ISSN 2321-8746

Biology, Agriculture, SciTech and Environment

An Peer Reviewed International Magazine for Research Notes/ Articles

Volume 4 [12] December 2024

Published By: Biology, Science, Agriculture and Environment Congress, India

Website: basecongress.com

ISSN 2321-8746

Biology, Agriculture, SciTech and Environment

An Peer Reviewed International Magazine for Research Notes/ Articles

Published By: Biology, Science, Agriculture and Environment Congress, India

Website: basecongress.com

ISSN 2321-8746

Biology, Agriculture, SciTech and Environment

An Peer Reviewed International Magazine for Research Notes/ Articles

Table of Content

Vol 4 [12] December 2024

BASE Indexed

Google Scholar, Europub, Scientific Journal Impact Factor, Research Publication Rating and Indexing, Zenodo, Openaire [Europe Database], CAS (American Chemical Society), IJFACTOR etc.

Published By: Biology, Science, Agriculture and Environment Congress, India

Website: basecongress.com

Biology, Agriculture, SciTech and Environment
Vol 4 [12] December 2024; 01-07
ISSN 2321-8746

Full Text: https://www.basecongress.com/ebase.html
OPEN ACCESS

Bioremediation as a Tool to Reduce Soil-Based Biomagnification

Riya Das[1] and Sitesh Chatterjee[2]*
[1]Bidhan Chandra Krishi Viswavidyalaya, Department of Agricultural Chemistry and Soil Science, Mohanpur, Nadia-741252, India
[2]Rice Research Station, Department of Agriculture, Government of West Bengal, Chinsurah (R.S.), Hooghly-712102, India
***Corresponding author:** sitesh.chatt1@gmail.com

ABSTRACT
An efficient and sustainable method for reducing soil contamination and the possibility due to biomagnification - the buildup and magnifying of toxic compounds through food chains—is bioremediation. This method offers a sustainable way to fight contamination by dangerous compounds like pesticides and heavy metals by using living creatures like bacteria, plants, or enzymes to break down or remove contaminants from the soil. One of the most extensively researched types of bioremediation is microbial remediation uses bacteria, fungus, and other microorganisms that have the innate capacity to break down contaminants into less dangerous forms. Complex organic contaminants, like pesticides, are broken down by these microbes into harmless byproducts which have no pesticidal property. In contrast, phytoremediation employs plants to absorb, concentrate, or change pollutants in the soil. Some plants, referred to as hyperaccumulators, have the ability to absorb pesticides and heavy metals, thereby reducing soil contamination. A less invasive method of decontaminating soil is to use enzymatic techniques, which make use of plant or microbial enzymes to help break down toxins like metals and organic pollutants. Bioremediation has a number of obstacles in spite of its potential. The kind of pollutant, the characteristics of the soil, and the surrounding environment can overall affect how effective these methods are. The efficacy of bioremediation procedures in circumstances of severe contamination may also be limited by their slowness. However, a viable long-term strategy for avoiding the buildup of toxic materials in soil, maintaining healthier ecosystems, and lowering the possibility of biomagnification in food chains is bioremediation.
Keywords: Bioremediation, Soil contamination, Biomagnification, Microbial remediation, Phytoremediation, Hyperaccumulators

Received 23.11.2024 Revised 28.11.2024 Accepted 30.11.2024

CITATION
Riya D and Sitesh C. Bioremediation as a Tool to Reduce Soil-Based Biomagnification. Biol. Agricul. SciTech and Environ. Vol 4 [12] December 2024; 01-10

INTRODUCTION

Heavy metal, herbicide, and other persistent organic pollutants (POP)-induced soil pollution is a serious environmental issue that endangers ecosystems and public health. When these contaminants build up in soil, they have the potential to infiltrate the food chain and trigger biomagnification, a process whereby the concentration of harmful compounds rises as trophic levels are reached. Higher-level creatures are negatively impacted by this, including people who eat tainted food. For example, persistent environmental heavy metals like lead and mercury can build up in plant and animal tissues, causing long-term health concerns like kidney failure, neurological impairment, and reproductive disorders (Glick, 2010).

Conventional soil restoration techniques, like chemical treatments and excavation, are frequently expensive, energy-intensive, and occasionally worsen environmental damage. Additionally, these approaches might not be able to effectively address the underlying pollution. This has led to the demand for more economical and environmentally friendly substitutes. Bioremediation, which uses biological agents like bacteria, plants, or enzymes to eliminate, break down, or neutralize pollutants in soil, is one potential approach. For instance, certain plants can absorb and store toxins in their tissues, a process known as phytoremediation; microorganisms can also break down toxic substances into less damaging compounds (Pilon-Smits, 2005).

What is Biomagnification:

The process by which harmful compounds, such as pesticides, heavy metals, and other contaminants, concentrate more as they go up the food chain is known as biomagnification. It happens because organisms find it difficult to break down or get rid of these chemicals. Therefore, more of the poisonous material is accumulated by creatures at higher trophic levels (predators) than by those at lower trophic levels (primary producers or herbivores).

The problem is made worse by pesticide runoff from agricultural fields into adjacent water bodies, which promotes toxicant biomagnification and bioaccumulation. As water quality metrics deteriorate, the balance of aquatic plants and animals is upset, harming aquatic ecosystems. Aquatic organism mortality cases increase in frequency, highlighting the magnitude of the ecological cost. Concurrently, pesticide drift exacerbates the problem by negatively affecting populations of pollinators, natural enemies, beneficial pests, and non-target pests. Urgent action is required to lessen the effects of this complex influence on soil and water ecosystems, highlighting the significance of sustainable farming methods and strong regulatory frameworks to protect ecosystems and advance environmental health (Dey et al, 2024).

Despite their immediate advantages, pesticides can eventually be fatal and seriously harmful to human health. Many bug genera become resistant to and resurgent in response to the regular application of certain pesticides. However, because of their environmentally favourable qualities, farmers should be urged to switch to botanical pesticides (Roy et al, 2024).

What is Bioremediation:

Bioremediation is the practice of cleaning up the environment through the use of living organisms, including but not limited to, bacteria, fungi, plants, or enzymes. This process specifically targets, soil, water, and air. This is an eco-friendly approach to pollution control as compared to the traditional methods and is effective in terms of cost. Bioremediation outcomes are achieved through the interaction of plants and other microorganisms, which employ their metabolic processes to transform and or break down toxic substances into less or non-toxic compounds.

Bioremediation can broadly be classified into two types:

a) In situ bioremediation: This is bioremediation where the contaminants are treated where they are found without taking the pollution away from the site. This method focusses on the biodegradation and neutralization of pollutants by seeking active boring microbes found within the area. This involves addition of nutrients and oxygen or any other agents that increase microbial activity to hasten the degradation of the pollutants.

b) Ex situ bioremediation: Contaminated areas such as soil or water is being taken to some other area for management and it is done through process of a bioreactor or other treatment plant, which is safe for contaminants. Such materials are only returned once pollutants have been broken down or taken out or appropriate waste disposal has been administered.

Biomagnification of pesticides:

Biomagnification of pesticides is the increase in concentration of pesticide chemicals that occurs with each step in the food chain. Although they are intended to be used for particular organisms, they tend to be scattered throughout the environment and are certain to be found in soils, water and plants. These pesticides enter the food web and become concentrated as one progresses up the trophic level, which can be detrimental to both animals and man.

This is how pesticides magnify between trophic levels:

- **Pesticides in the environment:** Pesticides can be introduced into the environment through agricultural runoffs, leaching through the soils or through direct applications. These compounds tend to adhere to soil particles or get taken up by plants and may remain with them for a long duration especially persistent DDT or organochlorines.
- **Absorption by primary producers (plants and algae):** Pesticides tend to be absorbed from either the water or the soil by plants and crops, which includes grasses and aquatic plants. Owing to the fact that pesticides are known not to degrade easily, they can become deposited in plant bodies over time.
- **Consumption by herbivores:** Small herbivores, such as insects, rodents, or small fish, eat these contaminated plants. The pesticide concentration in their bodies is now higher than in the plants they consume because they accumulate the chemicals in their tissues as they feed.
- **Transfer through higher trophic levels:** As predators eat contaminated herbivores, the concentration of pesticides increases in the predator's body. For example, larger fish eating smaller fish, or birds of prey eating contaminated rodents, accumulate even more pesticides. This process continues as predators higher up the food chain consume contaminated organisms, leading to increasingly higher concentrations of pesticides in their tissues.
- **Impact on top predators (including humans):** Organisms at the top of the food chain, such as apex predators (e.g., eagles, large fish, and humans), can accumulate dangerous levels of pesticides. These substances can cause a wide range of health issues, including reproductive disorders, immune suppression, and neurological damage. In some cases, pesticides like DDT have been shown to thin

eggshells in birds, causing reproductive failure. In humans, long-term exposure to pesticide biomagnification has been linked to cancer, developmental disorders, and endocrine disruption.

A classical example of biological magnification or bio-magnification is given below:
Assume that irrigation or rainfall causes pesticides or pesticidal residues to be rinsed off of crops. Through leaching or surface runoff, these leftovers have the potential to penetrate the soil and eventually reach water bodies. The chemical characteristics of the pesticide, the type of soil, the flow of water, and the surrounding environment can all affect the concentration of pesticides in the soil and water throughout this process. The balance of the ecosystem, water quality, and soil health may all be significantly impacted by this movement.
Suppose a pesticide present in soil washes into water bodies (ponds, rivers, ditches, lakes, sea etc.) and suppose the concentration of pesticide remains in water bodies as 0.00000000001%.
Suppose, through water bodies, the pesticide enters into micro flora and fauna **(primary consumer)** into 100 times, then,
Each micro flora or fauna contains,
0.00000000001% x 100
= 0.000000001% concentration of pesticide
If an insect **(secondary consumer)** feeds 100 numbers of flora and fauna each day, then,
Each insect contains,
0.000000001% x 100
= 0.0000001% concentration of pesticide
If one small fish **(tertiary consumer)** feeds 100 numbers of insects each day, then,
Each small fish contains,
0.0000001% x 100
= 0.00001% concentration of pesticide
In the same way, if one large fish **(top level consumers/ quaternary consumer)** consumes 100 numbers of small fish each day, then,
Each large fish contains,
0.00001% x 100

= 0.001% concentration of pesticide
In this way the concentration of pesticide is being increased from the lower level of consumers to the higher level of consumers in the trophic level.

A. Food chain:
An arrangement of organisms that each provide food for the one after it is known as a food chain. It symbolizes how nutrients and energy move through an environment within a food chain:

The producers are eaten by the primary consumers, or herbivores

↓

The primary consumers are eaten by secondary consumers, or carnivores

↓

Secondary consumers are consumed by tertiary consumers, or apex predators

↓

Dead organisms are broken down by decomposers, such as bacteria and fungi, which recycle nutrients back into the environment

The term **"trophic level"** refers to each level of the food chain. There are fewer apex predators than producers since energy diminishes as it goes up the hierarchy.

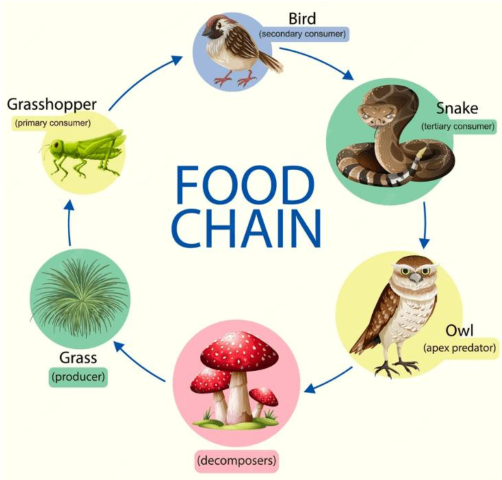


Fig. 1. Flowchart of Food chain

B. Food web:

A food web, which consists of several overlapping food chains, is a highly intricate and linked system of feeding connections within an ecosystem. It illustrates how different creatures are connected in numerous ways, displaying diverse feeding relationships, in contrast to a food chain, which depicts a single linear channel of energy and nutrients. The intricacy of actual ecosystems, where the majority of organisms consume and are consumed by many species, is better depicted by the food web than by a food chain. Because energy and nutrients move through multiple pathways due to this interconnectedness, the ecosystem is more resilient to shocks like the extinction of a single species.

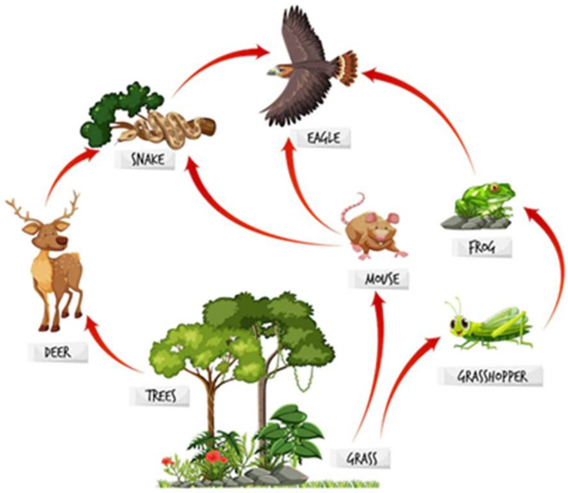


Fig. 2. Flowchart of Food web

METHODS

Microbial Bioremediation

Utilising bacteria, fungus, and other microorganisms to break down or immobilise contaminants is known as microbial remediation. Bacillus, mycorrhizal fungi, and pseudomonas are often employed species (Ahemad & Khan, 2011).

Mechanism:

Microbial bioremediation breaks down or immobilizes pollutants by using bacteria, fungus, and other microorganisms. The procedure entails:

- **Contaminant Metabolism:** Through enzymatic mechanisms, microbes convert harmful chemicals (such as pesticides and heavy metals) into less complex, non-toxic molecules.
- **Enzymatic Breakdown:** Microbes generate oxidative or reductive enzymes that break down or change contaminants into innocuous forms. For example, they can change heavy metals into less harmful states or hydrocarbons into carbon dioxide and water.
- **Immobilization:** Toxic compounds are bound by some microbes, such as mycorrhizal fungus, which reduces their mobility and lessens environmental damage.

Phytoremediation
Plants are used in phytoremediation to absorb, stabilise, or change contaminants. *Vetiveria zizanioides* for organic pollutants and *Brassica juncea* for heavy metals are common species (Pilon-Smits, 2005).
Types include phytodegradation, phytoextraction, and phytostabilization.

- **Phytodegradation:** Pollutants are broken down into less dangerous forms by plants through absorption and metabolic activities. For instance, organic contaminants such as pesticides can be broken down by plants into less dangerous, simpler forms.
- **Phytoextraction** is the process by which pollutants, such heavy metals, are taken up by plants from the soil and concentrated in their tissues, usually the leaves or stems. When the plants are harvested, this procedure enables the pollutants to be eliminated from the environment.
- **Phytostabilization:** By immobilizing pollutants in the soil, plants stop them from spreading through erosion or leaching. This lessens the possibility that pollutants will enter groundwater or be absorbed by other living things.

Enzymatic bioremediation
Enzymatic approaches involve the use of purified enzymes, such as laccases and peroxidases, to degrade complex organic pollutants (Chen & Wong, 2008).
Integrated approaches
Combining multiple bioremediation methods often results in synergistic effects, enhancing efficiency and applicability (Singh & Singh, 2020).

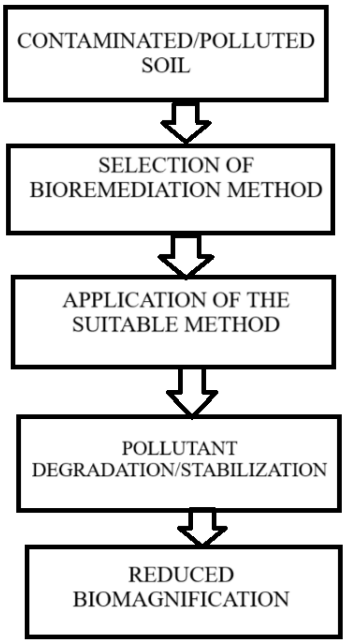


Fig. 3. Flowchart of Bioremediation Process

RESULTS AND DISCUSSIONS
Harmful effects of pesticides through biomagnification:

- The following are some negative consequences of pesticides through biomagnification: **Increased Toxicity:** Pesticide concentrations rise as they build up in the bodies of higher trophic level species (predators, for example), producing more potent toxic effects. Large fish and birds of prey are examples of top predators that can become poisoned.
- **Ecosystem Disruption:** By endangering important species that are essential to preserving the equilibrium of an ecosystem, such pollinators or aquatic life, the accumulation of pesticides in the food chain has the potential to upset entire ecosystems.
- **Reproductive Harm:** Since many pesticides are endocrine disruptors, they may affect wildlife's ability to reproduce. Birth problems, decreased fertility, or a fall in a species' population can result from this.
- **Decline in Biodiversity:** Ecosystems lose biodiversity as a result of sensitive species dying off or failing to reproduce as a result of significant pesticide accumulation.

- **Risks to Human Health:** Pesticide buildup in food can potentially affect humans, particularly those at the top of the food chain. Health problems include cancer, neurological diseases, and hormone abnormalities can result from prolonged exposure.

The risks of pesticide use are brought to light by biomagnification, especially when the chemicals linger in the environment and gradually build up in living things.

Efficiency of microbial remediation

Microbial remediation has proven to be highly effective in degrading hydrocarbons and immobilizing heavy metals. This can be proved by studies that show a reduction of oil contamination by 70–90% after six months of microbial application (Ahemad & Khan, 2011).

Performance efficiency of phytoremediation

Plants such as *Populus deltoides* and *Helianthus annuus* have demonstrated very high efficiency in phytoextraction, with up to 40% reduction of cadmium concentrations in contaminated soils in the course of one year (Pilon-Smits, 2005).

Problems of bioremediation

Soil-specific variations of pH, temperature, and availability of nutrients tend to affect microbial activity and plant growth. Treatment periods become somewhat lengthy for phytoremediation. Very few highly contaminated soils can be applied (Chen & Wong, 2008).

FUTURE PROSPECTS

Advances in genetic engineering and nanotechnology are likely to boost the efficiency of bioremediation technologies. Engineered microbes and hyperaccumulator plants are likely to revolutionize the field (Singh & Singh, 2020).

How to overcome biomagnification:

Several tactics, such as the use of bio-based and green insecticides, cultural control, and integrated pest management (IPM), can be used to combat biomagnification and lessen the negative impacts of pesticides. These methods operate as follows:

Utilizing Green and Bio-based Insecticides:

Bio-insecticides: These are less damaging to the environment and non-target species because they come from natural sources like fungi, bacteria, or plants. Examples include neem oil, which is extracted from the neem tree and acts as a natural insecticide, and *Bacillus thuringiensis* (*Bt*), a bacterium used to control pests like caterpillars.

Green pesticides are safer for beneficial insects, people, and wildlife than synthetic chemicals. Examples of these include diatomaceous earth, insecticidal soaps, and essential oils (such as citronella and eucalyptus).

Cultural Management of Insects: By altering farming methods, this strategy lowers pest populations without using chemical pesticides. Among the examples are:

Crop rotation is the process of switching up crops to interfere with the life cycles of pests.

Planting various crops together to confound pests and slow the spread of disease is known as intercropping.

Breeding plants that are resistant to pests is known as selective breeding. Physical barriers: To keep pests away from plants, use row coverings or nets.

Agro-Ecosystem Analysis (AESA): This entails routinely observing the agricultural ecosystem to evaluate weather patterns, pest numbers, and the efficacy of management measures. By decreasing the needless use of pesticides, AESA assists in determining when and how to apply treatments based on pest dynamics rather than preset schedules (Dhar et al,2023).

IPM, or Integrated Pest Management: IPM is a comprehensive strategy that uses a variety of techniques to control pests with little harm to the environment (DPPQS):

<u>Biological control</u> involves the introduction of natural parasites or predators, such as ladybugs for aphids.

<u>Physical and mechanical controls</u> include barriers, traps, and hand pest removal.

<u>Chemical control:</u> When required, apply targeted, low-risk pesticides (bio-insecticides or environmentally friendly alternatives) at the best periods to minimize damage.

<u>Monitoring:</u> Consistent data gathering and pest surveillance to assess pest populations and identify the best course of action.

Alternative Techniques:

- **Use of Resistant types:** Chemical interventions are less necessary when genetically resistant or improved crop types that are less vulnerable to pests and diseases are planted.
- **Natural Predators and Enemies:** Promoting beneficial creatures like birds and predatory insects (like beetles and spiders) aids in the natural management of pest populations.

When it comes to lowering risk, there are three key areas to consider:

- appropriate handling and storage;
- appropriate storage and disposal; and

- appropriate use of Plant Protection Equipment (PPE), such as chemical-resistant gloves, aprons, goggles, hats, and covering shoes.

The field must be inspected to ensure that there are no humans or animals present, and the area where pesticides are mixed must be away from ponds, streams, ditches, and wells. Pesticide cans, packages, etc. shouldn't be disposed of in fields, ponds, rivers, etc. It can be burned or buried deep in the ground. Pesticides should be kept locked up in secure locations out of the reach of domestic animals, children, and other family members (Chatterjee, 2021).

CONCLUSION

Bioremediation is thus a promising, environmental-friendly solution to alleviate soil pollution, thereby minimizing the harmful impacts of biomagnification in food chains. With this approach, sustainable remediation of soil is provided through the use of living resources and enzymes, utilizing their natural properties to degrade contaminants. In terms of remediation through microorganisms, plants, and enzymes, each process has its benefits, and together they may exhibit increased efficiency and wider applicability. However, the process of bioremediation has certain limitations in treating highly contaminated sites. Remediation periods might be long, and variable soil conditions can also challenge bioremediation processes.

Future breakthroughs in genetic engineering, nanotechnology, and bioreactor designs would help to cross these barriers and improve the efficiency of bioremediation. Bioremediation can then continue to transform soil health, protect ecosystems, and embrace sustainable agriculture. The present study emphasizes the adoption of bioremediation technologies in dealing with the increasing threats posed by soil pollution and biomagnification.

REFERENCES

1. Ahemad, M., & Khan, M. S. (2011). Microbial applications in agriculture and the environment: A review. *Environmental Sustainability*, 2(3), 149–162.
2. Chatterjee, S. (2021). Hazards and Safe Use of Pesticides in Agricultural Field. 5. 28.
3. Chen, J., & Wong, M. H. (2008). Environmental fate of organic contaminants and remediation. *Critical Reviews in Environmental Science and Technology*, 38(6), 399–432.
4. Dey, S., Adak, S., Dhar, A., Jana, S., Sarkar, S., & Chatterjee, S. (2024). How Pesticides Can Harm You and Your Environment: A Review of Drift Exposure Routes and Health Risks. 05. 137-144.
5. Dhar, A., Biswas, P., & Chatterjee, S. (2023). Agro-Ecosystem Analysis (AESA): A sustainable approach for crop pest management. *Agro-Ecosystem Analysis*, 5(6), 1–5.
6. Glick, B. R. (2010). Using soil bacteria to facilitate phytoremediation. *Biotechnology Advances*, 28(3), 367–374.
7. IPM Techniques retrieved from https://ppqs.gov.in/divisions/integrated-pest-management/components-ipm
8. Pilon-Smits, E. (2005). Phytoremediation. *Annual Review of Plant Biology*, 56, 15–39.
9. Roy, R., Dimitrov, S.E. and Chatterjee, S. (2024). Pesticide Poisoning in India: A Major Public Health Issue and its Antidotes. *Food and Scientific Reports*, 5(1): 17-26
10. Singh, R., & Singh, P. (2020). Advances in bioremediation of contaminated soil and water. *Environmental Progress & Sustainable Energy*, 39(2).90

Biology, Agriculture, SciTech and Environment
Vol 4 [12] December 2024; 08-10
ISSN 2321-8746

Full Text: https://www.basecongress.com/ebase.html
OPEN ACCESS

Agrivoltaics- climate smart approach for the emerging world

Rohit V Raj[1], Krishna[2]
[1]M.Sc. Scholar, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) – 125004
[2]M.Sc. Scholar, Department of Vegetable Science, Maharana Pratap Horticultural University, Karnal (Haryana) – 132001
Email – rohitvrajvr@gmail.com

ABSTRACT
The Industrial Revolution brought technological advances that improved quality of life but at significant environmental costs, such as climate change and its impact on agriculture and energy needs. Agrivoltaic systems, which integrate agricultural cultivation with solar photovoltaic panels, offer a sustainable solution by combining food and energy production on the same land. Originating in the 1980s and popularized in recent decades, agrivoltaics enhances land use efficiency, protects crops, increases yields, and generates renewable energy while promoting rural electrification and reducing greenhouse gas emissions. Despite its benefits, the adoption of agrivoltaics faces challenges such as high costs, legal restrictions, and limited awareness. Overcoming these barriers requires policy support, financial incentives, and pilot projects. Agrivoltaics demonstrates significant potential to balance land demands for food and energy, improve farm resilience, and contribute to global sustainability goals, particularly in arid and developing regions.
Key word – Revolution, Agrivoltaic systems, electrification, sustainability

Received 23.11.2024 Revised 28.11.2024 Accepted 30.12.2024

CITATION
Rohit V Raj, Krishna . Agrivoltaics- climate smart approach for the emerging world. Biol. Agricul. SciTech and Environ. Vol 4 [12] December 2024; 08-10

INTRODUCTION

Since the Industrial Revolution, the world has experienced a dramatic transformation, driven largely by rapidly advancing technologies and the widespread use of fossil fuel-powered vehicles and machinery. These innovations have reduced human labor and greatly enhanced the quality of life. However, this progress has come with significant costs, increasingly evident in recent decades. Human activities have been a major contributor to climate change, resulting in severe climate events that have caused widespread damage to lives and property. Over time, these challenges have become more pressing, affecting agricultural systems and daily life. The rapid growth of the global population has intensified the demand for sufficient food supplies and clean, sustainable energy sources, further complicating the situation. The Green Revolution, while revolutionizing agriculture, made it heavily dependent on inputs, increasing the energy required for crop production. This has led to a heightened reliance on non-renewable, polluting energy sources, exacerbating atmospheric pollution. Additionally, land—a critical resource for agriculture—faces competing demands, particularly when shifting to renewable energy production to meet rising energy needs, potentially threatening food security for the growing population. To tackle these intertwined challenges, a promising innovation known as agrivoltaic systems has been introduced, offering a potential solution to balance food and energy production sustainably.

Agrivoltaic systems integrate soil-based agricultural cultivation with solar photovoltaic panels, resulting in a synergy of food production and energy generation while reducing competition for limited land resources. This novel technique not only stabilizes agricultural output but also protects crops that are vulnerable to climate change, benefiting rural economies and livelihoods. Adolf Goetzberger and Armin Zastrow established the notion of agrivoltaics in the early 1980s. However, widespread adoption occurred in the second decade of the twenty-first century. The term "agrivoltaics" was coined by a group of French scientists led by Christophe Dupraz to describe a system that combines solar panels and crops on the same piece of land to maximize land use efficiency. Later research in France indicated that this technology may enhance worldwide land productivity from 35% to 73%, making it an appealing choice for farmers and solar energy providers alike. Global agrivoltaics capacity increased from 5 MW in 2014 to 2.8 GW in 2020, with China leading the trend with 1.9 GW installed capacity, followed by developed nations such as Japan and Germany

(Trommsdorff, Gruber *et al*., 2022). This method is especially attractive for developing tropical countries since it allows them to achieve development and climate goals while preserving agricultural land.
Agrivoltaic systems are classified into three types: elevated, inter-row, and a combination of both. In the elevated system, solar panels are installed directly above the crops, usually at a height of 6 feet. This structure protects crops from adverse weather conditions while also reducing light exposure, making it suitable for plants that like shade. The inter-row system grows crops between rows of solar panels rather than underneath them. While it does not provide the same level of extreme weather protection, it does allow for more sunlight exposure, which is beneficial to crops such as grasses, grains, and hardy vegetables.

POTENTIAL BENEFITS OF AGRIVOLTAICS:

1. **Enhanced Land Use Efficiency**: By allowing the simultaneous production of food and energy from the same area, agrivoltaics greatly increases the efficiency of land use and maximizes the potential output of the land.
2. **Food-Energy Synergy**: This system promotes a mutually beneficial interaction between the production of food and energy, providing a sustainable solution to the problems caused by climate change and ensuring a brighter future.
3. **Higher Crop Yields**: Agrivoltaics can increase crop yields for crops that like shade, increasing farming's profitability. This encourages economic growth in agricultural areas and helps to reduce poverty.
4. **Additional Income Source**: Farmers face difficulties due to the unpredictabilities of traditional farming, which include low returns, excessive expenses, poverty, debt, and unsecured loans. Because grid-connected solar panels enable farmers to sell extra electricity to utility companies, agrivoltaics offers an alternate source of revenue.
5. **Protection from Severe Weather**: Crops are better protected against severe weather conditions like hailstorms and excessive sunlight. In addition, the crops produce a microclimate that protects the solar panels, extending the agrivoltaic system's lifespan
6. **Promotes Rural Electrification**: Combining solar energy systems with agricultural methods can promote rural electrification in underdeveloped areas with plenty of sunlight. There is a lot of potential for this kind of integration because solar energy is one of the most readily available renewable resources in the world. For example, agrivoltaic systems in Japan have produced an astounding 284 million MWh of electricity year (Gonocruz *et al*., 2021). Remote locations around the world can be electrified with this technology in a sustainable and dependable manner.
7. **Reduces Greenhouse Gas Emissions**: Electricity generation from non-renewable sources contributes heavily to greenhouse gas emissions. Agrivoltaics reduces reliance on these sources by promoting renewable energy production. For example, the European Commission aimed for 32% of energy to be sourced from renewables by 2020 (Renewable Energy Target, European Commission), a goal that agrivoltaic systems can help achieve through their integration of sustainable energy and agriculture.

Challenges of adopting agrivoltaics

1. **Cultivation Challenges**: Farmers may find it challenging to adopt agrivoltaic technology due to the unpredictability of crop reactions to this technology. Extensive testing is frequently necessary to identify the best crop-system combination, which can be costly and time-consuming.
2. **Expensive**: Compared to conventional solar panels, agrivoltaic system installation is more expensive and requires a large amount of maintenance. These expenses can be prohibitive for small-scale producers. To properly handle and maintain the panels, farmers also require training. Long-term advantages, however, may outweigh these expenditures.
3. **Land Use Restrictions**: Legal and regulatory limitations prevent large-scale commercial solar developments from being established in many developing nations, which restricts the broad use of agrivoltaic systems.
4. **Impact on Soil Quality**: Installing solar panels may lead to soil compaction, negatively affecting soil health. Farmers must implement soil remediation measures, which can increase their workload and financial burden.
5. **Limited Awareness and Fear of Failure**: A lack of awareness about the potential benefits of agrivoltaics among the farming community hampers its adoption. Furthermore, apprehension about the risks and uncertainties associated with this technology creates additional challenges for its acceptance and implementation.

Way forward

- **Policy and Regulatory Support**: Challenges in adopting agrivoltaic systems can be addressed through well-designed government policies and regulations. For example, tropical countries have introduced various initiatives to promote agrivoltaic adoption. In India, the government launched the PM-KUSUM scheme to help farmers implement agrivoltaic systems on a small scale.

- **Financial Incentives for Farmers**: Providing price support, such as subsidies, can encourage farmers to adopt new technologies like agrivoltaics. These incentives will extend the system's benefits to remote rural areas, fostering widespread adoption and increasing agricultural and energy efficiency.
- **Centres of Excellence**: Creating specialized centres of excellence at technical colleges and universities can be extremely important for agrivoltaic technology training and capacity building. These facilities can help developers reach more potential users and educate rural communities about the advantages of agrivoltaics.
- **Pilot Projects and Business Model Testing**: Pilot projects should test new designs and technologies and experiment with various crop selections to assess the commercial viability of agrivoltaic systems. These initiatives will increase the versatility and profitability of agrivoltaic systems and enable them to be refined for a variety of situations.

CONCLUSION

Agrivoltaics offers a promising solution to the competition between food and energy production for land. It has the potential to reduce greenhouse gas emissions, generate renewable energy, and improve the climate resilience of farms. The technology also provides additional benefits, such as increased land use efficiency, income generation, poverty alleviation, and enhanced crop yields, making it a highly attractive option for farmers, particularly in developing countries. Despite its advantages, agrivoltaics is still in its early stages of development, requiring further research to unlock its full potential on a larger scale. Additionally, overcoming legal, cultural, and political obstacles necessitates comprehensive studies and policy interventions. Pilot projects conducted to date have shown particular promise in arid and semi-arid regions, where the adoption of agrivoltaic systems has proven highly beneficial. As a result, agrivoltaics not only provides a stable environmental framework for farmers but also aligns with global efforts to curb greenhouse gas emissions and promote sustainable development.

REFERENCES

1. Trommsdorff, M., Dhal, I. S., Özdemir, Ö. E., Ketzer, D., Weinberger, N., & Rösch, C. (2022). Agrivoltaics: solar power generation and food production. *In Solar energy advancements in agriculture and food production systems* (pp. 159-210). Academic Press.
2. Gonocruz. R, A., Nakamura, R., Yoshino, K., Homma, M., Doi, T., Yoshida, Y., Tani, A. Analysis of the rice yield under an Agrivoltics system: A case study in Japan. *Environment* 2021, 8, 65.
3. Renewable energy target, European Commission. https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en.

Biology, Agriculture, SciTech and Environment
Vol 4 [12] December 2024; 11-14
ISSN 2321-8746

Full Text: https://www.basecongress.com/ebase.html
OPEN ACCESS

Enhancing Nutritional Value Through Biofortification in Vegetable Crop: Strategies, Benefits and Challenges

Krishna[1], Nitika [2], Vikas Kumar[3]
[1]M.Sc. Scholar, Department of Vegetable Science, Maharana Pratap Horticultural University, Karnal (Haryana) – 132001
[2]M.Sc. Scholar, Department of Vegetable science, Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) – 125004
[3]Assistant Scientist, Department of Vegetable Science, CCS HAU, Hisar, Haryana-125004
Contact. No- 8295108338
Email – jangrakrishna759@gmail.com

ABSTRACT
Biofortification enhances crop nutrient levels through agronomic practices, selective breeding, and genetic engineering, addressing malnutrition in resource-limited areas by providing nutrient-dense foods. Agronomic methods use fertilizers and microbes, while breeding improves yield and nutritional value. Genetic engineering introduces traits that boost nutrient bioavailability and crop quality. Notable biofortified crops include Pusa Betakesari-1 (cauliflower), Kufri Neelkanth (potato), and Pusa Meghali (carrot). Genetic advances like ferritin-enriched lettuce and anthocyanin-rich tomatoes further enhance food nutrition. Despite challenges such as consumer awareness and anti-nutritional factors, biofortification offers a sustainable way to improve public health and farmer livelihoods.

Received 23.10.2024 Revised 18.11.2024 Accepted 24.12.2024

CITATION
Krishna, Nitika, Vikas K. Enhancing Nutritional Value Through Biofortification in Vegetable Crop: Strategies, Benefits and Challenges. Biol. Agricul. SciTech and Environ. Vol 4 [12] December 2024; 11-14

INTRODUCTION
Biofortification—derived from the Greek word "*bios*"(meaning life) and the Latin "*fortificare*"(meaning to strengthen)—refers to the process of enhancing the levels of bioavailable micronutrients in crops. This can be achieved through agronomic methods, selective breeding, or genetic engineering, providing a cost-effective and sustainable way to improve the nutritional quality of food. Primarily intended for populations with limited access to fortified foods, biofortification increases nutrient intake and boosts crop resilience in nutrient-deficient soils (Borg et al., 2009). While biofortified foods generally contain lower nutrient levels than supplements, they help improve daily micronutrient intake. This approach is particularly valuable in low-income regions, aiding in the reduction of micronutrient deficiencies and supporting overall health (Waters and Sankaran, 2011).
Importance

- To improves the plant or crop quality.
- To increase the nutritional quality in daily diets.
- To overcome malnutrition in human beings.
- To promote food security.
- Application of biofortified crops would benefit farmers by increasing their income in the long term.

Methods of Biofortification:

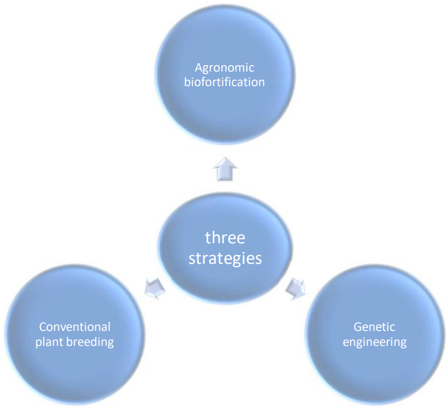


Fig1: Methods of Biofortification

Agronomic Biofortification

Fertilizers are often applied to enhance the micronutrient levels in the edible portions of crops. Key micronutrients suitable for agronomic biofortification include zinc (using foliar sprays of $ZnSO_4$), iodine (through soil applications of iodide or iodate), and selenium (as selenate). Foliar application is an efficient and straightforward technique for increasing plant concentrations of micronutrients such as iron (Fe), zinc (Zn), and copper (Cu). Research also shows that mycorrhizal associations boost Fe, Se, Zn, and Cu levels in plants, with arbuscular mycorrhizal (AM) fungi enhancing the uptake and utilization of essential micronutrients like Zn, Cu, and Fe. Additionally, sulfur-oxidizing bacteria can raise the sulfur content in crops such as onions.

Table 1: Nutritional trait improvements through agronomical biofortification

Crop	**Targeted micro nutrient**
Radish	Se
Carrot	I, Fe and Se
Broccoli	Zn, P, S, K, Fe, K, Cu, Mn
Cucumber	K and Ascorbic acid
Lettuce	Fe, P, K, I, Zn, Se
Tomato	Se
Potato	I

Biofortification of crops with Iron

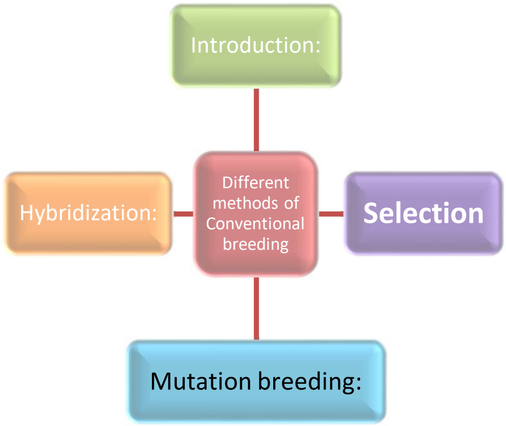
Tomato plants are capable of tolerating elevated iodine levels, storing it within their tissues and fruits at concentrations that satisfy human dietary requirements, making them well-suited for iodine-biofortification efforts. In plants treated with 5 mM of iodide, the iodine content in the fruit exceeded the recommended daily intake of 150 µg. Furthermore, the application of *Spirulina platensis* as a microbial inoculant has demonstrated an ability to raise iron levels in *Amaranthus gangeticus*, thus enhancing its biofortification potential.

Biofortification of crops with Zinc

The concentration of zinc in tubers and its application as a foliar treatment follows a saturation curve, reaching a maximum of approximately 30 mg Zn per kg of dry matter (DM) with an application rate of 1.08 g Zn per plant. An application of 2.16 g Zn per plant resulted in a 40-fold increase in shoot zinc concentration compared to untreated controls. In the cultivation of sweet pepper, eggplant, and tomato, using the fertilizer "Riverm" enhanced zinc content by 6.60-8.59% compared to controls.

Conventional plant breeding

Over the past forty years, plant breeding has primarily focused on increasing yield and disease resistance, often neglecting nutritional quality, which has resulted in nutrient declines in some crop varieties. Recently, conventional breeding has shifted towards enhancing vitamins, antioxidants, and essential micronutrients in edible parts of plants. By selectively choosing breeding materials, these techniques have successfully raised levels of β-carotene, carotenoids, amino acids, amylase, carbohydrates, and minerals, thus improving the nutritional quality of crops (Gregorio et al., 2000). This strategy promotes ecologically and economically sustainable crop development with added nutraceutical benefits. Techniques such as selection, introduction, and hybridization have played a crucial role in enhancing the nutraceutical value of vegetables and tuber crops, allowing for the identification and transfer of resistant traits



.

Fig 2: Different methods of Conventional plant breeding

Cauliflower: The variety *Pusa Betakesari-1* was introduced in 2015–16 by the Indian Agricultural Research Institute (IARI), New Delhi, as the first biofortified cauliflower developed in India through marker-assisted backcrossing. This variety contains high levels of beta carotene (8–10 µg per gram) and is ready for harvest in December–January, classifying it within the mid-late maturity group of Indian cauliflower. Created to address beta carotene deficiency and related malnutrition issues in India (Parulekar et al., 2019), *Pusa Betakesari-1* has orange, compact curds that are visually appealing, with a semi self-blanching growth habit.
Potato: *Kufri Neelkanth* is a potato variety recognized for its attractive purple, ovoid tubers with shallow eyes and yellow flesh, featuring a medium dry matter content of 18%. It offers excellent flavor, good storability, and higher antioxidant levels than other indigenous red-skinned varieties. As a main-season table potato, it has medium maturity, high tuber yield, and field resistance to late blight, making it well-suited for cultivation in the North Indian plains. This variety was developed at CPRI, Shimla, through clonal selection from the cross of MS/89–1095 and CP3290 (Luthra et al., 2020).
Carrot: Pusa Meghali: This variety, developed at IARI, New Delhi, through selection by crossing *Pusa Kesar* and *Nantes*, has an exceptionally high beta carotene content of 11,571 IU per 100 grams. It belongs to the tropical group and features orange-colored flesh. With an average root yield of 25–30 tons per hectare, it is suitable for early sowing and reaches maturity within 100–120 days.
Brinjal: *Pusa Safed Baingan-1* is a nutritionally enhanced brinjal variety released by IARI in 2018. It has a total phenol content of 31.21 mg per 100 grams and antioxidant activity of 3.48 mg per 100 grams. Notably, it is the first white oval-fruited brinjal suitable for kharif season cultivation in the northern plains. This variety was developed through single plant selection from indigenous material gathered from farmers in West Garo Hills, Meghalaya, by the Division of Vegetable Science at ICAR-IARI, Pusa, New Delhi (Kumar et al., 2021).
Amaranthus: *Pusa Kiran* is a variety known for its high iron content, developed through the natural crossing of *Amaranthus tricolor* and *Amaranthus tristis*. It features glossy green leaves and stems, with an average yield of 55 tons per hectare.

Genetic engineering

Genetic engineering uses a broad gene pool to introduce desirable traits from one organism to another, creating elite cultivars and enhancing crop value. When sufficient trait variation is lacking within a species or conventional breeding is unsuitable, genetic engineering provides an effective alternative to increase micronutrient concentration and bioavailability in edible tissues (Prasad et al., 2015). Recent advancements enable trait incorporation unattainable through traditional breeding. Transgenic crops, with enhanced nutritional quality, also resist insects, viruses, and pathogens. Genetic modifications in vegetables improve flavor, nutrition, ripening, sweetness, and reduce anti-nutritional factors (Tripathy et al., 2020).

Crop	Gene	Content
Tomato	pGAntho	Anthocyanin
Potato	AmA1	Protein
Lettuce	Ferritin	Iron
Cauliflower	Or gene	Beta-Carotene
Sweet potato	IBOR-INS	Lutein and Carotene
Carrot	CAX1	Calcium

FUTURE CHALLENGES

- Consumer preference.

- Awareness generation.
- Research intervention.
- Decrease the level of anti-nutritional compounds.
- Enhancing the mineral uptake efficiency of the important crops.
- Promoting large-scale prospective studies on assessing the effects of nutrient enhancement in major staple crops to reduce malnutrition-related disorders in the future.
- Availability of choice of nutrient rich foods and vegetables in the market.

CONCLUSION

Hunger and malnutrition are major issues which need attention on priority. Biofortification provides a feasible means of reaching malnourished populations in relatively rural areas, delivering naturally fortified foods to people with limited access to commercially-marketed fortified foods, which are more readily available in urban areas. Development, production and consumption of biofortified vegetables need to be popularized for preventing various health issues. Thus, the suitable remedy to eliminate undernutrition as a public health problem is to provide higher consumption of a wide range of non-staple foods in developing countries

REFERENCES

1. Borg, S., Brinch-Pedersen, H., Tauris, B., Holm, P. B., (2009). Iron transport, deposition and bioavailability in the wheat and barley grain. Plant and Soil 325(1), 15–24.
2. Gregorio., Glen, B., Senadhira, D., Htut, H., Graham, R.D., (2000). Breeding for trace mineral density in rice. Food and Nutrition Bulletin 21(4), 382–386.
3. Kumar, R., Munshi, A.D., Saha, P., Behera, T.K., Lyngdoh, Y.A., Tomar, B.S., Bhanushree, N., (2021). Pusa Safed Baingan-1: A new brinjal variety. Indian Horticulture 66 (2), 29–31.
4. Luthra, S.K., Gupta, V.K., Kumar, R., Rawal, S., Lal, M., Kumar, S., Dalamu, Tiwari, J.K., Raigond, P., Bandana, Kumar, V., Singh, B.P., Chakrabarti, S.K., (2020). Kufri Neelkanth: purple skin coloured speciality potato variety of India. Potato Journal 47 (1), 1–8.
5. Parulekar, Y.R., Haldankar P.M., Dalvi, N.V., Salvi, B.R., Bhattacharyya, T., (2019). Nutraceuticals and their biofortification in vegetable crops: a review. Advanced Agricultural Research & Technology Journal 3(2), 219–229.
6. Prasad, B.V.G., Smaranika, M., Rahaman, S., Bareily, P., (2015). Biofortification in horticultural crops. Journal of Agricultural Engineering and Food Technology 2(2), 95–99.
7. Tripathy, B., Tripathy, P., Sahu, P., Rout, S., Sindhu, M.S., (2020). Biofortification of vegetable crops - a new tool to alleviate micronutrient malnutrition. Agriculture and Rural Development: Spatial Issues, Challenges and Approaches 14, 83–97
8. Waters, B.M., Sankaran, R.P., (2011). Moving micronutrients from the soil to the seeds: genes and physiological processes from a biofortification perspective. Plant Science 180(4), 562–574.

Biology, Agriculture, SciTech and Environment
Vol 4 [12] December 2024; 15-20
ISSN 2321-8746

Full Text: https://www.basecongress.com/ebase.html
OPEN ACCESS

Hypertension: The Invisible Threat

[1]Manish Kumar, [2]Varsha Raj and [3]Kamalesh Kumar
[1]Department of Zoology, Narain College (Dr B R Ambedkar University, Agra), Shikohabad, UP
[2] Kharvel Subharti College of Pharmacy, Swami Vivekanand Subharti University, Meerut, UP
[3] Department of Zoology, MLKPG College, Balrampur, UP
Corresponding Author's Email: varsharaj01@gmail.com

ABSTRACT
Hypertension, often referred to as the "silent killer," is a prevalent condition that affects millions worldwide. Despite its widespread occurrence, it often goes unnoticed until serious health complications arise. This paper explores the causes, risk factors, symptoms, and potential consequences of hypertension. It also examines strategies for prevention, management, and the importance of early detection. As a condition that rarely shows noticeable symptoms, the invisible nature of hypertension makes it crucial for individuals to understand its risks and take proactive steps to monitor and control their blood pressure.
Keywords: Hypertension, Symptoms, Betablockers

Received 23.10.2024 Revised 28.11.2024 Accepted 20.12.2024

CITATION
Manish K, Varsha R and Kamalesh K. Hypertension: The Invisible Threat . Biol. Agricul. SciTech and Environ. Vol 4 [12] December 2024; 15-20

INTRODUCTION

Hypertension is one of the most common chronic conditions globally, yet it remains largely undiagnosed and untreated in many individuals. According to the World Health Organization (WHO), nearly 1.13 billion people are living with hypertension worldwide, with a significant portion unaware of their condition. This paper aims to delve into the significance of hypertension as a silent threat, its potential risks, and the strategies for effective management and prevention. Given its asymptomatic nature, hypertension poses a unique challenge to public health, requiring continuous awareness and proactive interventions (WHO, 2021).

WHAT IS HYPERTENSION? (WHO, 2021 and AHA, 2023)

Hypertension, or high blood pressure, is a condition where the force of the blood against the artery walls is consistently too high. The two types of blood pressure readings—systolic (the pressure when the heart beats) and diastolic (the pressure when the heart rests)—are used to diagnose hypertension. Generally, a reading of 130/80 mmHg or higher is considered high blood pressure.

While blood pressure naturally fluctuates throughout the day, hypertension occurs when these levels remain elevated over time, placing strain on the cardiovascular system. If left untreated, hypertension can lead to severe health complications, including heart disease, stroke, kidney damage, and even death.

Pathophysiology of Hypertension

Hypertension, or high blood pressure, occurs when the force exerted by the blood against the walls of the arteries is consistently too high. This can be caused by a variety of factors, leading to complex changes in the cardiovascular and renal systems. Understanding the pathophysiology of hypertension involves looking at several physiological mechanisms and factors that contribute to its development and progression. These mechanisms are often interconnected and can vary depending on the type of hypertension (primary or secondary).

Regulation of Blood Pressure

Blood pressure is determined by the interaction between cardiac output (CO) and systemic vascular resistance (SVR), which can be summarized in the equation:

Blood Pressure=Cardiac Output×Systemic Vascular Resistance\ {Blood Pressure} = \{Cardiac Output} \times \{Systemic Vascular Resistance}Blood Pressure=Cardiac Output×Systemic Vascular Resistance

- **Cardiac Output (CO)**: The volume of blood the heart pumps per minute, which is a product of heart rate and stroke volume.
- **Systemic Vascular Resistance (SVR)**: The resistance of the blood vessels to blood flow, influenced by the diameter and elasticity of the arteries.

Normal blood pressure is maintained by complex regulatory mechanisms that involve the autonomic nervous system, kidneys, endothelial cells, and hormones like renin-angiotensin-aldosterone system (RAAS) and natriuretic peptides. When these systems become dysregulated, hypertension can develop.

2. Primary (Essential) Hypertension

Primary hypertension is the most common form, accounting for about 90-95% of cases. Its exact cause is unknown, but several contributing factors can lead to its development. The pathophysiology of primary hypertension involves both increased cardiac output and increased systemic vascular resistance.

a) Increased Cardiac Output

- **Increased Fluid Volume**: Sodium and water retention in the kidneys can lead to an increased circulating blood volume, which increases the heart's workload and elevates blood pressure. This is often mediated by the renin-angiotensin-aldosterone system (**RAAS)** and is exacerbated by a high-sodium diet.

b) Increased Systemic Vascular Resistance

- **Vascular Remodeling and Increased Arterial Stiffness**: Chronic hypertension can lead to structural changes in the arteries, including thickening of the arterial walls and decreased elasticity. This increases vascular resistance and further raises blood pressure.
- **Sympathetic Nervous System Overactivity**: The autonomic nervous system can become hyperactive in hypertension, leading to excessive release of norepinephrine, which causes vasoconstriction and raises blood pressure.
- **Endothelial Dysfunction**: The endothelium, which lines blood vessels, plays a key role in regulating vascular tone. In hypertension, endothelial cells produce less nitric oxide (a vasodilator) and more vasoconstrictors like endothelin, contributing to increased vascular resistance.

c) Renal Dysfunction

- **Salt and Water Retention**: The kidneys play a major role in regulating blood pressure by controlling the volume of extracellular fluid. In hypertension, the kidneys may become less efficient at excreting sodium, leading to fluid retention, which increases blood volume and thus blood pressure.
- **RAAS Activation**: The renin-angiotensin-aldosterone system (RAAS) is a major regulator of blood pressure. In primary hypertension, RAAS can become abnormally activated, leading to increased production of angiotensin II and aldosterone. Angiotensin II causes vasoconstriction, while aldosterone promotes sodium retention by the kidneys, both of which contribute to raised blood pressure.

Secondary Hypertension

Secondary hypertension occurs as a result of an underlying condition. Unlike primary hypertension, it has a clear, identifiable cause. Conditions that lead to secondary hypertension include:

a) Renal Disease

- **Chronic Kidney Disease (CKD)**: Reduced kidney function can impair sodium excretion and activate RAAS, leading to increased fluid retention and high blood pressure.
- **Renal Artery Stenosis**: Narrowing of the renal arteries leads to decreased renal blood flow, triggering RAAS activation, which raises blood pressure.

b) Endocrine Disorders

- **Hyperaldosteronism (Conn's Syndrome)**: Overproduction of aldosterone causes sodium and water retention, leading to increased blood volume and blood pressure.
- **Pheochromocytoma**: A tumor of the adrenal glands that produces excess catecholamines (like adrenaline), causing episodic hypertension.
- **Cushing's Syndrome**: Excess cortisol production increases sodium retention and raises blood pressure.
- **Thyroid Disorders**: Both hyperthyroidism and hypothyroidism can contribute to blood pressure dysregulation.

c) Obstructive Sleep Apnea

- The repeated episodes of oxygen desaturation during sleep cause sympathetic nervous system activation, which leads to vasoconstriction and increased blood pressure.

d) Coarctation of the Aorta

- A congenital narrowing of the aorta causes increased resistance to blood flow and elevated blood pressure in the upper body, while blood pressure may be normal in the lower extremities.

PATHOLOGICAL CONSEQUENCES OF HYPERTENSION

Over time, chronic hypertension can lead to significant damage to various organs and tissues. The key pathological consequences include (Williams et al, 2023) :

a) Cardiovascular System

- **Left Ventricular Hypertrophy (LVH)**: Chronic high blood pressure leads to thickening of the heart's left ventricle as it works harder to pump blood against the increased resistance.
- **Coronary Artery Disease (CAD)**: Hypertension accelerates the development of atherosclerosis, increasing the risk of heart attack and other cardiovascular events.
- **Heart Failure**: Chronic hypertension can lead to heart failure due to increased workload and myocardial damage.

b) Cerebrovascular System

- **Stroke**: High blood pressure causes damage to blood vessels in the brain, increasing the risk of both ischemic and hemorrhagic strokes.
- **Vascular Dementia**: Chronic hypertension can reduce blood flow to the brain and contribute to cognitive decline.

c) Renal System

- **Chronic Kidney Disease**: Hypertension causes damage to the small blood vessels in the kidneys, leading to impaired kidney function and, eventually, kidney failure.

d) Retinal Damage

- **Hypertensive Retinopathy**: High blood pressure can damage the blood vessels in the eyes, leading to vision impairment and potentially blindness.

Risk Factors and Causes (Whelton, 2018).

Several factors contribute to the development of hypertension. These include:

1. **Genetics**: A family history of hypertension increases the likelihood of developing the condition.
2. **Age**: Blood pressure tends to rise with age, particularly after 45 years.
3. **Dietary Factors**: Excessive sodium intake, obesity, and a diet high in saturated fats contribute to high blood pressure.
4. **Physical Inactivity**: A sedentary lifestyle is a significant risk factor for hypertension.
5. **Chronic Stress**: Prolonged stress can cause hormonal changes that contribute to high blood pressure.
6. **Smoking and Alcohol Consumption**: Both smoking and excessive alcohol intake can raise blood pressure.
7. **Underlying Conditions**: Conditions like diabetes, kidney disease, and sleep apnea increase the risk of hypertension.

Symptoms of Hypertension: The Silent Nature

One of the most dangerous aspects of hypertension is that it often presents no obvious symptoms. Individuals may have high blood pressure for years without realizing it, even though the damage to the cardiovascular system is already taking place. In some cases, people may experience vague symptoms like headaches, dizziness, or shortness of breath, but these are often dismissed and attributed to other causes. Because of this, hypertension is often diagnosed only when complications arise, such as heart disease, stroke, or kidney failure. Therefore, regular monitoring of blood pressure is crucial, especially for individuals with known risk factors (James, et al. 2014)..

Consequences of Uncontrolled Hypertension (WHO, 2021)

Hypertension, if left untreated or poorly managed, can lead to a wide range of severe health issues:

1. **Heart Disease**: Chronic high blood pressure increases the risk of coronary artery disease, heart failure, and heart attacks.
2. **Stroke**: Elevated blood pressure can cause damage to the arteries, increasing the likelihood of a stroke.
3. **Kidney Damage**: Hypertension is a leading cause of chronic kidney disease and kidney failure.

4. **Vision Loss**: High blood pressure can damage the blood vessels in the eyes, leading to vision problems and even blindness.
5. **Aneurysms**: Prolonged high blood pressure can weaken blood vessel walls, leading to aneurysms.
6. **Cognitive Decline**: There is evidence linking hypertension to cognitive decline and an increased risk of dementia.

PREVENTION AND MANAGEMENT OF HYPERTENSION

Hypertension, or high blood pressure, is a major risk factor for cardiovascular disease, stroke, kidney damage, and other serious health complications. The prevention and management of hypertension are crucial to reducing its impact on individual health and public health systems. Effective prevention involves lifestyle modifications, early detection, and, when necessary, pharmacological treatment. The management of hypertension focuses on controlling blood pressure and preventing complications associated with prolonged elevated blood pressure.

1. Prevention of Hypertension (Chobanian, et al.2003).

Prevention involves efforts to avoid the onset of hypertension, especially in individuals at risk. It primarily focuses on lifestyle changes that support overall cardiovascular health.

a) Healthy Diet

- **Reduce Sodium Intake:** High sodium consumption is strongly associated with elevated blood pressure. Limiting sodium intake to less than 2,300 mg per day (ideally around 1,500 mg for most adults) is recommended.
- **Increase Potassium Intake:** Potassium helps balance the effects of sodium. A diet rich in fruits, vegetables, and legumes can help boost potassium levels.
- **Adopt the DASH Diet:** The Dietary Approaches to Stop Hypertension (DASH) diet emphasizes a high intake of fruits, vegetables, whole grains, lean proteins, and low-fat dairy, while reducing salt, sweets, and red meat. This diet has been shown to effectively lower blood pressure.
- **Limit Alcohol Consumption:** Excessive alcohol intake can elevate blood pressure. It is recommended to consume alcohol in moderation, which is defined as up to one drink per day for women and two drinks per day for men.
- **Avoid Excessive Caffeine:** While the direct effect of caffeine on blood pressure is still debated, it can lead to a temporary spike in blood pressure, especially in people who are sensitive to it.

b) Regular Physical Activity

- **Aerobic Exercise:** Engaging in regular physical activity, such as walking, jogging, swimming, or cycling, helps maintain healthy blood pressure. Aim for at least 30 minutes of moderate-intensity exercise most days of the week.
- **Strength Training:** In addition to aerobic exercise, strength training (using weights or resistance bands) at least two days per week can further improve cardiovascular health.

c) Weight Management

- **Achieve and Maintain a Healthy Weight:** Being overweight or obese is a major risk factor for hypertension. Even a modest weight loss (5-10% of total body weight) can significantly reduce blood pressure in overweight individuals.

d) Stress Management

- **Reduce Chronic Stress:** Long-term stress can contribute to hypertension by increasing sympathetic nervous system activity. Stress management techniques such as meditation, yoga, deep breathing exercises, and mindfulness can help lower blood pressure.
- **Adequate Sleep:** Poor sleep quality or insufficient sleep is associated with an increased risk of hypertension. Adults should aim for 7-9 hours of quality sleep per night.

e) Smoking Cessation

- **Quit Smoking:** Smoking damages blood vessels and increases blood pressure. Quitting smoking not only reduces blood pressure but also improves overall cardiovascular health.

2. Management of Hypertension

For individuals diagnosed with hypertension, effective management is essential to control blood pressure and prevent long-term complications. Management strategies typically involve a combination of lifestyle changes and medications (Williams, et al. 2018)..

a) Lifestyle Modifications

Even if blood pressure-lowering medications are prescribed, lifestyle changes remain a cornerstone of hypertension management.

1. **Follow a Heart-Healthy Diet:** Emphasizing fruits, vegetables, lean proteins, and whole grains while limiting sodium, unhealthy fats, and processed foods.
2. **Engage in Regular Physical Activity:** Regular exercise (such as walking or swimming) helps reduce blood pressure by improving heart function and reducing vascular resistance.
3. **Limit Alcohol:** Reducing alcohol intake can help lower blood pressure.
4. **Quit Smoking:** Smoking cessation is a critical step in managing hypertension and preventing cardiovascular complications.
5. **Maintain a Healthy Weight:** Weight loss (if overweight or obese) can have a significant impact on reducing blood pressure levels.

b) Pharmacological Management

For individuals with sustained high blood pressure, medication is often required to manage the condition. Medications may be prescribed alone or in combination depending on the severity of hypertension and individual patient needs (Kearney, et al, 2005).

1. **Diuretics (Water Pills):** Diuretics, such as hydrochlorothiazide, help the body eliminate excess sodium and water, reducing blood volume and lowering blood pressure.
2. **ACE Inhibitors (Angiotensin-Converting Enzyme Inhibitors):** ACE inhibitors (e.g., enalapril, lisinopril) block the action of the enzyme that converts angiotensin I to angiotensin II, a hormone that causes blood vessels to constrict. This helps relax blood vessels and lower blood pressure.
3. **Angiotensin II Receptor Blockers (ARBs):** ARBs (e.g., losartan, valsartan) work similarly to ACE inhibitors but block the receptors for angiotensin II, reducing its effect on blood vessels.
4. **Calcium Channel Blockers:** Medications such as amlodipine and diltiazem relax and widen blood vessels by blocking calcium from entering the cells of the heart and blood vessels.
5. **Beta-Blockers:** Beta-blockers (e.g., metoprolol, atenolol) reduce the heart rate and the force of the heart's contractions, which lowers blood pressure.
6. **Alpha-Blockers:** Alpha-blockers (e.g., doxazosin) help relax the muscles in blood vessels, reducing vascular resistance and lowering blood pressure.
7. **Renin Inhibitors:** Medications like aliskiren block the activity of renin, an enzyme involved in the RAAS system, which can help lower blood pressure.

c) Monitoring and Adjusting Treatment

- Regular Blood Pressure Monitoring: For patients on treatment, regular blood pressure checks are necessary to assess the effectiveness of the medication and determine whether adjustments are needed.
- Combination Therapy: Sometimes, a combination of different classes of antihypertensive drugs is used to achieve optimal blood pressure control, especially when one medication is not sufficient.

d) Addressing Secondary Causes

If hypertension is secondary to another condition (e.g., kidney disease, hyperaldosteronism), it is crucial to address the underlying cause in addition to managing blood pressure. This might involve surgical intervention (e.g., for renal artery stenosis or pheochromocytoma) or medications specific to the condition (Mancia, et al.2013)..

GOALS OF HYPERTENSION TREATMENT

The main objectives of hypertension treatment are to:

1. Lower and control blood pressure: The goal is to achieve a target blood pressure of less than 130/80 mmHg for most individuals, according to current guidelines.
2. Prevent cardiovascular and renal complications: Reducing blood pressure minimizes the risk of stroke, heart attack, kidney damage, and other complications.
3. Improve overall quality of life: Effective management of hypertension helps reduce the symptoms of high blood pressure and prevents the development of severe complications.

Special Considerations

- Older Adults: In elderly patients, blood pressure management should be carefully balanced to avoid excessive lowering of blood pressure, which can increase the risk of falls and other complications.
- Pregnancy: Hypertension in pregnancy, including conditions like preeclampsia, requires careful monitoring and management to avoid maternal and fetal complications.

CONCLUSION

Hypertension is a widespread and often undiagnosed condition that poses a serious risk to public health. Its "silent" nature makes it particularly dangerous, as it can lead to life-threatening complications without warning. Early detection, through regular monitoring, and proactive management through lifestyle changes and medication, are essential to combat the detrimental effects of hypertension. Public health initiatives should focus on raising awareness about the risks of hypertension, the importance of regular check-ups, and how lifestyle modifications can prevent and control this condition.

REFERENCES

1. World Health Organization (WHO). "Hypertension." WHO, 2021.
2. American Heart Association (AHA). "Understanding Blood Pressure." AHA, 2023.
3. Williams, B., et al. "2018 ESC/ESH Guidelines for the management of arterial hypertension." European Heart Journal, 2018.
4. Chobanian, A. V., et al. "The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure." JAMA, 2003.
5. Whelton, P. K., et al. (2018). "2017 Guidelines for High Blood Pressure in Adults: Report From the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines." *Hypertension*, 71(6), 1269-1324.
6. Mancia, G., et al. (2013). "2013 ESH/ESC Guidelines for the Management of Arterial Hypertension." *European Heart Journal*, 34(28), 2159-2219.
7. James, P. A., et al. (2014). "Evidence-Based Guidelines for the Management of High Blood Pressure in Adults." *Journal of the American Medical Association (JAMA)*, 311(5), 507-520.
8. Williams, B., Mancia, G., Spiering, W., et al. (2018). 2018 ESC/ESH Guidelines for the management of arterial hypertension. *European Heart Journal*, 39(33), 3021-3104.
9. Chobanian, A. V., Bakris, G. L., Black, H. R., et al. (2003). The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *JAMA*, 289(19), 2560-2572.
10. Kearney, P. M., Whelton, M., Reynolds, K., et al. (2005). Global burden of hypertension: Analysis of worldwide data. *Lancet*, 365(9455), 217-223.

Biology, Agriculture, SciTech and Environment
Vol 4 [12] December 2024; 21-34
ISSN 2321-8746

Full Text: https://www.basecongress.com/ebase.html
OPEN ACCESS

Assessment of Malaria Incidence and Associated Risk factor among Children Aged 1-15 Years in Specialist Hospital, Jimeta-Yola.

[1]Samuel Danley and [2]Elizabeth Oluwatosin Olugbami
[1*]Sociocapital Impact Group. No.4 Natasha Akpoti Street, Kado Abuja Nigeria.
[2]Modibbo Adama University Yola, Along Yola-Mubi Road, Adamawa State. Nigeria
*Email: Sammyvimeh@gmail.com

ABSTRACT
This study aims to assess the incidence of malaria and associated risk factors among children aged 1-15 years attending Specialist Hospital Jimeta-Yola, Adamawa State, Nigeria. Utilizing a cross-sectional study design, data were collected from 188 pediatric patients through structured questionnaires, venipuncture blood samples for malaria diagnosis, and packed cell volume (PCV) assessments. Key socio-demographic, environmental, and behavioral risk factors were examined to understand their influence on malaria prevalence. The findings indicate a high malaria prevalence rate of 95.7%, with Plasmodium falciparum being the most detected species. Younger children (ages 1-3) were more susceptible to malaria, while a significant portion of cases (p > 0.05) was observed in children from families with lower socioeconomic status and inadequate housing conditions. Environmental risk factors, such as the presence of stagnant water around homes, and inconsistent use of mosquito nets were strongly associated with higher malaria incidence. The study underscores the need for targeted malaria control measures, including improved access to preventive resources, community health education, and the strengthening of healthcare infrastructure to reduce malaria transmission and improve health outcomes among children in endemic areas.
***Keywords**: Malaria, Risk Factors, paediatric patients*

Received 09.12.2024 Revised 28.12.2024 Accepted 30.12.2024

CITATION
Samuel D and Elizabeth O O. Assessment of Malaria Incidence and Associated Risk factor among Children Aged 1-15 Years in Specialist Hospital, Jimeta-Yola**.** Biol. Agricul. SciTech and Environ. Vol 4 [12] December 2024; 21-34

INTRODUCTION

Malaria remains a significant public health challenge globally, particularly in sub-Saharan Africa, where it disproportionately affects children under the age of 15. According to the World Health Organization (WHO), in 2022, over 249 million malaria cases were reported worldwide, with 94% occurring in the African region. Nigeria alone accounted for 27% of these cases and 31% of malaria-related deaths, highlighting the nation's critical burden in the fight against malaria (WHO, 2023).

In Nigeria, the risk of malaria transmission is ubiquitous throughout the year, with particularly high incidence rates in the northern and northeastern regions, including Adamawa State. Jimeta-Yola, situated in Adamawa State, is no exception, with the disease posing a persistent threat to child health and survival. This is compounded by socio-economic disparities, environmental conditions, and inadequate healthcare infrastructure that exacerbate the vulnerability of pediatric populations.

Malaria is primarily transmitted through the bites of infected female Anopheles mosquitoes, with Plasmodium falciparum being the predominant and most deadly parasite in the region. While the disease is preventable and treatable, late diagnosis and inadequate treatment often lead to severe complications, including anemia, organ failure, and death. Children aged 1-15 years are particularly susceptible due to their developing immune systems and increased exposure to mosquito breeding sites.

This study focuses on assessing the incidence of malaria and its associated risk factors among children attending the Specialist Hospital in Jimeta-Yola. By examining socio-demographic, environmental, and behavioral determinants, the research aims to provide targeted insights into the region's unique epidemiological profile. This knowledge is essential for designing effective intervention strategies that prioritize high-risk groups and optimize resource allocation, ultimately contributing to the reduction of malaria transmission and improvement of health outcomes among children in this endemic area.

keywords: Malaria incidence, Risk factors, *Plasmodium falciparum*, Environmental factors, Packed Cell Volume (PCV).

Statement of the Problem

Nearly half of the world's population is at risk of malaria. In 2022, an estimated 249 million people contracted malaria in 85 countries. That same year, the disease claimed approximately 608 000 lives (WHO, 2023).

Some people are more susceptible to developing severe malaria than others. Infants and children under 5 years of age, pregnant women and patients with HIV/AIDS are at particular risk. Some people in areas where malaria is common will develop partial immunity. While it never provides complete protection, partial immunity reduces the risk that malaria infection will cause severe disease. For this reason, most malaria deaths in Africa occur in young children, whereas in areas with less transmission and low immunity, all age groups are at risk (WHO, 2023). Understanding the incidence rates and associated risk factors is crucial for effective prevention and control measures.

Despite ongoing malaria control efforts, there remains a lack of comprehensive data on the incidence of malaria and risk factors such as environmental, socio-demographic, and behavioral factors associated with the disease among children aged 1-15 years in Yola specifically. This knowledge gap hinders the development and implementation of targeted interventions aimed at reducing malaria burden and improving health outcomes in this vulnerable population.

Aim and Objectives of the Study

This study aims to address the gap in knowledge and provide insights into the demographic and clinical characteristics contributing to malaria prevalence and its associated risk factors among children aged 1-15 years.

The Objectives of the study are:

- To determine the frequency of malaria cases and their severity among children aged 1-15 years attending a Specialist Hospital.
- To identify socio-demographic, environmental, and behavioral factors associated with increased risk of malaria among pediatric patients.
- To assess the relationship between these factors and malaria severity.

MATERIAL AND METHODS

Materials

Study Area

The study was carried out at the Specialist Hospital in Adamawa State, Nigeria's Yola North Local Government Areas (LGA). For the residents of its catchment area and neighboring states, the medical facility provides secondary and tertiary care. There are distinct dry and rainy seasons in the region's tropical climate. The rainy season, which normally lasts from June to October and peaks in August and September, accounts for around 25% of the average 1113.3 mm of annual rainfall. The dry season, on the other hand, runs from late October through April or May. Yola can reach as high as 43°C in April and as low as 20.3°C in December and early January. The year-round relative humidity varies, with February being the driest month and January recording about 26%. On the other hand, relative humidity levels are higher from May to October, peaking in July and August at about 80%. The breeding and spread of parasitic diseases are facilitated by these climatic conditions.

Because of human activities like farming, grazing, building, and gathering wood for fuel, the majority of the vegetation in Yola and the surrounding areas is secondary vegetation. The region's ecological balance and disease dynamics are affected by this change to the native vegetation. With a diverse population working in a range of professions, including civil service, agriculture, fishing, petty trading, poultry, and livestock keeping, Yola North LGA is the administrative center of Adamawa State.

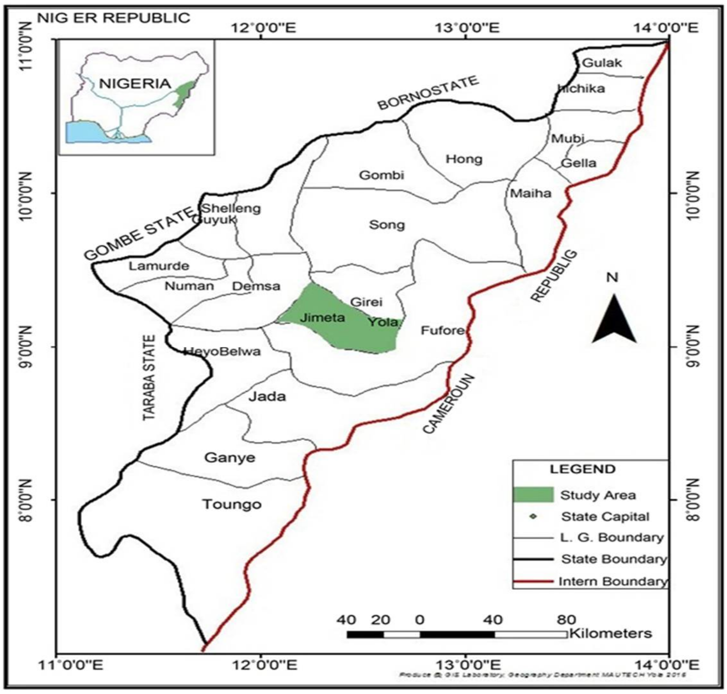


Figure 1: Map of Adamawa State showing Jimeta-Yola, the site where Specialist Hospital is Located (Adebayo 1999).

Participants

The source population consisted of all children aged one to fifteen who visited the designated medical facility, Specialist Hospital, Yola, during the study period.

Questionnaire

A structured questionnaire was prepared to collect data covering:

- Demographic information,
- Socio-economic status,
- Environmental information (housing conditions, rural or urban environment)
- Behavioural information
- Malarial recurrence within a year, and
- Malaria prevention and control practices.

Data Collection

Data collection tools

Data collected from questionnaires was systematically organized and cleaned using Excel.

Statistical software

Data analysis, prevalence calculations, and risk factor identification were conducted using IBM Statistical Package for the Social Sciences (SPSS) for Windows version 29.0.

Consent forms (for parents/guardians)

Participants' informed consent is obtained through this method. Each respondent received a thorough explanation of the study's goals and methodology. An independent interpreter acting as their legal guardian translated the questionnaire from English to their native tongue for those respondents who were illiterate, and back translation to English was done to ensure consistency in the responses. The respondents were informed that they could decline or stop taking part at any moment. Before the study began, all adult respondents and parents/guardians acting on behalf of their children provided written and verbal informed consent. Throughout the study, privacy and confidentiality were maintained.

Ethical approval letter

An application letter was sent to the Adamawa State Ministry of Health prior to sample collection, and they granted an ethical clearance. The management of Yola Specialist Hospital was also notified about the research and their consent was obtained. Before requesting their consent, the parents/guardians were informed of the study's significance. The information was kept private.

Methods

Cross-sectional study

Children who were admitted or visited the hospital for treatment during the study period provided data.

Survey
The participants' parents or guardians used and completed the survey questionnaires for related risk factors.

Sample collection and Laboratory Tests
A licensed laboratory scientist helped with the blood sample collection. Venipuncture was used as the sample collection method (50). Every blood sample was properly labeled and matched the subject's number on the survey. The hospital used laboratory tests, particularly blood smears and microscopy, to confirm the diagnosis of malaria. To improve visibility under a microscope, a blood sample was drawn from the patient and stained with Giemsa dye. Next, the stained blood smear was inspected under a microscope to check for malaria parasites like *Plasmodium vivax* or *Plasmodium falciparum*. The diagnosis of malaria was validated by the presence of parasites in the blood. The hospital measured the Packed Cell Volume (PCV) in addition to microscopy of the patient's blood. A patient's blood sample was taken as the first step in the Packed Cell Volume (PCV) analysis. After being extracted into a sterile tube, the blood was centrifuged to separate its constituent parts. A centrifuge, which separates blood into various components so that the red blood cell volume can be calculated, was used to take the PCV measurement.

Data Analysis
Data was imported into Excel, cleaned, and exported to IBM SPSS (version 29.0, IBM Corp., Armonk, NY, USA) for analysis. Quantitative data were expressed as mean ± standard deviation, and malaria prevalence was determined using frequencies. Variables with a P-value < 0.05 were considered significant, with 95% confidence intervals for odds ratios. The independent variable with the lowest odds ratio was the reference ("Ref").
SPSS analyses included: Descriptive Statistics, Frequency Analysis, Cross-tabulation & Chi-Square Test, T-tests & ANOVA, Cluster Analysis, Correlation Analysis.

RESULT
Out of the 188 subjects analyzed, 106 of them had positive malaria tests. *Plasmodium falciparum* was the species of malaria observed.
Frequency Analysis on Socio-Demographic Information
The frequency and percentage of children ages 1 to 15 who visited the Specialist Hospital in Jimeta-Yola for malaria cases are displayed in Table 4.1, which also shows the age distribution data. 30.3% of the total, or 57 children, fell into the 1-3 year age group, suggesting that malaria is more common in younger children. With 41 children, the group aged 4-6 makes up 21.8% of the total, which is the second-highest. There were 44 children (23.4%) in the 7-9 age group, which is a larger percentage than the 4-6 age group. There are 25 children (13.2%) in the 10–12 age group, which indicates a decline in malaria cases when compared to younger groups. Finally, with 21 children (11.1%), the 13–15 age group has the lowest frequency, supporting the idea that older kids are less susceptible to malaria.
According to the data on gender distribution, 97 boys, or 51.5% of the total number of children, were present. However, 91 of the children were girls, accounting for 48.4% of the total (Table 4.1). According to the data on the distribution of educational levels, 66 children, or 35.1% of the total, do not attend school. 32 kids (17.0%) in the nursery category are enrolled in nursery school. 63 children (33.5%) are in primary school, which accounts for a sizable percentage of those impacted. The smallest of the groups, with 27 children (14.3%), is the secondary school group (Table 4.1).
Several insights are revealed by the data on the occupations of parents or guardians of children undergoing treatment for malaria at the Specialist Hospital in Jimeta-Yola. Farmers are 19.6% of the group, with 37 parents/guardians identified as such. With 84 parents or guardians, traders make up the largest occupational group (44.6%). 51 parents/guardians, or 27.1% of the group, are civil servants. Furthermore, 33.5% of guardians and parents do not have a job. According to the data, parents or guardians are most likely to be traders (44.6%), followed by civil servants (27.1%) and farmers (19.6%) (Table 4.1).
Families seeking treatment for malaria cases at the Specialist Hospital in Jimeta-Yola exhibit a wide range of incomes. Most families, 43.6% of them, make between #50,000 and #100,000 a month, placing them in the middle income range. On the lower end of the income spectrum, 12.7% of families make less than #10,000, and 23.4% make between #10,000 and #50,000. On the other hand, a smaller but noteworthy percentage, 17%, make more than #100,000 a month (Table 4.1).

Table 4.1: Frequency Analysis: Socio-Demographic Information		
Age of the Child	**Frequency**	**Percentage**
1-3 years	57	30.3
4-6 years	41	21.8
7-9 years	44	23.4
10-12 years	25	13.2
13-15 years	21	11.1
Gender of the child	**Frequency**	**Percentage**
Male	97	51.5
Female	91	48.4
Education level of the child	**Frequency**	**Percentage**
Not in school	66	35.1
Nursery	32	17.0
Primary	63	33.5
Secondary	27	14.3
Parent/Guardian educational level	**Frequency**	**Percentage**
No formal educational level	37	14.3
Primary	20	10.6
Secondary	68	36.1
Tertiary	63	33.5
Parent/Guardian occupation	**Frequency**	**Percentage**
Farmer	37	14.3
Trader	84	44.6
Civil servant	51	27.1
Unemployed	15	33.5
Family Income level per Month	**Frequency**	**Percentage**
Below #10,000	24	12.7
#10,000 - #50,000	44	23.4
#50,000 - #100,000	82	43.6
Above #100,000	32	17.0

Frequency Analysis on Environmental Factors

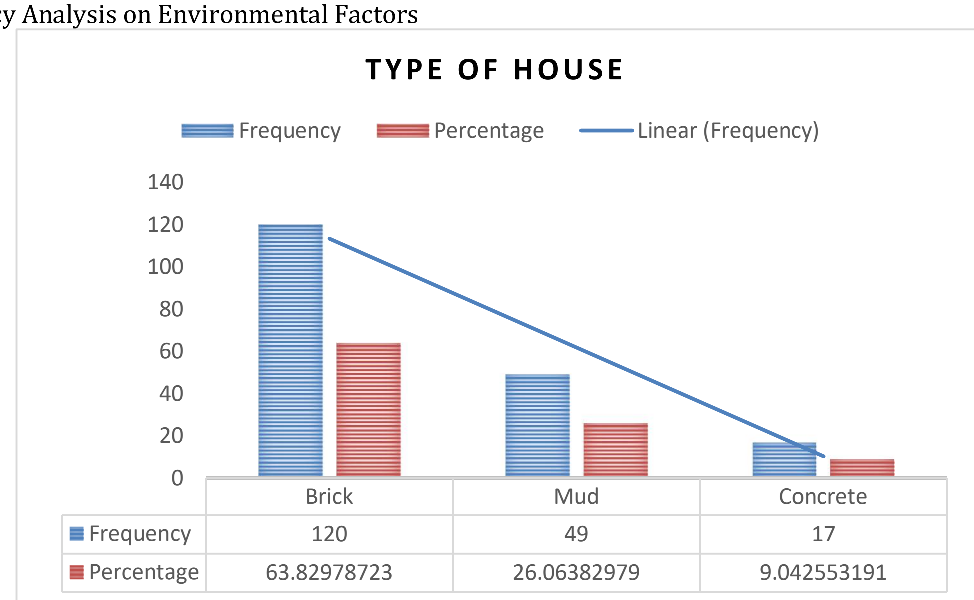


Figure 2:Type of House

Brick homes are the most prevalent, with 63.8% of families living in them, according to data on housing types for children who are treated for malaria cases at the Specialist Hospital in Jimeta-Yola in Figure 2. On the other hand, 9.0% reside in concrete homes and 26.0% in mud homes. Given that brick homes are more common and provide superior mosquito protection, these households may be at lower risk of contracting malaria.

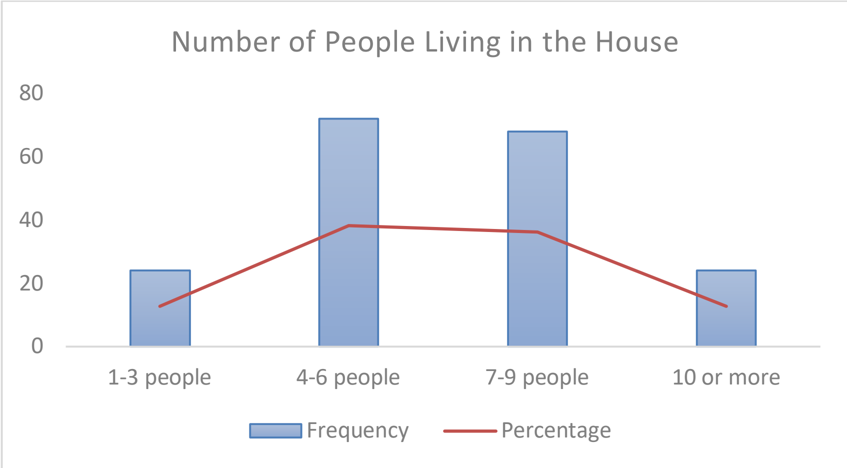


Figure 3: Number of People Living in the House

According to the household size data in Figure 3, the largest percentage of households—38.2%—have four to six people living in them. Furthermore, 12.7% have one to three residents, 12.7% have ten or more, and 36.1% have seven to nine residents. Because larger households may increase the risk of exposure, these household size dynamics may have an impact on the transmission of malaria.

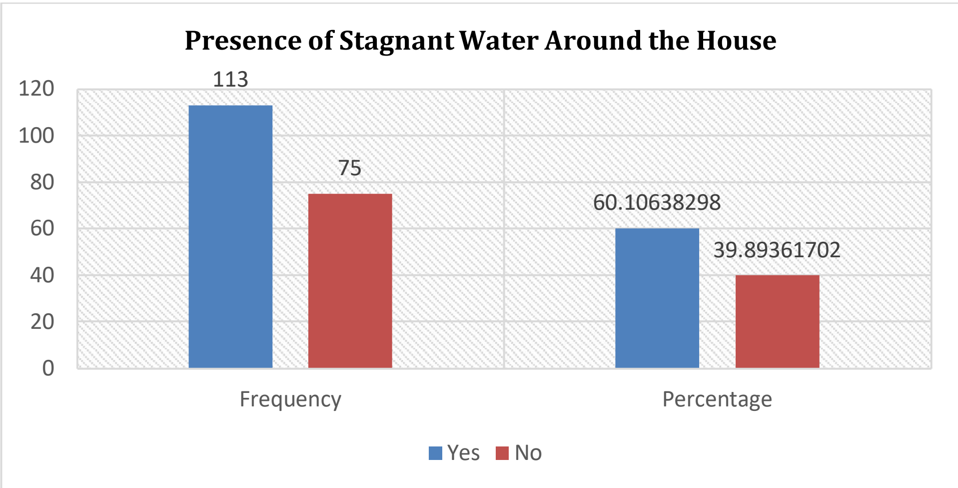


Figure 4: Presence of Stagnant Water around the House

Figure 4's data on standing water near residences indicates a substantial environmental risk factor for the spread of malaria. While 39.8% of households do not have stagnant water nearby, the majority (60.1%) do.

Behavioral Factor

The daily outdoor playtime of children receiving treatment for malaria at the Specialist Hospital in Jimeta-Yola suggests a primarily indoor lifestyle, as shown in Table 4.2. Significantly, 76.0% of kids spend less than an hour outside every day, indicating that they do not get enough exposure to the outdoors. However, only 6.3% of kids spend more than two hours playing outside, while 17.5% of kids play outside for one to two hours.

A noteworthy 80.8% of children, or 152 in total, who were treated for malaria cases at the Specialist Hospital in Jimeta-Yola reported sleeping under a mosquito net, according to data on sleeping habits. But according to Table 4.2, 19.1% of kids—36 in all—do not sleep under a mosquito net.

The following trends can be seen in the data on children's nighttime outdoor activities who are receiving treatment for malaria at the Specialist Hospital in Jimeta-Yola: Nearly half (48.4%) of the kids regularly spend their evenings outside. A smaller percentage (12.7%) say they never engage in nighttime outdoor activities, while another sizable portion (38.2%) say they do so occasionally (Table 4.2).

The following information relates to the use of preventive measures during the rainy season by children who are treated for malaria at the Specialist Hospital, Jimeta-Yola. Constantly (81.9%): During the rainy season, 154 kids (81.9%) said they regularly used preventive measures. Sometimes (11.1%): 21 kids (11.1%) said they occasionally take preventative action. Never (6.3%): Twelve kids (6.3%) said they had never taken precautions during the rainy season (Table 4.2).

Table 4.2: Frequency Analysis: Behavioral Factors

Q. Child playing outside (per day)	**Frequency**	**Percentage**
Less than one hour	143	76.0
1-2 hours	33	17.5
More than 2 hours	12	6.3
Q. Child Sleeping Habits	Frequency	Percentage
Sleeps under a mosquito Net	152	80.8
Sleeps without a mosquito Net	36	19.1
Q. Nighttime outdoor activity	Frequency	Percentage
Often	91	48.4
Occasionally	72	38.2
Never	12	6.3
Q. Use of preventive measures during the rainy season	Frequency	Percentage
Always	154	81.9
Sometimes	21	11.1
Never	12	6.3

Frequency Analysis: Malaria Incidence

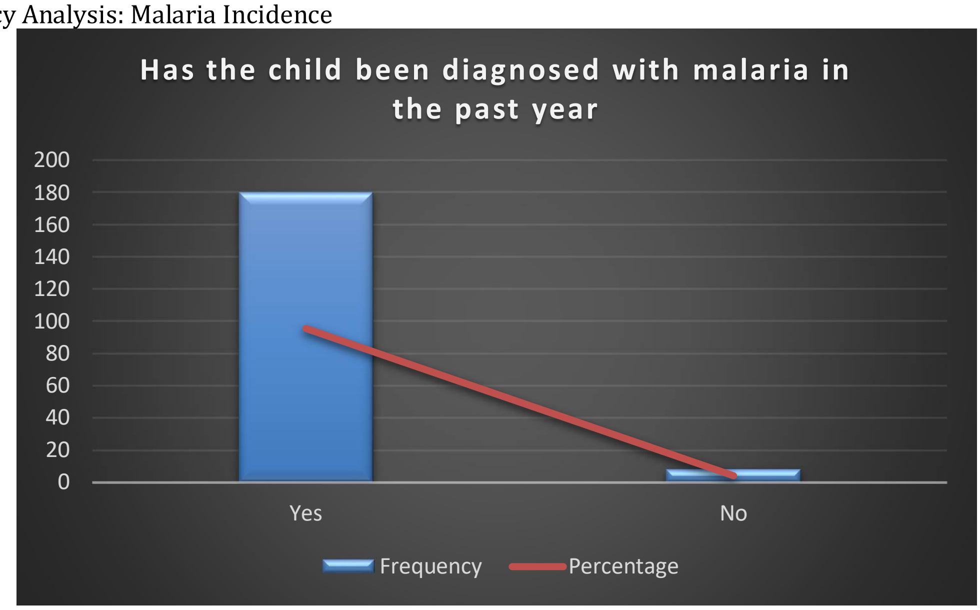


Figure 5: Has the child been diagnosed with malaria in the past year

Figure 5 displays the data on children who were diagnosed with malaria during the previous 12 months at the Specialist Hospital in Jimeta-Yola. Yes (95.7%): 180 (95.7%) of the children who participated in the survey said they had received a malaria diagnosis within the previous 12 months. No (4.2%): Merely 8 children (4.2%) reported that they had not received a malaria diagnosis within the previous 12 months.

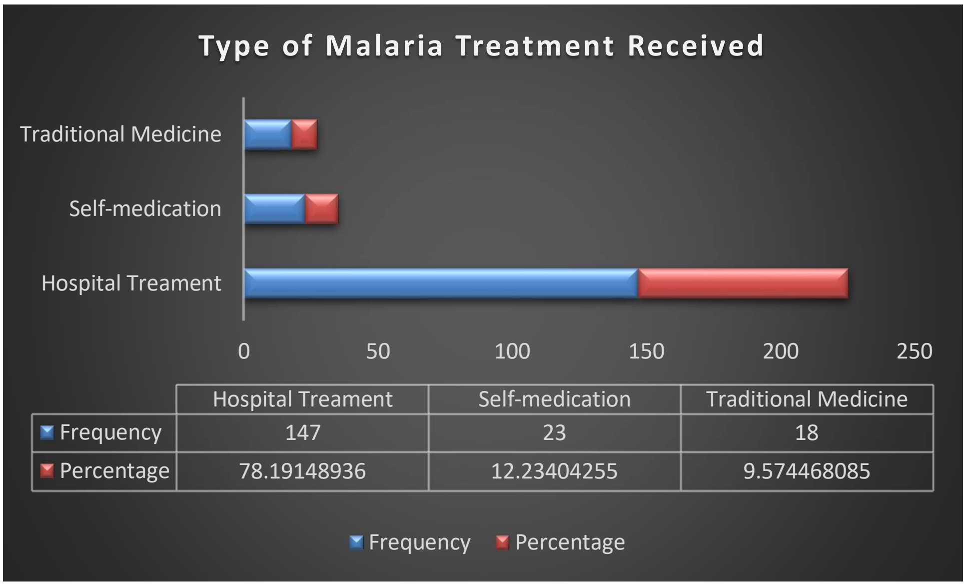


Figure 6: Type of Malaria Treatment Received

According to Figure 6, 78.1% of children who were diagnosed with malaria within the previous year were treated in hospitals. As an alternative, some sought treatment through traditional medicine (9.5%) or self-medication (12.2%). Alternative, 12.2% of people turned to self-medication, and 9.5% to traditional medicine.

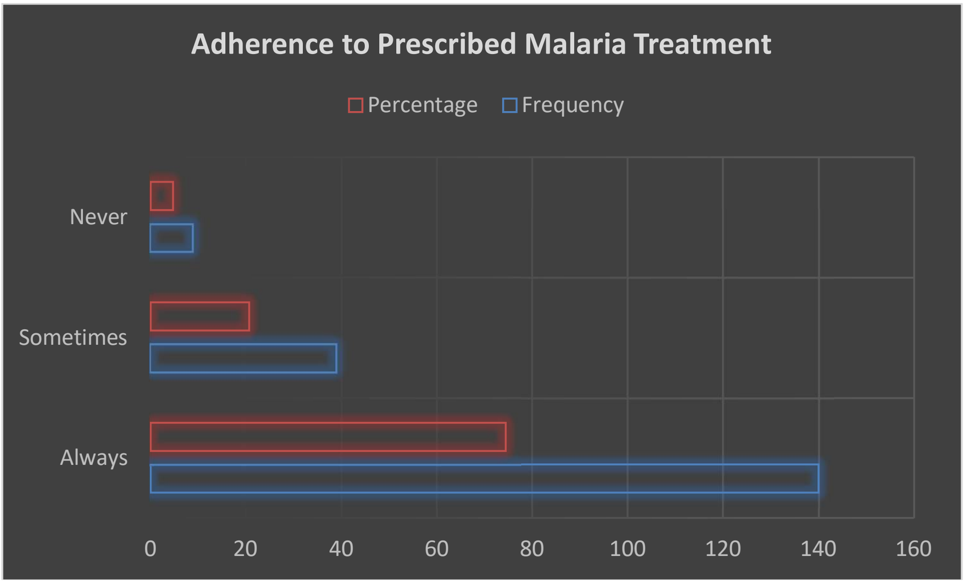


Figure 7: Adherence to Prescribed Malaria Treatment

The majority of children (74.4%) who are diagnosed with malaria consistently finish the entire course of treatment as directed, as seen in Figure 7. Nevertheless, 20.7% only occasionally adhere, and 4.7% never finish the course of treatment.

Descriptive Statistics of PCV Value

The average PCV is 28.23%, according to Table 4.3. 29% was the median PCV. Half of the children had a PCV value below 29%, according to this median value, which was marginally higher than the average. 8% was the lowest PCV that was noted. Conversely, the highest PCV was 54%. 8.98% was the standard deviation.

Table 4.3: Descriptive Statistics of PCV Value (%)

.

Average	**28.2**
Median	29
Min	8
Max	54
STD	8.9

Cluster Analysis: Comparison between Negative (-) and Positive (+) Malaria Test Results within age groups.

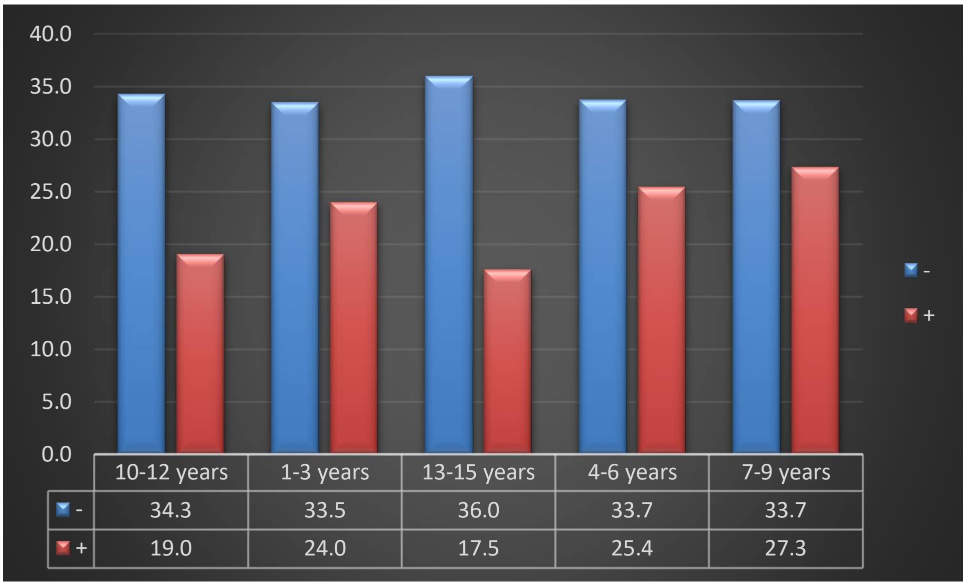


Figure 8: Comparison between Negative (-) and Positive (+) Malaria Test Result

It appears that the prevalence of malaria is generally higher in younger children (10-12 years) compared to older children (13-15 years). 10-12 years: This group shows the highest number of positive malaria cases. 13-15 years: This group has the lowest number of positive malaria cases. 1-3 years, 4-6 years, 7-9 years: These groups show moderate levels of malaria incidence. The number of negative tests consistently outnumbers positive tests across all age groups. The difference between negative and positive tests is most pronounced in the 13-15 years age group. Age-Related Susceptibility younger children might have weaker immune systems, making them more susceptible to malaria infection. Environmental Factors the prevalence of malaria-carrying mosquitoes might vary seasonally or geographically, influencing the infection rates in different age groups. Socioeconomic Factors access to healthcare, preventive measures (like mosquito nets and repellents), and nutritional status could impact the risk of malaria in different age groups.

Cross-tabulation and Chi-square Test

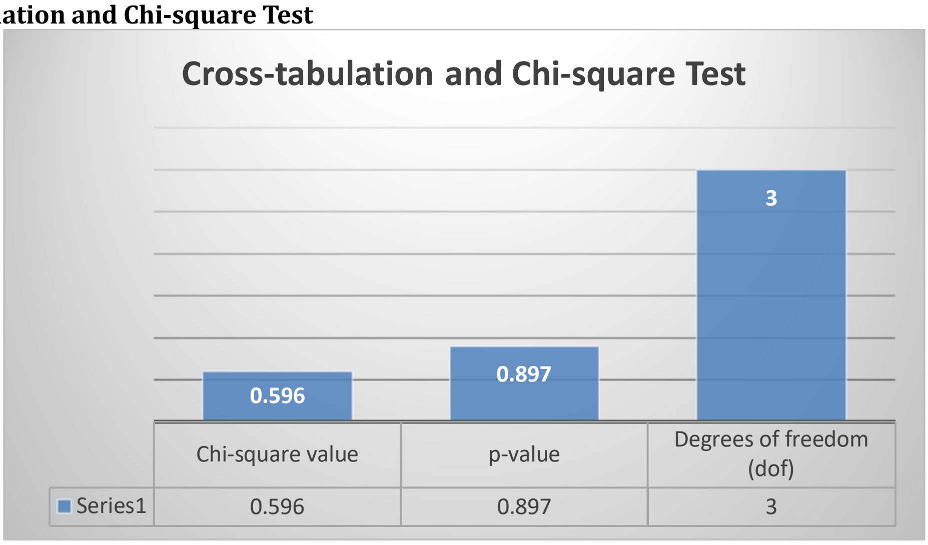


Figure 9: The cross-tabulation and Chi-square test results between malaria diagnosis and use of preventative measures

As seen in Figure 9:

Cross-tabulation

Children diagnosed with malaria most of them (148) had used preventative measures Always, while 20 used them Sometimes, and 11 Never. Children not diagnosed with malaria 6 used preventative measures Always, and 1 Never or Sometimes.

Chi-square test results

- Chi-square value: 0.596

- p-value: 0.897
- Degrees of freedom (dof): 3

The likelihood of receiving a malaria diagnosis within the previous year is not statistically correlated with the use of preventative measures, as the p-value (0.897) is significantly higher than the conventional significance level of 0.05.

Analysis of Variance of PCV value and Malaria status

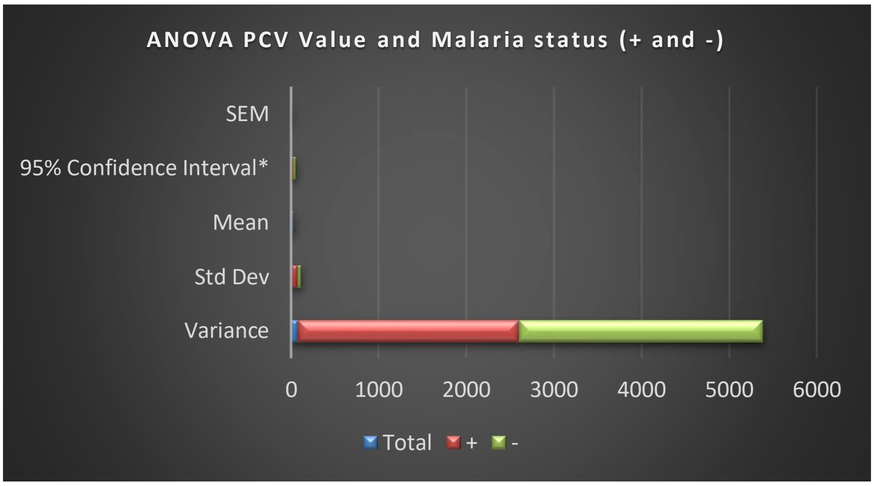


Figure 10: ANOVA PCV value and Malaria Status

KEY: SEM = Standard Error of the Mean, Std Dev = Standard Deviation

A statistical analysis of the association between PCV (Packed Cell Volume) and malaria status is presented in the ANOVA table in Figure 10.

+ Group (Malaria): The mean PCV is 8.2212.

- Group (No Malaria): The mean PCV is 6.3846.

+ Group: The standard deviation is 67.5889, indicating a wide range of PCV values in this group.

- Group: The standard deviation is 40.763, suggesting a less dispersed distribution of PCV values in this group.

95% Confidence Intervals

- For the + group, the true mean PCV is estimated to be between 23.8019 and 32.5484.
- For the - group, the true mean PCV is estimated to be between 22.2186 and 35.852.

Standard Error of the Mean (SEM)

- The SEM is smaller for the - group (0.7072) compared to the + group (0.8204), suggesting that the mean PCV estimate for the - group is more precise.

Correlation Analysis between Age of Child and PCV Value

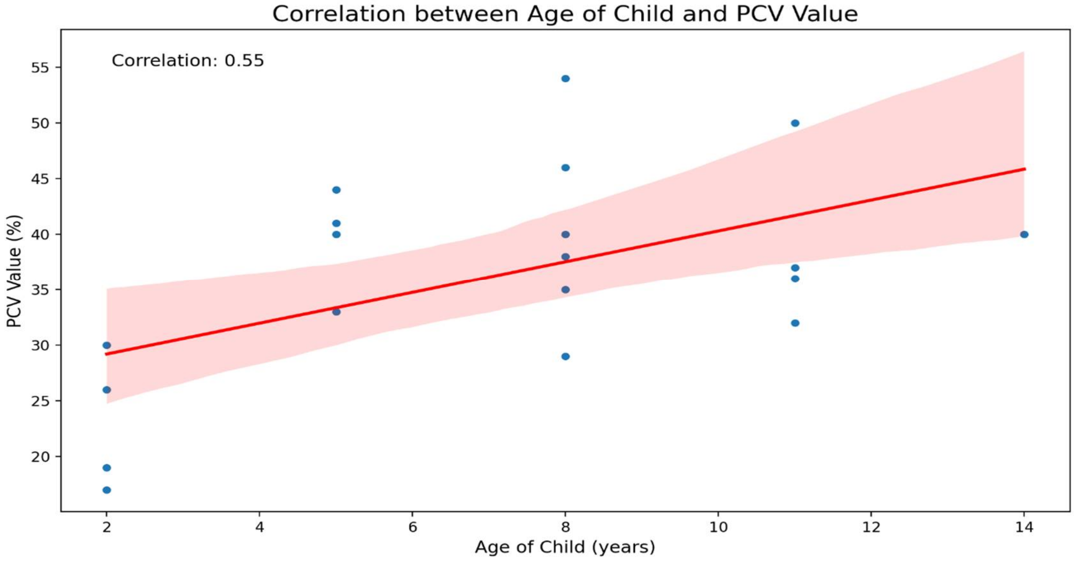


Figure 11: Correlation Analysis of PCV and the Age of the Child

The scatter plot illustrates the correlation between the PCV Value (y-axis) and the Child's Age (x-axis), as seen in Figure 11. In the dataset, each point corresponds to a distinct child. The regression line, represented by the red line, displays the relationship's general trend. From the chart, it shows:

1. Positive correlation: Age and PCV value have a moderately positive correlation, as indicated by the regression line's upward slope.
2. Strength of correlation: The chart shows a correlation coefficient of roughly 0.55. This suggests a somewhat favorable correlation.
3. Scatter: The regression line is surrounded by a significant amount of scatter in addition to a definite positive trend. This implies that although age affects PCV values, other factors probably have an impact as well.
4. Age range: The midpoints of the age groups we used in our analysis are represented by the x-axis, which displays the age range of roughly 2 to 14 years.
5. PCV range: The PCV values are displayed on the y-axis and seem to fall between 20% and 40%, with a few outliers falling outside of this range.

DISCUSSION

Important new information about the malaria burden in this area was provided by this study's evaluation of the incidence of malaria and related risk factors in children ages 1 to 15 at Specialist Hospital, Jimeta-Yola.

This study's malaria prevalence (95.7%, 106/188) was greater than that of other studies carried out in the same location, which found a prevalence of 50.6% (157/310) (Kunihya *et al.,* 2022). The study was carried out during the rainy season, which contributed to the prevalence rate of malaria infection. Additionally, a high number of malaria cases were found in August and September, suggesting that, among other reasons, Yola's poor drainage, poor sanitation, and water blockage contributed to an increased rate of malaria transmission. Plasmodium falciparum was the malaria species found in this investigation, which is consistent with the results of (Kunihya *et al.,* 2022).

Risk factors included sociodemographic characteristics like parental unemployment, lower educational attainment, and younger age (1-6 years). The Nigeria Malaria Indicator Survey (2021), which identified age and education as important predictors of malaria risk, is supported by these findings. This pattern emphasizes the significance of focused interventions for these age groups, such as improved preventative techniques like regular mosquito net use and timely medical care to lower the chance of developing severe malaria. A noteworthy trend in children's malaria susceptibility is revealed by this study, with younger age groups showing increased vulnerability. Children under the age of six are disproportionately affected, especially those ages one to three, who make up a significant portion of all malaria cases. This increased vulnerability is caused by a number of factors, such as immature immune systems and increased outdoor mosquito exposure. Pre-school-aged children, between four and six years old, also remain at considerable risk. It is interesting to note that children aged 7 to 9 have a slightly higher incidence of malaria, which may be related to increased outdoor activities and mosquito exposure.

Malaria susceptibility decreases as children reach the preteen and early teenage years (10–15). Stronger immune responses and increased awareness of preventive measures are credited with this declining trend. The age-related pattern in malaria susceptibility that has been observed is consistent with the results of other studies, including the one conducted by (Ranjha *et al.,* 2023). This consistency across studies reinforces the importance of age-specific approaches in malaria prevention and treatment strategies.

A fairly equal distribution of malaria cases between genders is suggested by the gender distribution data for children who attend the Specialist Hospital for malaria cases. The data shows that boys have a slightly higher incidence of malaria, but the difference is small (51.5% male vs. 48.4% female) (Kunihya *et al.,* 2022). This suggests that in this population, the risk of contracting malaria is almost equal for boys and girls, and interventions should target both sexes without making any notable distinctions in malaria prevention and treatment.

Additionally, this study examined the relationship between malaria prevalence and educational attainment, finding that children in primary school and those not enrolled in any educational program (35.1%), primary school (33.5%) represented the largest groups affected by malaria. This implies that younger, less educated children are more susceptible to infection, most likely as a result of their families' socioeconomic struggles or a lack of knowledge about preventive measures. These results are consistent with the research of (Makenga *et al.,* 2023), which identified comparable risks in school-age children. Secondary school students (14.3%) seemed to be at a lower risk, which is indicative of improved self-management and awareness of preventive measures.

Parental or guardian occupations also played a significant role in determining children's risk of contracting malaria. The largest occupational groups were civil servants (27.1%), traders (44.6%), and farmers

(19.6%). Farmers who work outdoors are inherently more susceptible to malaria, but traders who frequently operate in open markets close to standing water are also at higher risk. Despite having greater access to healthcare, civil servants did not exhibit a significantly lower prevalence of malaria, suggesting that exposure to malaria is not entirely explained by occupation. Significantly, 33.5 percent of the children were from households with unemployed parents or guardians, highlighting the socioeconomic factors that increase the risk of malaria.

Another important factor influencing the risk of malaria was income levels. 12.7% of the study population were families with monthly incomes under #10,000, and they faced significant financial barriers that prevented them from accessing healthcare services and mosquito nets. Malaria was more common among those making between #10,000 and #50,000 (23.4%) because they also had financial difficulties. However, malaria incidence remained high even among families with relatively higher incomes (43.6%), indicating that financial resources alone are not enough to reduce malaria risk. Other studies (Isiko *et al.,* 2023) similarly observed that socio-economic status, while important, is not the sole determinant of malaria incidence. Access to healthcare and the surrounding environment are important factors.

When housing conditions were also looked at, it was found that even though brick homes provided better protection from mosquitoes, children living in these homes (63.8%) still had a high malaria burden. Children who lived in concrete homes (9.0%) and mud houses (26.0%) were at different levels of risk, with mud houses being especially at risk because of environmental conditions that encourage mosquito breeding (Nawa *et al.,* 2024). Despite the fact that contemporary housing greatly lowers the risk of contracting malaria, this study discovered that even families living in more structurally sound homes were susceptible to the disease.

Additionally, a significant proportion of households (60.1%) had stagnant water nearby, which further increases the risk of malaria, as stagnant water serves as an ideal breeding ground for mosquitoes, and community efforts to address this environmental issue, such as drainage improvements and clean-up initiatives, are crucial to reducing malaria transmission (Tsegaye *et al.,* 2021). In addition, the prevalence of malaria was higher in larger households (7-9 residents) than in smaller households (1-3 residents), suggesting that household size also affected the spread of the disease.

The study also looked at behavioral practices like using mosquito nets, going outside, and following precautions during the rainy season. According to this study, 80.8% of kids slept under mosquito nets, which is encouraging for preventing malaria. However, 19.1% did not use nets, indicating a gap in protection that could be addressed through increased education and access to nets. Children who frequently engaged in nighttime outdoor activities (48.4%) were at higher risk of malaria due to increased mosquito exposure, particularly during peak transmission periods.

The results of this study showed that 81.9% of families regularly used preventive measures during the rainy season, which was encouraging. However, only 6.3% of families said they had never used preventive measures, highlighting the need for focused interventions to increase knowledge and provide access to preventive resources during times of high risk.

The prevalence of malaria and treatment-seeking behavior among children in a particular community were also investigated in this study. A high disease burden was indicated by the results, which showed that 95.7% of the children polled had received a malaria diagnosis in the previous 12 months. This implies that malaria is a serious health concern for this population, highlighting the pressing need for community-wide effective malaria prevention and control strategies. In terms of treatment-seeking behavior, the majority of children (78.1%) were treated in hospitals, which is positive and indicates that they are actively using community healthcare services. But a significant 12.2% of kids self-medicated, and 9.5% turned to conventional medicine, which raises questions about the possible dangers of self-diagnosis and self-treatment. Following treatment recommendations is essential to controlling malaria. It is encouraging for the management of malaria that 74.4% of children followed the entire course of treatment as directed by the study. Nonetheless, 4.7% of children never adhered, and 20.7% of children occasionally adhered, indicating areas that require improvement to guarantee that all children finish their treatment.

The results emphasize the necessity of better health education, treatment adherence, and efficient malaria prevention and control measures. Given the high number of children who receive a malaria diagnosis and the gaps in treatment compliance and health education, it is likely that malaria will continue to be a major public health concern.

With an average PCV of 28.23%, below the normal range of 35-45%, descriptive analysis of the children's PCV values shows a high prevalence of malaria-induced anemia among the children, suggesting a widespread problem of low hemoglobin levels. This anemia, which is associated with the destruction of red blood cells brought on by a malaria infection, is especially severe in cases where the minimum PCV was 8%, indicating an urgent need for medical attention.

With a p-value of 0.897, this study showed that there was no statistically significant correlation between the diagnosis of malaria and the use of preventive measures according to the cross-tabulation and Chi-square test. This finding suggests that other factors, such as environmental conditions and access to healthcare, may have a more substantial influence on malaria transmission, which is in line with (Chiziba *et al.,* 2024) which emphasizes the need to consider broader factors beyond preventive measures when addressing malaria transmission.

This study's ANOVA analysis, which is shown in Figure 9, clarifies the complex relationship between children's Packed Cell Volume (PCV) levels and malaria status. It also reveals a number of important findings that have important ramifications for the diagnosis and treatment of pediatric malaria. Contrary to expectations, the analysis showed that children with a malaria diagnosis had higher average PCV levels than children with a negative test result. Differences in hydration or physiological reactions to the infection could be the cause of this. The high standard deviation of PCV levels among children with malaria indicates that the disease affects people differently, necessitating more individualized treatment strategies.

This study's analysis of the relationship between a child's age and their Packed Cell Volume (PCV) value also revealed a moderately positive correlation (0.55) between the two variables. This suggests that although PCV levels tend to improve as children age, the relationship is not strong enough to be the only factor determining anemia levels, as the scatter plot illustrates.

The average PCV values of children who tested negative for malaria fell within the normal range (33.5-36.0%), whereas children who tested positive for the disease had significantly lower PCV values (17.5-27.3%), according to a comparison of the test results. This emphasizes how malaria negatively affects red blood cell counts.

CONCLUSION

This study successfully highlighted the multifaceted nature of malaria prevalence and its associated risk factors in children. Our knowledge of how demographic, environmental, and behavioral factors affect malaria incidence and anemia, as measured by Packed Cell Volume (PCV) levels, has improved as a result of the study. The results highlight the significance of a thorough strategy for the prevention and treatment of malaria, stressing the necessity of focused interventions that take into account the unique risk factors influencing this susceptible group. In the end, this study not only adds to the body of knowledge already in existence, but it also lays the groundwork for further investigations targeted at reducing the impact of malaria and enhancing the health of children in areas where the disease is endemic. The study's cross-sectional design, which makes it impossible to analyze seasonal transmission trends, and its reliance on self-reported data, which is prone to bias and lacks objective verification of bed net ownership and usage, are its two primary limitations. The results emphasize the need for integrated strategies that address the social, environmental, and behavioral determinants of malaria and have important policy and practice implications. Furthermore, the study emphasizes how crucial it is to keep funding malaria research and control initiatives, especially when it comes to creating novel approaches to deal with the intricate problems this enduring illness presents.

RECOMMENDATION

According to the study, children between the ages of one and six are most at risk of contracting malaria, and as they get older, their vulnerability gradually declines. These results highlight the urgent need for focused interventions aimed at younger populations. The impact of malaria on children can be lessened by healthcare initiatives that prioritize protection for the most susceptible age groups. Recommendations include:

Strengthen Malaria Prevention Programs

- Community Education: Put in place targeted educational programs that stress the value of regularly using mosquito nets and repellents as well as environmental management by clearing standing water close to homes. Prioritizing education for families with young children is essential.
- Availability of Preventive Resources: Increase accessibility to reasonably priced mosquito repellents and insecticide-treated mosquito nets. Families living in high-risk areas and those with lower incomes should be the focus of distribution efforts.

Improve Access to Healthcare and Treatment Adherence

- Improve Access to Healthcare: Make sure that kids with malaria get prompt, quality hospital treatment. Promoting the use of official healthcare services while discouraging self-medication and reliance on conventional remedies is crucial.
- Adherence to Treatment: Provide mechanisms for follow-up to guarantee that families finish the full course of treatment for malaria. Support mechanisms, such as reminder services or visits from community health workers, can significantly improve adherence rates.

Address Anemia through Nutritional Support

- Management of Anemia: Provide dietary interventions, such as supplements of iron and folic acid, especially for kids with low PCV levels. The underlying problem of childhood anemia can be addressed by incorporating nutritional education into malaria prevention initiatives.
- Regular Anemia Screening: To detect and treat anemia early, implement routine PCV screening for children in areas where malaria is endemic, particularly for those under five.

Targeted Interventions for Vulnerable Groups

- Young Children: Since they are the most impacted group, with the highest rates of malaria and the lowest PCV levels, focus malaria control and anemia management efforts on children ages 1-3.
- Families with Limited Resources: Tailor malaria prevention tactics to target families with lower socioeconomic status and those with less education, as they may face more barriers to accessing preventive resources.

REFERENCES

1. World Health Organization. (2022). World malaria report 2022: Tracking progress and gaps in the global response to malaria. Retrieved February 16, 2023, from https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2022
2. World Health Organization. (2023). Malaria. Retrieved May 12, 2023, from https://www.who.int/news-room/fact-sheets/detail/malaria
   World Health Organization. (2016). World malaria report 2016. WHO: Geneva. Available at: https://www.who.int/malaria/publications/world-malaria-report-2016/report/en (accessed February 3, 2017).
3. Kunihya, I. Z., Samaila, A. B., Qadeer, M. A., & Joseph, R. (2022). Prevalence of Malaria Infection and Malaria Anaemia Among Children Attending Specialist Hospital Yola, Adamawa State, Nigeria. DOI: 10.5281/zenod0.16528
4. Ranjha, R., Singh, K., Baharia, R. K., Mohan, M., Anvikar, A. R., & Bharti, P. K. (2023). Age-specific malaria vulnerability and transmission reservoir among children. *Global Pediatrics*, 6, 100085
5. Makenga, G., Menon, S., Baraka, V., Minja, D. T. R., Nakato, S., Delgado-Ratto, C., Francis, F., Lusingu, J. P. A., & Van Geertruyden, J.-P. (2020). Prevalence of malaria parasitaemia in school-aged children and pregnant women in endemic settings of sub-Saharan Africa: A systematic review and meta-analysis. *Parasite Epidemiology and Control*, 11, e00188.
6. Isiko, I., Nyegenye, S., Bett, D.K. et al. (2024). Factors associated with the risk of malaria among children: analysis of 2021 Nigeria Malaria Indicator Survey. *Malaria Journal* 23, 109. doi: 10.1186/s12936-024-04939-6
   Nawa, M., Mupeyo-Mudala, C., Banda-Tembo, S., et al. (2024). the effects of modern housing on malaria transmission in different endemic zones: A systematic review and meta-analysis*. Malaria Journal,* 23(1), 235.
7. Tsegaye, A. T., Ayele, A., & Birhanu, S. (2021). Prevalence and associated factors of malaria in children under the age of five years in Wogera district, northwest Ethiopia: A cross-sectional study. *PLOS ONE*, 16(10), e0257944. doi: 10.1371/journal.pone.0257944
8. Chiziba, C., Mercer, L. D., Diallo, O., Bertozzi-Villa, A., Weiss, D. J., Gerardin, J., & Ozodiegwu, I. D. (2024). Socioeconomic, demographic, and environmental factors may inform malaria intervention prioritization in urban Nigeria. *International Journal of Environmental Research and Public Health*, 21(1), 78. doi: 10.3390/ijerph2101007
9. Adebayo, A.A. (1999). Estimation of Land Surface Temperature of Yola, North Eastern Nigeria Using Landsat-7 ETM+ Satellite Image. *ResearchGate.*