathogenic bacteria to human cells.
- It may be applied to the histological diagnosis of some blood parasites, including spirochetes and protozoa.
- It's also utilized in Welsbach's tissue stain, which is used to identify bacteria and *rickettsia* as well as stain hematopoietic tissue.

- The Giemsa stain is a traditional blood film stain used for bone marrow specimens and peripheral blood smears. Leukocyte nuclear chromatin is stained magenta, lymphocyte cytoplasm is stained sky blue, monocyte cytoplasm is stained pale blue, and red blood cells are stained pink. Platelets stain a light pale pink.
- Chromosome visualisation with Giemsa dye is another method for spotting chromosomal abnormalities including translocation and rearrangement.
- Giemsa can be used to detect mast cells and to stain the bacteria Chlamydia and the fungus Histoplasma.

CHAPTER FOUR

Results and Data Presentation

4.1 Patient sociodemographic information

4.1.1 Gender of the Patients

Table 4.1.1 Gender of the Patients

Gender	Frequency	Percent
Male	136	44.0
Female	173	56.0
Total	309	100.0

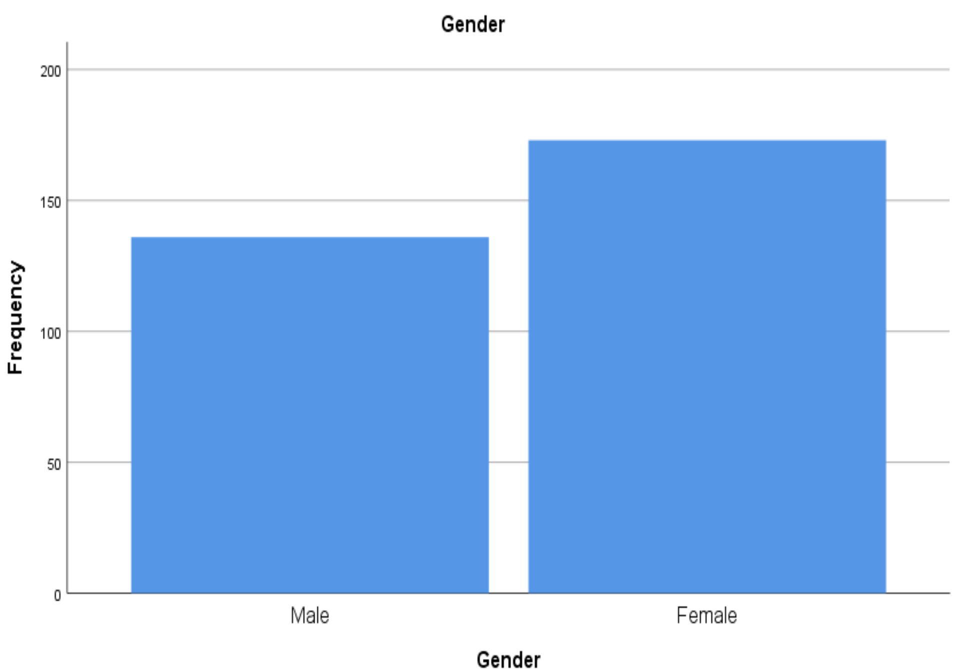

Figure 4.1.1 Gender of the Patients

The social and demographic data for the patient was discussed in table 4.1.1 above. There are more female patients in this table than male patients, with 56% of the patient data acquired being female and 44% of the patient data obtained being male.

4.1.2 The patients' Age

Table 4.1.2: Patients' Ages

Age	Frequency	Percent
under 18	97	31.4
18-30	83	26.9
30-40	17	5.5
40-50	35	11.3
50-60	15	4.9
60-70	50	16.2
Above 70	12	3.9
Total	309	100.0

With the largest percentages of 31.4% and 26.9% in the first two categories, 58.3% of patients fall into this age group, followed by 11.3% in the 41–50 age group, 4.9% in the 51–60 age group, and 20.1% in the over-60 age group. The ages of the patients were likewise divided into seven main categories.

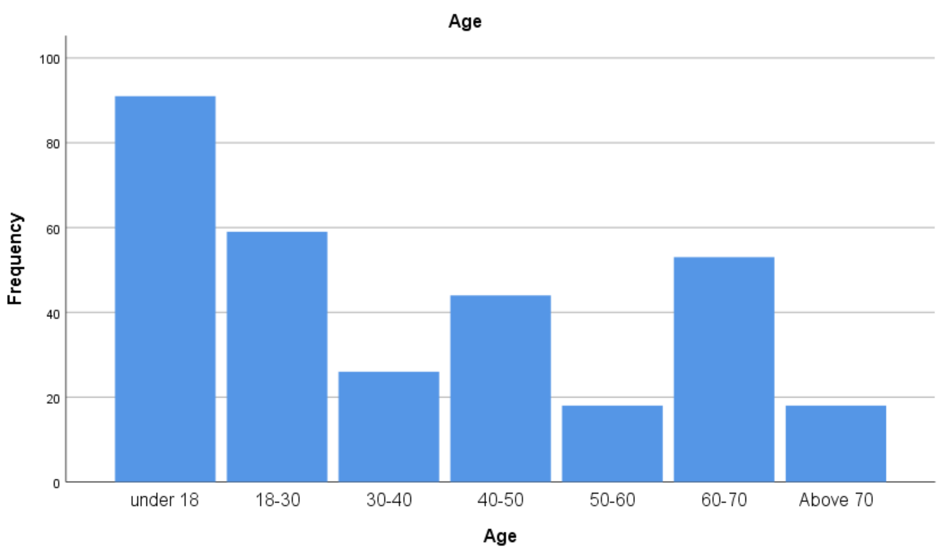

Figure 4.1.2 Age of the patients

4.2 Result of Rickettsia Transmitting Arthropods

Table 4.2. Result of Rickettsia Transmitting Arthropods

Results	Frequency	Percent
There is	78	25.2
No	231	74.8
Total	309	100.0

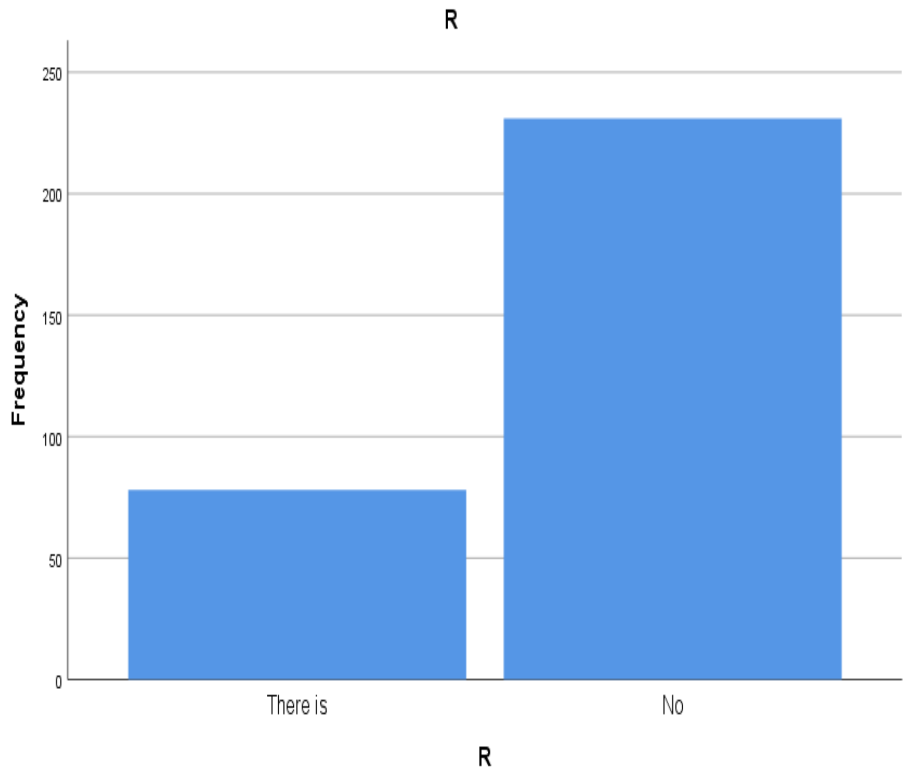

Figure 4.2 Result

This chart provides a thorough evaluation of the results of rickettsia-transmitting arthropods; it indicates that 25.2% of the results are positive and 74.8% are negative.

4.3 Weil-Felix Proteus

Table 4.3 Weil-Felix Proteus

Weil-Felix proteus	Frequency	Percent
Negative	193	62.5
1/80 at the limit	28	9.1
1/320 Positive	20	6.5
1/40 Negative	12	3.9
1/640 positive	19	6.1
1/160 Positive	28	9.1
1/20 Negative	4	1.3
1/1280 Positive	5	1.6
Total	309	100.0

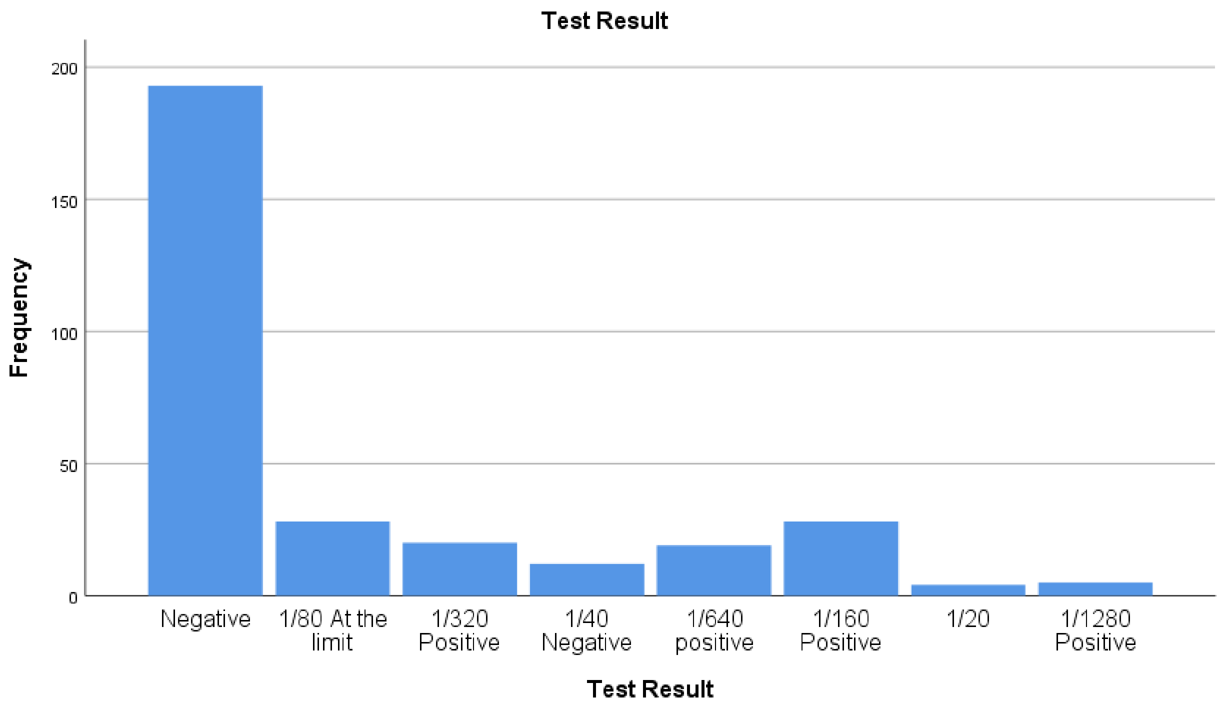

Figure 4.3 Weil-Felix Proteus

The test results are shown in the above chart and table. The largest result is 62.5 percent negative, and the smallest results are 1/20 Negative and 1/1280 Positive, which are 1.3 and 1.6 percent, respectively. The test results for the following groups are different percentages: 9.1, 6.5, 3.9, 6.1, and 9.1 percent, respectively; at the limit, 1/320 Positive, 1/40 Negative, 1/640 Positive, and 1/160 Positive.

4.4 Requesting section Name

Table 4.4 Requesting section Name

Requesting section Name	Frequency	Percent
Infection	40	12.9
Internal medicine	47	15.2
Child health diseases	70	22.7
Laboratory	44	14.2
Neurology	8	2.6
Hematology	16	5.2
Cardiology	8	2.6
Urgent	36	11.7
Dermatology	20	6.5
Pediatric Immunology and Allergy	4	1.3
ENT (Ear, Nose, and Throat) department	4	1.3
Chest Diseases and Allergy	4	1.3
Gastroenterology	4	1.3
Oncology	4	1.3
Total	309	100.0

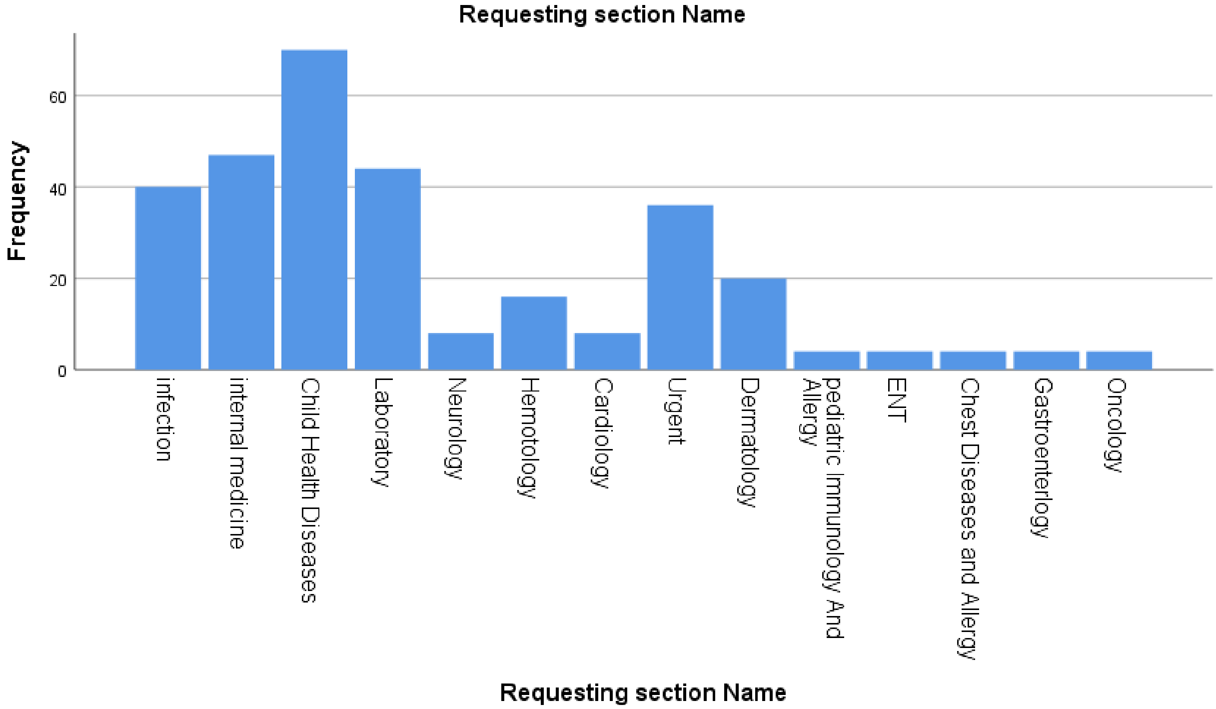

Figure 4.4 Requesting section Name

The section name and percentages that are being requested are shown in the above chart. Children's health diseases accounted for the largest percentage of requests (22.7%), while the smallest percentages were found in pediatric immunology and allergy, ENT, Chest Diseases and Allergy, Gastroenterology and Oncology (1.3%), internal medicine, child health diseases, Laboratory and urgent care (15.2, 22.7, 14.2, and 11.7 percent, respectively). Neurology and cardiology had the same percentages (22.6%), while the remaining two sections were in haematology and dermatology, with 5.2 and 6.5 percent, respectively.

CHAPTER FIVE CONCLUTIONS AND RECOMMENDATIONS

5.1 Conclusions

Numerous diseases, including bacteria, viruses, parasites, and RNA and DNA viruses, are linked to rodents and other small animals. These differ not just in terms of their genetic organisation but also in terms of their geographic distribution, association with certain reservoir hosts, and mode of transmission. Rodents are reservoir hosts for a variety of illnesses, according to many studies (Mills & Childs, 1998; Haydon et al., 2002; Essbauer et al., 2009b; Ulrich et al., 2009). Rats and other zoonoses account for a sizable portion of Emerging Infectious Diseases (EID), accounting for 60.3% of cases. Moreover, the majority of these illnesses (71.8%) originated in animals and have become significantly more common over time. Over 50% of EIDs are caused by bacteria, according to Jones et al. (2008).

Currently, dengue is thought to be the most significant virus spread by mosquitoes worldwide.

The virus and its vectors have now expanded quickly throughout tropical and subtropical parts of the planet, particularly in the last 50 years. The most severe strains of dengue have been caused by fast increases in outbreaks, incident cases, and hyperendemicity, as well as by extensive geographic expansion. The World Health Organisation (WHO) has declared that dengue is now spreading to every part of the world, with over 125 countries classified as dengue endemic.

According to the objectives of the WHO Global Strategy for Dengue Prevention and Control, 2012–2020, surveillance and improved case reporting are essential for evaluating the true state of things globally.

Vector-borne Rickettsial illnesses that influence human health are extremely important globally, with a recognised historical relevance as well as a revival and emergence. According to a recent data on notifiable illnesses in the US, instances of tick-borne spotted fever *Rickettsiosis* increased by 23% between 2016 and 2018. This developing trend is clearly seen across the country.

A rich substrate for examining host-pathogen interactions is provided by the variety of *Rickettsia* genomes and transmitting vectors (see to Outstanding Questions). Gaining insight into the intricate processes via which *Rickettsiae* can adjust to the dynamic transition between vector and vertebrate hosts would improve our comprehension of the molecular mechanisms underlying transmission.

The management of Rickettsial illness is limited by the lack of knowledge on the molecular and biological processes that underlie *Rickettsial* virulence and the vector-derived variables that govern transmission. The different diets of pan-Arthropoda *rickettsiae* vectors necessitate a detailed examination of physiologically feasible transmission strategies. Since ticks are vulnerable to rickettsial infection, it is important to ascertain the extent to which *Rickettsia* spp. control the vector for effective transmission. Because they offer several routes of transmission, insect vectors offer a unique opportunity to investigate *rickettsiae* in different physiological stages. All arthropod vectors of *rickettsiae* rely on microbiological effect on rickettsial transmission.

All around the world, ticks are a bloodsucking arthropod that feeds on mammals, birds, reptiles, and amphibians. As carriers of many bacterial, viral, and parasite diseases, they mostly affect people and cattle from early spring to late autumn in temperate countries during certain seasons (Anderson and Magnarelli, 2008; Guglielmone et al., 2014; Madison-Antenucci et al., 2020).

ixodid ticks, fleas, and lice are examples of transient obligatory ectoparasites that are commonly encountered on the same vertebrate hosts. The way that *rickettsiae* travel from the vector to vertebrate hosts may be affected by the wide variations in their feeding patterns and techniques for digesting blood meals. All stages of ticks and lice are blood feeders, but only adult fleas take blood from their host.

While *fleas* and *lice* eat irregularly and digest blood meals fast, ixodid ticks feed for several days and break down their food extremely slowly.

Warfare and vector-borne illnesses have always coexisted. Some diseases, like yellow fever and Japanese encephalitis, are no longer a threat to military personnel and operations thanks to commercially available immunization programs, but other diseases, like newly emerging and old diseases that are reemerging, still need to be taken seriously in the absence of effective preventive measures. Arthropod-borne diseases have become less hazardous to military personnel as a result of scientific advancements, however there is still a chance that these diseases could recur due to inadequacies in vector management or PPM application.

"Arthropod Borne Diseases," also known as "Vector Borne Diseases" (VBD) in medical entomology, refer to a class of infections that affect both humans and animals and are brought on by various pathogen organisms (such as bacteria, viruses, helminthes, and protozoa) that are spread by the bite of a bloodsucking insect or arachnid. Although it is well recognized that arthropod-transmitted infectious diseases primarily afflict tropical and subtropical regions, certain of these diseases have been, or are presently, prevalent in the northern hemisphere, where they are typically kept under control. Although they are remain among the most significant public health issues in endemic areas, VBD are also starting to worry wealthier nations.

During the later decades of the 20th century, several VBD have been geographically expanding, with initial records being made in regions outside of their original range. The particular epidemiological features of these diseases—which are thought to be the most vulnerable to changes in the environment, climate, and socioeconomic status—are the only explanation for this occurrence. A brief synopsis of the endemic and emerging VBD in Italy is provided in this article. We also talk about the likelihood that some exotic illnesses and/or vectors could be brought to Italy and spread there.

3.2 billion individuals in 97 nations and territories are still thought to be at risk of contracting malaria, nevertheless.

There are significant barriers to sustaining and expanding the current gains in the estimated 214 million cases of malaria that happened in 2015, with 438,000 deaths. Spending on basic research, drugs, and vaccines more than quadrupled to US$550 million between 1993 and 2013. Nevertheless, greater funding for R&D is required, as is a prompt release of new instruments. The Plasmodium parasite and mosquitoes' capacity to adapt is causing an increase in resistance to drugs and insecticides. Evidence of resistance to artemisinin-based combination therapies (ACTs) has been observed in five countries in Southeast Asia. If these tensions extended to the Indian subcontinent or Africa, it may be catastrophic.

Resistance to two or more insecticides has been identified in two-thirds of the African countries where malaria is endemic. After an initial infection, *Plasmodium vivax* parasites can lie dormant for months or even years, with up to 80% of individuals exhibiting no symptoms. The low parasite density in low-transmission zones makes it difficult to identify them using existing field testing.

Taking everything into account, the pipeline for cutting-edge malaria treatment and preventive techniques has never been healthier. Their use has contributed to the widespread emergence of resistance to current treatments, which has created an urgent need for enhanced field diagnostic instruments and cutting-edge strategies to precisely, quickly, and affordably identify and prevent the importation of malaria parasites in low-endemic environments.

It is imperative to devise suitable ways for both scaling up and rolling out these technologies to ensure that they can successfully aid in the rapid decrease of malaria transmission. By identifying the primary locations and channels through which malaria spreads, improved monitoring techniques will focus resources on diagnosis, treatment, and prevention where they will have the greatest effect on accelerating the elimination of parasites and saving lives. Using new strategies will also make it simpler to determine the best ways to carry out interventions. If these activities are correctly executed in an integrated and complementary way, there will be a significant rise in the likelihood of eradicating malaria. By doing this, we'll be able to keep up and even surpass the impressive savings we've already accomplished.

5.2 Recommendations

- Put Integrated Vector Management (IVM) Techniques into Practice: Stress the value of integrated strategies that incorporate several interventions, like biological control, targeted insecticide-based tactics, and surveillance. A more thorough and long-lasting control over vector populations is made possible by IVM.
- Enhance Monitoring and Vector Surveillance Systems: To improve early detection and response to outbreaks of vector-borne diseases, make investments in surveillance and monitoring system enhancements. This includes gathering and analyzing data on infection rates, vector populations, and their dispersion on a regular basis.
- Create and Assess Novel Insecticides: Provide funds for the investigation and creation of novel pesticides, keeping in mind the growing problem of pesticide resistance. Assess these innovative pesticides' environmental effect and efficacy to make sure they are appropriate for vector control programs.
- Promote Community Involvement and Education: Develop targeted public awareness programmers and educational materials to raise awareness of *Rickettsia* infections, their transmission, and preventative measures. Motivate communities to actively participate in vector control activities by adopting personal protective measures and maintaining a clean and sanitary living environment.
- Strengthen Cooperation and Organizing: Encourage cooperation between pertinent parties, such as community organizations, researchers, legislators, and public health authorities. Encourage the sharing of knowledge, skills, and resources in order to maximize vector control tactics and guarantee their successful application.
- Conduct Additional Research: Promote ongoing studies on the biology, ecology, and behavior of Cyprus's *rickettsia*-transmitting arthropods. Insights into the local dynamics of

vector-borne diseases can be gained from this research, which can also help design more effective control measures.

- Consistent Program Assessment and Modification: Provide a framework for routinely analyzing vector control initiatives in order to determine their efficacy and pinpoint areas in need of development. Make adjustments and improvements to the interventions based on the results to guarantee that the control measures remain effective.
- Public health officials and legislators can create and implement efficient vector control strategies to fight Rickettsia infections in Cyprus by putting these ideas into practice. Enhanced surveillance, community involvement, integrated interventions, and ongoing research and evaluation will all work together to lessen the prevalence and effects of these vector-borne illnesses on the general public.

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