

# Prolonged use of mosquito coil, mats, and liquidators: A review of its health implications

Nitin Ashok John, Jyoti John<sup>1</sup>

Department of Physiology, Indira Gandhi Medical College and Research Institute, Puducherry, <sup>1</sup>Department of Biochemistry, ESIC Medical College, Faridabad, Haryana, India

## Abstract

Mosquito coils are burnt indoors and outdoors in India to control mosquitoes. Human beings get exposed to a chemically complex mosquito coil smoke containing small particles (<1 µm), metal fumes, and vapors that may reach the alveolar region of the lung. Coils consist of an insecticide/repellent, organic fillers, binders, and additives such as synergists, dyes, and fungicide. Thus, the smoke contains pollutants of health concern. The concentrations of pollutants resulting from burning mosquito coils may exceed health-based air quality standards and have ill effect on health. Hence, in this review, we have discussed the health implications due to burning of mosquito coil, mats, and heating of mosquito refill liquidators.

**Key words:** Liquidators, mats, mosquito coil, prolonged use

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## INTRODUCTION

Human beings are often protected from nuisance and disease-bearing mosquitoes by insecticides. The four major types of residential insecticide products that are widely used globally are aerosols, mosquito coils, liquid vaporizers, and vaporizing mats.<sup>[1]</sup>

Mosquito coils and mats are burnt indoors and outdoors in India. Coils and mats consist of organic fillers (capable of burning with smoldering binders) and additives such as synergists, dyes, and fungicide.<sup>[2]</sup> The most common active ingredients in coils and mats are the various derivatives of pyrethroids. Pyrethroid-based coils and mats are effective against genera of mosquitoes including *Aedes*, *Anopheles*, and *Mansonia*. The liquid mosquito repellent bottle filled with the repellent and graphite rod at the center also produces fumes when heated, and it blocks the chemo sensors of mosquitoes so that they are unable to identify human beings.<sup>[1]</sup> The common brands of mosquito coils used in India label D-trans allethrin as an active ingredient with 99% other constituents, which

are not specified. Most of them are aromatic and aliphatic hydrocarbons, which are combustible products of wood, dust filters, and dyes. The fumes emitted by burning of the coils are responsible for ill effects on human health.

The coils and mats are often used overnight in sleeping quarters where elevated exposure may occur. Mosquito coil, mat, and liquidators smoke containing particulates (<1 µm), metal fumes, and vapors may reach the alveolar region of the lung on chronic and prolonged exposure, thereby affecting lung functions in humans.<sup>[3,4]</sup> The mosquito coils and mats contain octachlorodipropyl ether as a synergist or active ingredient. S-2 is chloroalkyl ether used both as an insecticide and insecticide synergist in mosquito coils and mats and the volatile constituents of S-2 include undefined genotoxic agents.<sup>[5-9]</sup> Pauluhn reported that bis-chloromethyl ether (BCME) is released during combustion of mosquito coils.<sup>[10]</sup> BCME might act

**Address for correspondence:** Dr. Nitin Ashok John, Department of Physiology, Indira Gandhi Medical College and Research Institute, Puducherry, India.  
E-mail: drnitinjohn@yahoo.co.in

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as a potent lung carcinogen for residents including children on long-term exposure even in unmeasured amount.<sup>[8-10]</sup>

Acute pyrethroid toxicity manifests as breathing problems, headache, eye irritation, bronchial irritation, and skin reaction. The subjects may complain of cough, cold, and running nose with fever or sneezing.<sup>[11-14]</sup> Research abroad has already established that prolonged use of mats is harmful to several organs in the human body. It can lead to corneal damage, shortness of breath, asthma, and might even damage the liver in long run.<sup>[15]</sup> Hence, we decided to review the various health implications due to toxicological effects of prolonged use of mosquito coils, mats, and liquidators.

### PYRETHRUM VERSUS PYRETHRIN HEALTH EFFECTS

The role of pyrethrins as the potent chemical in the *Chrysanthemum* plants responsible for the insecticidal properties in the crushed flowers was identified around the year 1800 in Asia. Pyrethrins are the natural extracts of *Chrysanthemum cinerariaefolium* and *Chrysanthemum coccineum* flowers. Pyrethroids, synthetic analogs, and derivatives of pyrethrins are globally used as insecticides and are the most common content of mosquito coil, mats, and liquidators. Pyrethrins and pyrethroids can enter the organism by accidental ingestion, by inhalation and/or by skin contact. These pesticides have relatively low-risk toxicity in mammals due to rapid metabolism with no significant accumulation. They can induce adverse health effects on chronic exposure.<sup>[15]</sup>

Pyrethrum and pyrethrins are extracted from plants of the *Chrysanthemum* family. Pyrethrins are the improvised purified versions of these extracts. Pyrethrins are the pesticide of choice as compared to organophosphates and organochlorides since other compounds have significant and persistent toxic effects to humans. As pyrethrins are biodegradable compounds and the purified

version, they are regarded preferable to pyrethroids as mosquito repellent. Pyrethrins are found to be low toxicity pesticides from a human health standpoint.<sup>[15]</sup>

### Insecticide and insect repellent effect of pyrethrin

Pyrethrins cause the delayed closure of voltage-gated sodium ion channels in the nerve cells of insects, resulting in repeated and extended nerve firings. This hyperexcitation causes loss of motor coordination and paralysis and death of the insect [Figure 1]. Pairing the insecticide with synthetic synergists such as piperonyl butoxide has helped overcome the resistance effects to pyrethrin. The combo of pyrethrin and piperonyl butoxide compounds prevent detoxification in the insect thus ensures insect death. Pyrethrin is a potent insecticide, and it also functions as an insect repellent at lower concentrations as depicted in Figure 2. Pyrethrins being an insecticide and insect repellent is very successful in reducing insect pest population affecting humans, livestock, crops, and pets as well potentially disease-carrying mosquitoes, fleas, and ticks.<sup>[1,3,15]</sup>

### Mosquito coil, mats, and liquidators and safe practices

Apart from the toxic effect due to prolonged use of pyrethrins-based mosquito coil, mats, and liquidators, lack of knowledge regarding health hazards and safe practices and lack of supervision and national guidelines regarding accepted formulation of contents of mosquito coil, mats, and liquidators have led to increase risk of health-related illnesses.

Fewer studies have been carried out to estimate the prevalence of usage, unsafe practices, and risk perception of household pesticides in India. A study carried in this regard in rural South India revealed that the most commonly used pesticides at homes were mosquito coils (75%), mosquito liquid vaporizers (36%), ant-killing powder (24%), and moth/naphthalene balls (18%). Moreover, 61% of the mosquito coil users kept the windows and doors closed while the coil was

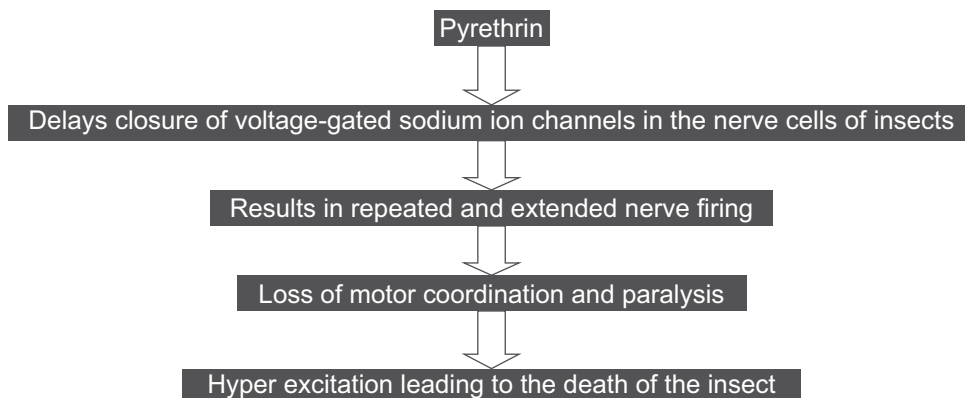
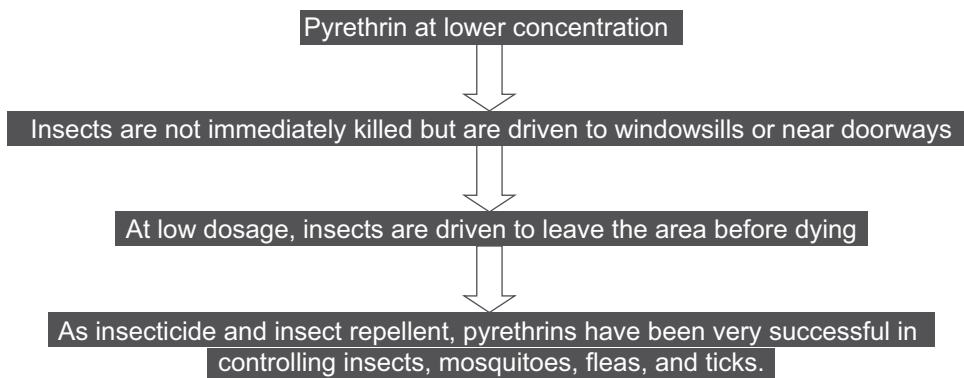


Figure 1: Pyrethrin as insecticide



**Figure 2:** Pyrethrin as an insect and mosquito repellent

burning. In addition about half of the users did not know that household pesticides were harmful to their health. The study recommended that the users of household pesticides must be educated about the health hazards and safe practices and nonchemical methods of pest control be promoted.<sup>[16]</sup>

The study carried out to characterize the emissions from four common brands of mosquito coils from China and two common brands from Malaysia revealed that Malaysian mosquito coils generated more measured pollutants than did the tested Chinese mosquito coils and a large suite of volatile organic compounds, including carcinogens and suspected carcinogens, in the coil smoke was also identified.<sup>[17]</sup> Thus, strict government regulatory supervision over composition content of mosquito coil, mats, and liquidators is warranted.

### **Pyrethroid and pyrethrin use and implication on health**

As pyrethroids and pyrethrins are largely used as insecticides, the numbers of illnesses and injuries associated with prolonged exposure to these chemicals are also at rise. Pyrethrins and pyrethroids are labeled low toxicity chemicals and until date as only a few cases leading to serious health effects in humans has been studied, they continue to be in use ubiquitous in home care products.<sup>[14,15]</sup>

### **Effect of pyrethroid and pyrethrin exposure in animals**

The smoke-exposed female albino rats to mosquito coil smoke for duration of 8 h a day, 6 days/week, for 60 days presented with smoke-induced histopathological lesions, including an inflammation of the tracheal epithelium, atelectasis of the lung parenchyma, emphysema, and morphological alteration of alveolar macrophages. The elevated level of lactate dehydrogenase, glutamate pyruvate transaminase, glutamate oxoacetate transaminase, and acid phosphatase enzymes were found in the serum of the smoke-exposed rats. This indicated that the enzymes were released from the damaged tissues into the bloodstream.<sup>[11,12]</sup>

The toxicological effects of fumes from two locally manufactured mosquito coil insecticides (with pyrethroids: transfluthrin and d-allethrin as active ingredients) on male albino rats exposed to mosquito fumes during 2, 4, 8, 12, and 16 weeks period revealed significant increase ( $P < 0.05$ ) in the levels of total protein, total albumin and bilirubin, when animals were exposed from 2 weeks to 16 weeks with transfluthrin, there was elevation in the activities of aspartate amino transferase, alanine amino transferase, and alanine phosphatase, and they increased significantly in both insecticides, there was increase in white blood cell count, packed cell volume, and red blood cell count for all the exposure periods; however, platelet count showed no significant increase ( $P > 0.05$ ), mutagenicity assessment revealed that sperm abnormality was statistically significant ( $P < 0.05$ ) compared with the control at 8, 12, and 16 weeks postexposure to transfluthrin, histological studies showed severe lung damage evidenced by interstitial accumulations, pulmonary edema and emphysema in exposed rats while intracellular accumulations and severe sinusoidal congestion of liver cells were observed from 12 weeks exposure, indicating liver damage. Thus, the study indicated that mosquito coil fumes do initiate gradual damage to the host. This also suggests that there may be health implications in human in case of prolonged exposure to mosquito coil, mats, and liquidator fumes. These pathological effects must be verified and compared with more detailed studies in humans which will be immensely helpful when regulating their long-term and indoor usage under malaria control program.<sup>[18]</sup>

### **Effect of pyrethroid and pyrethrin exposure in humans**

Chronic toxicity in humans occurs most quickly through respiration into the lungs, or more slowly through absorption through the skin [Figure 3]. Our earlier studies pointed out reduced force vital capacity, force expiratory volume in 1 s, forced expiratory flow 25–75%, peak expiratory flow rate, and maximum voluntary ventilation in prolonged pyrethrum coil and

mat users who had exposure history between 5 and 10 years, and average duration of use per day was around 8 h.<sup>[19]</sup>

Another of our study also revealed altered autonomic and nervous functions due to prolonged pyrethrum coil and mat use in individuals with exposure history of 5–10 years and the average duration of exposure was around 8 h. The reaction time for auditory low- and high-frequency sound and visual reaction time for red, green, and indigo light was delayed, and heart rate and blood pressure were slightly higher in pyrethrum coil and mat users as compared to control.<sup>[20]</sup>

Prolonged exposure to pyrethrum in high levels in humans may cause symptoms such as asthmatic breathing, sneezing, nasal stuffiness, loss of coordination, tremors, convulsions, headache, nausea, facial flushing, and swelling.<sup>[21,22]</sup>

Pyrethrum has an allergenic effect that neither pyrethrin nor pyrethroids have. Allergic reactions such as itching and burning sensations after exposure are rare because the allergenic component of pyrethrin has been removed. The exposure to pyrethrum, the crude form of pyrethrin, can also cause harmful health effects for mammals [Figure 4] and can lead to tongue and lip numbness, drooling, lethargy, muscle tremors,

respiratory failure, vomiting, diarrhea, seizures, paralysis, and death.<sup>[21-23]</sup>

Pyrethrin and pyrethroid toxicity mainly affects the nervous system as they act directly on the sodium channels of nerve cell axons leading to hyper excitability of neurons. Respiratory effects and paresthesia are among the concerns about pyrethrin/pyrethroid exposures. The exposure to mosquito coil smoke may be a risk factor for the development of lung cancer. The mosquito coil smoke exposure was more frequent in lung cancer patients than controls.<sup>[24,25]</sup> The risk of lung cancer was significantly higher in frequent burners of mosquito coils (more than 3 days/week) as compared to the nonburners.<sup>[23]</sup>

The common factors contributing to pyrethrin/pyrethroid-related illness include exposure from spills/splashes, improper storage, and failure to evacuate during pesticide application. There is a possibility of damage to the immune system leading to worsening of allergies following toxicity.<sup>[24,25]</sup>

Thus, prolonged exposure to pyrethrum coil and mat can lead to deleterious effect on health affecting pulmonary, autonomic, and nervous functions apart from allergic reactions and risk of pyrethroid poisoning.

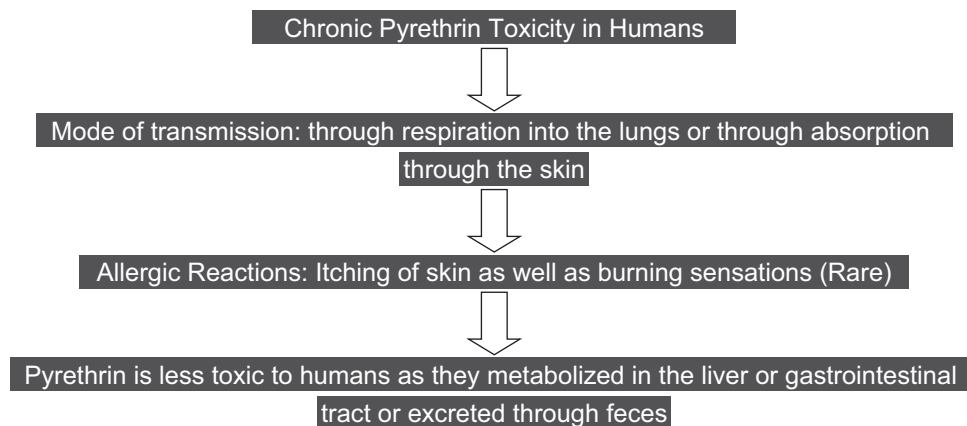


Figure 3: Pyrethrin toxicity in humans

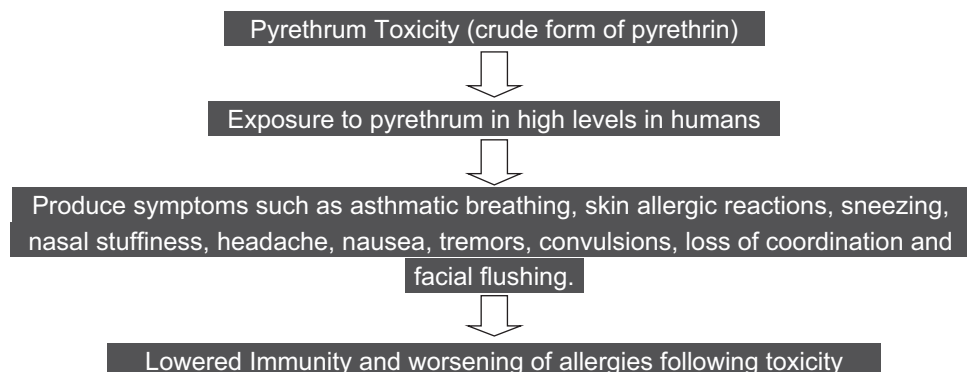


Figure 4: Pyrethrum toxicity in humans

## CONCLUSION

Although pyrethrum-based pesticides have relatively low-risk toxicity in mammals due to rapid metabolism with no significant accumulation, they can induce adverse health effects due to chronic exposure. Existing knowledge is not adequate to support safe residential use of mosquito coils containing uncharacterized combustion products, and it is unfortunate that the environmental data and experimental studies have not been more prominent in risk management. Extensive research is indicated in reference to standard size of the room, ventilation, and number of people sleeping in the room pertaining to safety and efficacy of mosquito coil, mat, and liquidator use. The guidelines for safe use of mosquito coil with standard defined regulations need to be ear marked and popularized by educating the general masses. The companies, manufacturing these mosquito coils, should specify the ingredients used with scientific references regarding its safe use and duration of use of such coils.

Thus, educating masses for safe use, practices, and standardization of the mosquito coil, mat, and liquidator products will help minimize exposure risk and health ill effects.

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### Conflicts of interest

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