INTERNATIONAL RESEARCH JOURNAL OF PHARMACY

www.irjponline.com ISSN 2230 – 8407

Review Article

A BRIEF STUDY ON MARIGOLD (*TAGETES* SPECIES): A REVIEW

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Article Received on: 10/11/12 Revised on: 11/12/12 Approved for publication: 01/01/13

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ABSTRACT

Tagetes species belonging to family Asteraceae, are most common in plant kingdom, which is used in different areas like cosmetic preparation, medicines as well as it is most widely used as ornamentals. It is found in different colors and different fragrance. Yellow color is most common. Flowers are mainly used for the all these purposes by the extraction process. Lutein is an oxycarotenoid, or xanthophyll, containing 2 cyclic end groups (one beta and one alpha-ionone ring) and the basic C-40 isoprenoid structure common to all carotenoids. It is one of the major constituents and the main pigment of *Tagetes erecta*. It has a strongly aromatic essential oil (*Tagetes* oil), quercetagetin, a glucoside of quercetagetin, phenolics, syringic acid, methyl-3, 5-dihydroxy-4- methoxy benzoate, quercetin, thenyl and ethyl gallate, terpines, and other important phytochemical constituents from the different part of the plant. The leaves are reported to be effective against piles, kidney troubles, muscularpain, ulcers, and wounds. The flower is useful in fevers, epileptic fits (Ayurveda), astringent, carminative, stomachic, scabies and liver complaints and is also employed in diseases of the eyes. It shows different pharmacological activities like Anti-bacterial Activity, Anti-microbial Activity, hepatoprotective activity, Insecticidal activity, Mosquitocidal activity, Nematicidal activity, Wound healing activity, Anti oxidant and Analgesic activity Larvicidal activity ,Sub acute toxicity studies also studies *Tagetes* species for Nematode Management in details.

KEYWORDS: Marigold, *Tagetes erecta*, Lutein, *Tagetes* oil, Antibacterial activities etc.

INTRODUCTION

At the present point in time the modern conventional healthcare is hampered with great problems of unsafe medicines, chronic diseases, resistant infections, auto immune disorders and degenerative disorders of ageing, even though great scientific advances. More than 70% of India's 1.1 billion populations still use these non-allopathic systems of medicine[1]. Medicinal plants and derived medicine are widely used in traditional cultures all over the world and they are becoming increasingly popular in modern society as natural alternatives to synthetic chemicals[2]. In the last few decades there has been an exponential growth in the field of herbal medicine. It is getting popularized in developing and developed countries owing to its natural origin and lesser side effects[3]. India possesses almost 8% of the estimated biodiversity of the world with around 0.126% million species[4]. The World Health Organization (WHO) estimated that approximately 80% of world population relies mainly on traditional medicines, mostly plant drugs in their health care. Today, Ayurveda coexists with modern system of medicine, and is still widely used and practiced. About 30% of the currently used therapeutics is of natural origin[5]. In the indigenous health care delivery system, numerous plant species and natural products derived from plants are to treat diseases of infectious origin[6]. Medicinal plants represent a rich source from which antimicrobial agents may be obtained. Plants are used medicinally in different countries and are a source of many potent and powerful drugs[7]. Clinical microbiologists have great interest in screening of medicinal plants for antimicrobial activities and phytochemicals as potential new therapeutics. The active principles of many drugs found in plants are secondary metabolites[8-9]. The beneficial medicinal effects of plant materials typically result from the combinations of secondary metabolites present in the plant such as alkaloids, steroids, tannins and phenolic compounds, flavonoids, resins, fatty acids and gums which are capable of producing definite physiological action on body. The reason for choosing herbs as antibacterial sources is the development of a drug resistance in human pathogens against commonly used antibiotics[10, 11]. *Tagetes erecta* L. (Asteraceae) is a medicinal and ornamental plant. It is used for its nematocide, cosmetic and medicinal properties. The essential oil of the flower contains antioxidants[12]. Growth of *Tagetes erecta* L. (Asteraceae) is influenced by chemical fertilizers, particularly phosphate fertilizers. Since, application of these fertilizers increase the soil and water pollution and accumulation of some heavy metals such as cadmium, they can threat the human health. Moreover, the long-term use of chemical fertilizers tends to the soil structure degradation[13]. Nowadays, attention to biological fertilizer has been increased due to price of chemical fertilizers and attention to sustainable agricultural systems14 Bio-fertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, phosphate solutions and agricultural production[15, 16]. Some bacteria provide plants with growth promoting substances and play major role in phosphate solubilizing[17]. Marigolds come in different colors, yellow and orange being the most common. Most of the *Tagetes* species have strong, pungent odor and have great value in cosmetic treatment. There are many varieties of *Tagetes* species available today.

Some of the major *Tagetes* varieties

African or American Marigolds (*Tagetes erecta*):

These marigolds are tall, erect-growing plants up to three feet in height. The flowers are globe-shaped and large. Flowers may measure up to 5 inches across. African Marigolds are very good bedding plants. These flowers are yellow to orange and do not include red colored Marigolds. The Africans take longer to reach flowering stage than the French type.

French Marigolds (*Tagetes patula*):

Marigold cultivars in this group grow 5 inches to 18 inches high. Flower colors are red, orange and yellow. Red and orange bicolor patterns are also found. Flowers are smaller (2 inches across). French Marigolds are ideal for edging flowerbeds and in mass plantings. They also do well in containers and window boxes.

Signet Marigolds (*T. signata* 'pumila'):

The signet Marigolds produce compact plants with finely divided lacy foliage and clusters of small, single flowers. They have yellow to orange colored, edible flowers. The

flowers of signet marigolds have a spicy tarragon flavor. The foliage has a pleasant lemon fragrance. Signet Marigolds are excellent plants for edging beds and in window boxes.

Mule Marigolds:

These marigolds are the sterile hybrids of tall African and dwarf French marigolds, hence known as mule Marigolds. Most triploid cultivars grow from 12 to 18 inches high. Though they have the combined qualities of their parents, their rate of germination is low.

Figure 1: *Tagetes erecta*

Botanical Study

Kingdom : Plantae
Order : Asterales
Family : Asteraceae
Genus : *Tagetes*
Species : *erecta*

Propagating and Growing of *Tagetes* species

Tagetes species can be propagated by seeds. The plants need about 45 days to flower after seeding. Marigold seeds should be sown 2 cm apart. Cover seeds with 1/4 inch of potting soil. Water sufficiently. Plants will appear within a few days. When true leaves have formed, transplant into individual containers or outdoors.

Marigolds are robust, non-fussy plants that bring a lot of sunshine in your garden. *Tagetes* species can be grown easily.

- Plant your seeds in half-sunny or sunny locations.
- The soil must be well-drained, moist and fertile.
- Add potash fertilizers to prolong the flowering period.
- Pinch off the first flowers before they open. This will lead to a larger number of flowers.

Facts About *Tagetes* species

- *Tagetes* (Calendula) is an extremely effective herb for the treatment of skin problems and can be used wherever there is inflammation of the skin, whether due to infection or physical damage; for example, crural ulceration, varicose veins, hemorrhoids, anal fissures, mastitis, sebaceous cysts, impetigo or other inflamed cutaneous lesions.
- As an ointment, Marigold (*Tagetes*) is an excellent cosmetic remedy for repairing minor damage to the skin such as sub dermal broken capillaries or sunburn. The sap from the stem is reputed to remove warts, corns and calluses.
- In the 12th century Macer wrote that merely looking at the *Tagetes* species plant would improve the eyesight and lighten the mood.
- In South Asia, bright yellow and orange *Tagetes* species flowers are used in their thousands and placed in garlands and to decorate religious statues and buildings. They are also used as offerings and decoration at funerals, weddings and other ceremonies.
- Pigments in *Tagetes* species are sometimes extracted and used as a food coloring for humans and livestock.

Traditional Uses

The leaves are reported to be effective against piles, kidney troubles, muscular pain, ulcers, and wounds. The pounded leaves are used as an external application to boils and carbuncles.

Chemical Constituents

The medicinal plant, *Tagetes erecta* Linn. (Family, Asteraceae) widely used in olden days for the treatment of wounds. It is commonly known as aromatic annual herb reaches 0.4-1 m height. It is very popular as a garden plant and yields a strongly aromatic essential oil (*Tagetes* oil), which is mainly used for the compounding of high-grade perfumes. Different parts of this plant including flower are used in folk medicine to cure various diseases[18]. The leaves are reported to be effective against piles, kidney troubles, muscular pain, ulcers, and wounds. The pounded leaves are used as an external application to boils and carbuncles. It is reported to have antioxidant, antimycotic, analgesic activity and 18 active compounds are identified by GC-MS, many of them are terpenoids[19-21]. The flower is useful in fevers, epileptic fits (Ayurveda), astringent, carminative, stomachic, scabies and liver complaints and is also employed in diseases of the eyes. They are said to purify blood and flower juice is given as a remedy for bleeding piles and also used in rheumatism, colds and bronchitis[22-23]. Phytochemical studies of its different parts have resulted in the isolation of various chemical constituents such as thiophenes, flavonoids, carotenoids and triterpeniods. The plant *T. erecta* has been shown to contain quercetagetin, a glucoside of quercetagetin, phenolics, syringic acid, methyl-3, 5-dihydroxy-4- methoxy benzoate, quercetin, thienyl and ethyl gallate[18, 23].

Lutein is an oxycarotenoid, or xanthophyll, containing 2 cyclic end groups (one beta and one alpha-ionone ring) and the basic C-40 isoprenoid structure common to all carotenoids. It is one of the major constituents and the main pigment of *Tagetes erecta*.

Pharmacological Actions

Anti-bacterial Activity

Rhama and Madhavan reported the anti-bacterial activity of different solvents of *Tagetes erecta* flowers against *Alcaligens faecalis, Bacillus cereus, Campylobacter coli, Escherchia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus vulgaris, Streptococcus mutans* and *Streptococcus pyogenes*. The flavonoid possesses anti-bacterial activity against all the tested strains and shows maximum zone of inhibition for *Klebsiella pneumoniae* (29.50 mm). The flavonoid-Patulitrin is one of the potential elements for its anti-bacterial activity[24].

Antimicrobial Activity

Ruddock et al reported the anti microbial activity in 19 plants used in Colombian traditional medicine for cutaneous infections, were screened against Neisseria gonorrhoeae (NG) by disc susceptibility assay. In all, 71% of the crude extracts exhibited antibacterial activity against the antibiotic susceptible NG strain, whereas 10% of the extracts inhibited penicillinase-producing NG strain GC1–182. The *Tagetes erecta* flower parts showed maximum inhibitory action against NG strain[25].

Anti-oxidant activity

Chivte et al reported the antioxidant studies on the ethanolic extract of *Tagetes erecta* flowers by three different assays like DPPH, reducing power and super oxide radical scavenging activity at different concentrations were used. In all the three assay, *Tagetes erecta* showed better reducing power than the standard (i.e. ascorbic acid), and super oxide

anion scavenging activity and DPPH antioxidant activity showed less than standard. However, ethanolic extract of *Tagetes* erecta demonstrated antioxidant property in all the in Vitro models[26].

Hepatoprotective activity

Bose et al reported the hepatoprotective activity in flowers of *Tagetes erecta* by carbon tetra chloride induced hepatopathy model. The ethanolic extract showed the increase in serum ALT, AST, ALP and bilirubin levels. Ethyl acetate fraction of *T. erecta* (EATE) at the dose of 400 mg/kg orally significantly decreased the elevated serum marker enzymes and level of bilirubin almost to the normal level compared to CCl4-intoxicated group. Histological changes in the liver of rats treated with 400 mg/kg of EATE extract and CCl4 showed a significant recovery except cytoplasmic vascular degenerations around portal tracts, mild inflammation and foci of lobular inflammation. Phytoconstituents such as flavonoids, terpenoids and steroids are responsible for the observed hepatoprotective activity[27].

Insecticidal activity

Nikkon et al reported the insecticidal activity in *Tagetes* erecta flowers against a stored product insect pest, Tribolium castaneum (Herbst). The chloroform fraction showed highest toxicity against both the larvae and adults of Tribolium castaneum followed by petroleum ether fraction and ethanol extract. The LC values of chloroform fraction against first, second, third, fourth, fifth and sixth instar larvae were 11.64, 14.23, 19.26, 29.02, 36.66, 59.51 µg/cm2 (72 h.), respectively and for adults the value was 65.93 µg/cm2 (72 h.). No mortality was observed in control. Finally they concluded that the flower of *Tagetes* erecta might be a pesticide against Tribolium castaneum[28].

Mosquitocidal activity

Nikkon et al reported the mosquitocidal activity in ethanolic, chloroform and petroleum ether extracts of *Tagetes* erecta flowers against different instars of Cx.quinquefasciatus. Among the tested samples the chloroform soluble fractions showed the highest toxicity and consequently the LC50 values (14.14µg/mL, 17.06µg/mL, 36.88µg/mL and 75.48µg/mL) for all instar larvae of Cx.quinquefasciatus. The larvae showed comparative tolerance in the course of increasing age and time. From this they concluded the flowers of *Tagetes* erecta having good mosquitocidal activity[29].

Nematicidal activity

Husain et al reported the nematicidal efficacy of four medicinal plants viz. Azadirachta indica, Calotropis procera, Datura stramonium and *Tagetes erecta* was ascertained for the control of M. incognita. All leaf amendments at different dosages significantly improved the plant growth characteristics of okra and reduced root-knot infections compared with the untreated control[30].

Wound healing activity

Ibrahim et al reported the wound healing activity of carbopol gels prepared from hydro alcoholic extracts of *Gymnema sylvestere* (GE) and *Tagetes erecta* Linn. (TE) in excision wound model and burn wound models in albino mice. In excision and burn wound models, the GE and TE treated animals showed significant reduction in period of epithelization and wound contraction and combined gel showed accelerated wound healing activity may be because of synergism. The enhanced wound healing activity of hydro alcoholic extracts may be due to free radical scavenging action and the phytoconstituents (flavonoids) present in it which either due to their individual or additive effect fastens the process of wound healing[31].

Anti oxidant and Analgesic activity

Bashir and Gilani reported the in vitro anti oxidant and in vivo analgesic activities (acetic-acid-induced abdominal writhing) on flower extracts of *Tagetes erecta*. The results revealed the presence of pronounced antioxidant potential on dose-dependent (100 and 300 mg/kg) and analgesic effect also. The antioxidant and analgesic activities obtained seem to be in good accordance with the medicinal uses of Aztec marigold as an anti-inflammatory and analgesic[32].

Larvicidal activity

Marques et al reported the larvicidal activity of essential oil from *Tagetes erecta* against 3rd instars of Aedes aegypti and to determine the amounts of larvicidal thiophenes in all plant tissues. The oil obtained by steam distillation and analyzed by gas chromatography/mass spectrometry showed 14 compounds. The main compounds were piperitone (45.72%), d-limonene (9.67%), and piperitenone (5.89%). The essential oil was active against larvae of Aedes aegypti, with LC50 of 79.78 µg/ml and LC90 of 100.84µg/ml. The larvicidal thiophene contents were higher in the roots and flowers as demonstrated by high-performance liquid chromatography analysis. Thus, *Tagetes erecta* constitutes a good source of varied compounds showing larvicidal activity against Aedes aegypti[33].

Sub acute toxicity studies

Nikkon et al reported the sub acute toxicity studies in chloroform fraction from ethanol extract of *Tagetes erecta* flower by solvent-solvent partitioning method. The sub acute toxicity of chloroform fraction was evaluated on Long Evan's rats at 200 and 400 mg/kg doses and the results obtained from chloroform fraction treated rats were compared with untreated controls. Treatment of chloroform fraction at 200 and 400 mg/kg doses did not make any significant alterations on the hematological and biochemical parameters of rats when data were compared with that of untreated controls. Histopathological examination also showed no detectable changes in liver, kidney, heart and lung of chloroform fraction treated rats. This study revealed that the chloroform fraction of *Tagetes erecta* had no toxic effects[34].structure of leutin is given below

***Tagetes* species for Nematode Management**

Microscopic in size, unsegmented roundworms, the main characerstics of Nematodes. Mostly found in terrestrial habitats. There are many different kinds of nematodes are found. They may be free-living, a term applied to nematodes that feed on fungi, bacteria, nematodes, or other microscopic organisms. Nematodes that feed on plants are called plant-parasitic nematodes. Plant-parasitic nematodes can seriously damage or even kill crops, turf, and ornamental plants. Plant-parasitic nematodes are difficult to control because they live underground or inside of plants. While some nematicides are available for use in commercial agriculture, there are no nematicides available for home gardners. One of the most damaging groups of plant-parasitic nematodes is the root-knot nematodes (*Meloidogyne* spp.). It may attack on a broad range of vegetable, fruit, and ornamental crops causing swellings or galls on the roots. If there is a severe infestation

of root-knot nematodes, the plant may be stunted, wilt, or die. A plant that is already weakened can easily become infected with bacteria or fungi as well. Once a plant is infected by nematodes, treatment options are very limited. Therefore, most nematode management strategies are pre-plant treatments. One such treatment is the planting of cover crops that can reduce nematode populations. A cover crop is a crop that is grown before the main cash crop is planted. This practice is used to either avoid soil erosion caused by fallowing land, or to reduce a pest that cannot reproduce on the cover crop for various reasons. Some cover crops release substances that are able to suppress other organisms. This is called allelopathy. *Tagetes* species, which is a popular bedding plant, can be used as such a cover crop. *Tagetes* species produces a substance called alpha-terthienyl, which can aid in the reduction of root-knot nematodes and other disease promoting organisms, such as fungi, bacteria, insects, and some viruses[35, 36]. African (*T. erecta*) and French marigolds (*T. patula*) are the most commonly used species of these plants. Each consists of varieties that differ in characteristics such as bloom size, shape, and color, as well as plant size and leaf shape.

Nematode Suppression

While they can be beneficial against a variety of pests, *Tagetes* species are best known for their ability to suppress plant-parasitic nematodes. In India, *Tagetes* species have been used for this purpose for hundreds of years[37], *Tagetes* can suppress 14 genera of plant-parasitic nematodes, with lesion nematodes (*Pratylenchus* spp.) and root-knot nematodes (*Meloidogyne* spp.) the most affected 38. Different varieties of *Tagetes* vary in their ability to suppress nematodes. In addition, nematode supression is influenced by crop plants, nematode species, and soil temperature.It was investigated the effects of 29 varieties of *Tagetes* on nematode populations. Although variation was pragmatic, *Tagetes* species had an overall suppressive effect on nematodes[39-40].

Mode of Action (Host Status)

Each species of nematode has certain plants it can feed and reproduce on and others it cannot. The ability of a plant to support reproduction of nematodes is referred to as host status. If a particular species of nematode is unable to reproduce on a crop, the nematode numbers will turn down as nematodes die. A susceptible plant is one on which the nematode population will increase. A resistant plant is one on which the nematode population will decrease. An intermediate plant is one on which the nematode population will remain stable or be capricious. A summary of the susceptibility of the various *Tagetes* species or varieties to different types of plant-parasitic nematodes are found. Susceptibility of *Tagetes* varieties to three species of root-knot nematodes those are common in Florida. Susceptibility of *Tagetes* depends on the *Tagetes* species and variety or cultivar, as well as the species of nematode. Varieties designated "resistant" could be used as cover crops to suppress that nematode. Varieties designated "susceptible" can increase population levels of the nematode and actually make the problem worse. It is probably safest to avoid varieties termed "intermediate" in their response, since these can be unpredictable. *Meloidogyne incognita* is a common and widely distributed species of root-knot nematode in Florida. However, additional species of root-knot nematodes are being discovered, which may be able to infect *Tagetes* species cultivars listed as resistant to other root-knot nematodes species. *Tagetes* species may be resistant to some nematode species but may be very susceptible to others. The lesion nematode (*Pratylenchus* spp.) is a problem is regions like Europe and other countries, but in Florida it is not considered to be a nematode of major concern and probably does not require management. However, French marigold cultivars (*T. patula*) appear to be most effective against the widest range of nematodes[41-47].

Allelopathic Effect

Allelopathy is the ability of an organism to produce chemicals that are toxic to other organisms. *Tagetes* species roots release the chemical alpha-terthienyl, one of the most toxic naturally occurring compounds found to date[48] (Gommers and Bakker, 1988). This compound is nematicidal, insecticidal, antiviral, and cytotoxic[49, 50].The presence of alpha-terthienyl inhibits the hatching of nematode eggs[51]. However if in a field setting, it is unclear if *Tagetes* producing alpha-terthienyl inhibit development because of the alpha-terthienyl itself or because *Tagetes* species are a non-host for certain nematodes. Nematodes may not feed or develop on non-host plants even when they do not contain allelopathic compounds. Furthermore, *Meloidogyne* spp. juveniles were unable to fully develop in the roots of *T. erecta*[52].

Planting Tips

Tagetes species is a summer crop in most of the United States, but can be grown year-round in parts of Florida. *Tagetes* can be grown ahead of time as a cover crop to suppress nematodes before planting a susceptible crop such as a vegetable crop. It also is a good choice to plant in ornamental planting beds where root-knot nematodes are a problem on other annuals. In order to be an effective cover crop in nematode management, *Tagetes* species should be planted at least two months before the desired vegetable crop. Furthermore, it must be planted at the same site in which the vegetable crop will be planted (see "Considerations" section below) otherwise no benefits can be gained from marigold root exudates. *Tagetes* species can be disked or hoed into the soil in the fashion of a green manure to prepare the field for planting of the actual crop. Providing proper nutrition and improved soil conditions can increase crop tolerance to nematodes. Follow the fertility and growing recommendations for marigold suggested by your County Cooperative Extension Office to ensure a healthy crop. Planting should be dense to ensure the best nematode control. It was suggested that the limiting the row spacing and spacing between individual plants to less than 7 inches to help prevent weeds. This is very important, since nematodes can reproduce on weeds and thereby nullify the effects of marigold[53]. This spacing may be practical if *Tagetes* species transplants are used. If *Tagetes* species are direct-seeded in Florida, much higher seeding densities may be needed to obtain a dense stand. *Tagetes* species cannot eradicate nematodes. In order for *Tagetes* to have a continuous effect on nematode populations it must be grown every season before the actual crop is planted[54], because nematode populations will increase over time in the presence of susceptible crops like most vegetables and bedding plants[55]. Intercropping *Tagetes* species with other crops to reduce plant-parasitic nematodes does not appear to be effective. It was showed that *Tagetes* species intercropped with cucurbit was less productive than cucurbit monoculture and no effect on plant-parasitic nematodes was observed[56]. On the other hand, It was also showed that *Tagetes* species used as an intercrop was effective in reducing *M. incognita* (Southern root-knot nematode). However, it should be pointed out that

this experiment was conducted in pots, where root-knot severity might have been reduced because of soil dilution and a decreased density of host plants available for nematode reproduction[57].

Considerations

All *Tagetes* varieties can not control all types of nematodes. For example, Cracker Jack marigold may show good control of the southern root-knot nematode, but is a host for other nematodes such as stubby-root and reniform nematodes. Other nematodes that can increase on *Tagetes* species are sting and awl nematodes[58] (Rhoades 1980). Therefore, growers should determine which marigold variety to use based on nematodes present in the field. Knowledge of nematodes present within a field can be obtained by sending soil samples from that field to a nematode assay laboratory. Furthermore, populations of the same species can vary in their aggressiveness in different locations[59]. Therefore it is important to verify the effect of *Tagetes* species on local nematode populations before attempting management on a large scale. In addition, although marigolds may suppress nematode numbers, they might not be able to reduce severe infestations sufficiently, which will limit the success of the next cash crop[60]. Therefore it is important to determine nematode population numbers before planting *Tagetes* species. Research has shown that the nematicidal compound (alpha-tertheinyl) is only released by active, living *Tagetes* roots, because exposure to near-UV light inactivates alpha-tertheinyl when taken out of the soil. Thus there is no benefit in amending a planting site with *Tagetes* extracts of homogenized plant parts[61].

CONCLUSION

Tagetes species, which is a popular bedding plant, is used as such a cover crop. *Tagetes* species produces a substance called alpha-terthienyl, which can aid in the reduction of root-knot nematodes and other disease promoting organisms, such as fungi, bacteria, insects, and some viruses. African (*T. erecta*) and French marigolds (*T. patula*) are the most commonly used species of these plants. Each consists of varieties that differ in characteristics such as bloom size, shape, and color, as well as plant size and leaf shape. It is most useful and important plant for the medicinal point of view. *Tagetes* species for Nematode Management is also reviewed.

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Source of support: Nil, Conflict of interest: None Declared