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Head lice prevalence in suburban Bangkok, Thailand, after the COVID-19 pandemic and herbal shampoo treatment

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Abstract The prevalence of pediculosis among 3,461 girls from 10 government kindergartens and primary schools in Ladkrabang district was 48.1% in the 1st semester (May- September 2022) and 44.6% in the 2nd semester (November 2022- March 2023), higher among primary school girls, at 51.8-55.4%, than in kindergarteners, at 30.2-33.1%. Over 80% of the infested girls came from a low-income family (<3,000 USD per year). The Zingiberaceae essential oil and shampoo treatments were highly effective with 100% cure rate for every infested girl after the 2nd treatment (on Day 10, after the 1st treatment on Day 1). Effective strategies for reducing head lice prevalence are improved living standards and head lice eradication by treatments with effective natural pediculicides and improved head lice educational program.

Keywords: Pediculosis, Head lice, Zingiberaceae

Introduction

Pediculus humanus capitis or head louse (plural: head lice) is a parasite from the Anoplura family that causes pediculosis. It is an ectoparasitic insect feeding exclusively two to six times per day on human blood from the scalp, behind the ears, and the back of the neck, causing discomfort, scalp itching and inflammation, scalp lesions, skin disorders, skin diseases, loss of sleep, absence from school, lymphadenopathy, chronic anemia, eosinophilia, psychological distress, and social problems (Meis and Ochsendorf, 2016; Coscione *et al*., 2017; Cummings *et al*., 2018; Alsaady *et al*., 2023). An outbreak of head lice mainly occurs in kindergartens or primary schools with children 5-13 years of age (Meis and Ochsendorf, 2016; Soleiman-Ahmad *et al*., 2017; Leung *et al*., 2021; Jabeen *et al.,* 2024). Significant factors associated with high head lice infestation rate were poor hygiene conditions, extreme poverty, low socio-economic status, and

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inadequate health education program (Woodruff and Chang, 2019; Dagne *et al*., 2020). Moreover, most Thai schoolgirls infested with pediculosis use topical chemical pediculicides to control head lice. Permethrin was the first-line treatment of choice for pediculosis, but it was neurotoxic to humans. Moreover, the increase of recurrent cases and treatment failure of pediculosis raised public health concerns about the growing resistance of permethrin among head lice populations (Brownell *et al.*, 2020). For this reason, many reseachers suggested non-neurotoxic topical agents for head lice treatment such as plant-based topical agents or plant essential oils like citronella oil, clove oil, eucalyptus oil, spearmint oil, and essential oils from Zingiberaceae plants (Iwamatsu *et al*., 2016; Gutiérrez *et al*., 2016; Sittichok and Soonwera, 2018; Sittichok *et al*., 2018a,b; Soonwera *et al*., 2018).

Before the COVID-19 pandemic, a high prevalence rate of head lice infestation was more than 40% such as 67.3% in Southeast Iran (Soleiman-Ahmad *et al.*, 2017) followed by Northwest Ethiopia = 65.7% (Dagne *et al.*, 2019) Kuwait = 50.4% (Henedi *et al.*, 2019) Cambodia = 43.3% (Liao *et al.*, 2019) and Sri Lanka = 42.0% (Gunathilaka *et al*., 2019). However, during the COVID-19 pandemic, many reports showed the prevalence rate of head lice infestation decreased significantly (Galassi *et al*., 2021; Mumcuoglu *et al*., 2022; Padzik *et al*., 2023) because the children were absence from school.

In Thailand, head lice infestation among girls before the COVID-19 pandemic was over 50%, particularly for children from low-income families (Yingklang *et al*., 2018). The main objective of the present study was to determine head lice infestation among kindergarteners and primary school girls in selected government schools in Ladkrabang district, Bangkok, Thailand, after the COVID-19 pandemic. Another objective was to investigate the insecticidal effect of Zingiberaceae essential oil and Zingiberaceae shampoo for head lice treatment. The findings from this study could be beneficially suggestive and helpful to schoolgirls and their families for prevention and safe eradication of head lice.

Materials and methods

Study area

This study was carried out during the periods of May 2022 to September 2022 (the 1st semester in a rainy season) and November 2022 to March 2023 (the 2nd semester in a winter season) at several government kindergartens and primary schools in Ladkrabang district, suburban Bangkok, Thailand. Ladkrabang district was an agricultural area along the perimeter of Bangkok. Ten schools out of

twenty-four government kindergartens and primary schools were selected based on cluster sampling and sample randomization. Large government schools with more than 100 children (5-6 years old) or primary schoolgirls (7-12 years old) were selected.

Plant essential oils and herbal shampoo

Curcuma zedoaria (Zedoary) and *Zingiber cassumunar* (Cassumunar ginger), belongs to Zingiberaceae family. Rhizomes of *Curcuma zedoaria* and *Zingiber cassumunar* were collected from Chumporn province, Thailand. Rhizomes of Zingiberaceae plants were cleaned, cut into small pieces and divided into two parts. One part of Zingiberaceae plants were put in a 5 L flask. Sterile water was added at a ratio of 1:2 (w/v) and the plant materials were extracted for essential oils (EOs) by a water distillation method. Another part of Zingiberaceae plants were crude extracted by maceration method. The plant materials were soaked in 500 mL of 70% ethanol for 7 consecutive days at ambient temperature in dark conditions. The herbal shampoo was provided by Medicinal Plant Laboratory, Faculty of Agricultural Technology, KMITL. The formulation of plant essential oils and herbal shampoo are shown in Table 1 and Figure 1.

Data collection

A total of 3,461 schoolgirls (aged 5-12 years old) made up of 1,114 kindergarten girls (aged 5-6 years old) and 2,317 primary schoolgirls (aged 7-12 years old) from ten kindergartens and primary schools in Ladkrabang district, Bangkok, Thailand, were examined for *Pediculus humanus capitis* (head lice). Head lice infestation was identified by KMITL researchers using a fine-tooth brush to comb the hair of each girl for 1 min. The girls whose hair had at least one live head louse (nymph or adult) or live egg were identified as having head lice infestation (Rassami and Soonwera, 2012). Movements of head, thorax, abdomen, or internal structure of a louse under a stereomicroscope (NIKON®, Type 102) indicated that it was a live head louse. An egg with a complete operculum and eye spots observed under a stereomicroscope was identified as a live egg (Moshki *et al*., 2019). The income per year of the family of every girl was obtained from an interview with their parents who would respond to a query about their family income whether it was less or more than 3,000 USD per year. All infested girls received one bottle of 50 ml Zingiberaceae essential oil and one bottle of 50 ml of Zingiberaceae shampoo for head lice treatment. The head lice treatment was two steps. In the 1st step, all infested girl rubbed 25 ml of

Zingiberaceae essential oil on their dry scalp for 5 min and then rinsed it off with clean water and combed their hair with a fine-tooth brush. The 2nd step started by all infested girl rubbing 25 ml of Zingiberaceae shampoo on their wet scalp for 5 min and then rinsed it off with clean water and combed their hair with a fine-tooth brush. The cure rate was recorded on day 2 and 10 after the treatment, as detailed in Figure 2. A cure was defined as a complete absence of live head lice at any developing stages.

Table 1. List of formulations of Zingiberaceae essential oil and shampoo for head lice control

Treatment	Formulation
Zingiberaceae EO	5% EO from *Curcuma zedoaria* rhizomes + 5% EO from *Zingiber cassumunar* rhizomes + 90% Soybean oil
Zingiberaceae shampoo	5% crude extract from *Curcuma zedoaria* rhizomes + 5% crude extract from *Zingiber cassumunar* rhizomes + 1% Sodium lauryl sulfate + 89% Distilled water

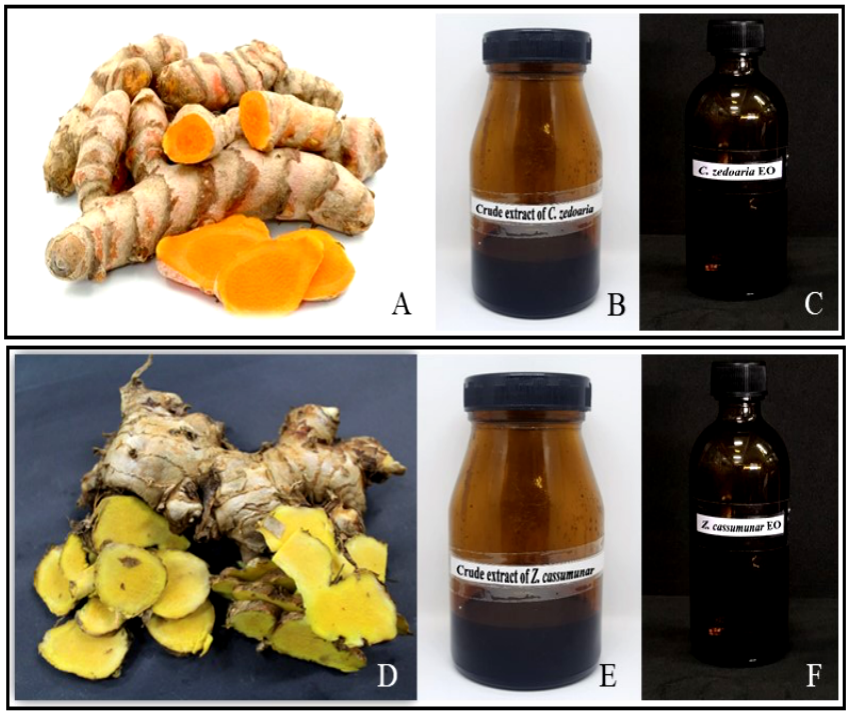

Figure 1. *Curcuma zedoaria* rhizomes (A), crude extract of *C. zedoaria* (B), *C. zedoaria* EO (C), *Zingiber cassumunar* rhizomes (D), crude extract of *Z. cassumunar* (E) and *Z. cassumunar* EO (F)

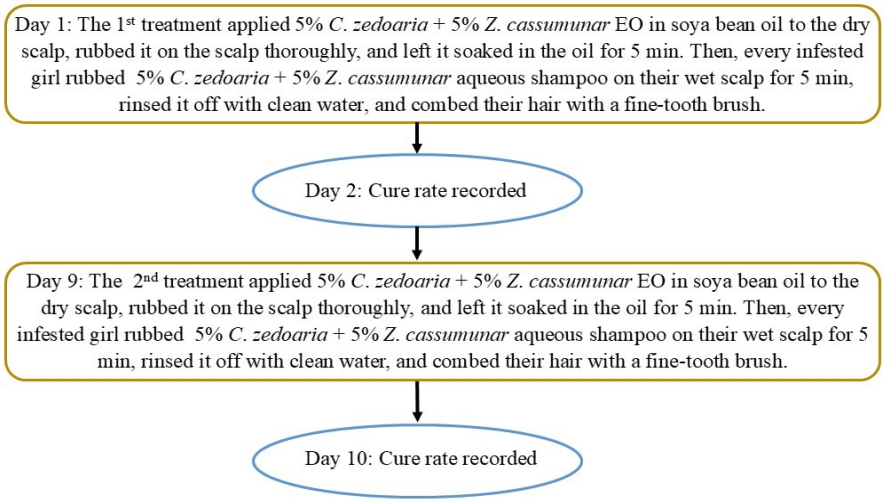

Figure 2. Head lice treatment program for lice-infested girls

Statistical analysis

Descriptive statistics were reported: frequency, means, and percentages. Data analysis was performed by using SPSS version 26.

Ethical approval

The conduct of this research was approved by the Institute for the Development of Human Research Protections (IHRP) Ethics Committee, Department of Medical Sciences Ministry of Public Health, Nonthaburi, Thailand (IHRP-76-2558). Prior to screening the subjects for this study, the researchers obtained consent from every kindergartener and primary school girl and their parents.

Results

As mentioned, 3,461 schoolgirls were examined for head lice infestation in the 1st semester of academic year 2022 (May-September 2022) and the 2nd semester (November 2022 - March 2023). The prevalence rate of head lice infestation among different age groups of kindergarten and primary school girls is shown in Table 2. The infestation rate in the 1st semester of those age groups varied from 32.4% to 66.7%, and in the 2nd semester, from 29.6% to 65.5%. For the 1st semester, the highest infestation rate was 66.7% in the 7-year-old age group. The lowest infestation rate was 32.4% in the 6-year-old age group. For other age groups, the prevalence rates were 61.7% (8-year-old), 58.3% (9-year-

old), 50.0% (10-year-old), 46.4% (12-year-old), 45.5% (11-year-old), and 33.8% (5-year-old). The infestation rates for the 2nd semester follow the same trend to those in the 1st semester. The 7-year-old age group also showed the highest infestation rate of 65.5%, while the 5-year-old age group showed the lowest infestation rate of 29.6%. The prevalence rates for other age groups were 59.2 % (8-year-old), 54.2% (9-year-old), 43.4% (10-year-old), 41.9% (12-year-old), 41.8% (11-year-old), and 30.8% (6-year-old).

The family incomes of infested girls are summarized in Table 3. In detail, 86.3% of the infested kindergarten and primary school girls in the 1st semester had a family income of less than 3,000 USD per year, while 92.9% of the infested girls in the 2nd semester had that kind of family income. Similarly, 78.9% to 79.0% of the infested kindergarten girl group in the 1st semester had a family income of less than 3,000 USD per year. The poverty condition of the families of the group of infested primary school girls was the worst; more than 85.0% of them were low-income families that earned less than 3,000 USD per year. Categorizing according to their age, more than 90% of the families of the infested 7, 8, and 9-year-old age groups in the 1st semester earned less than 3,000 USD. For the infested kindergarten girls in the 2nd semester, 78.8% to 90.3% of their families had an income per year of less than 3,000 USD, and more than 82.0% of the infested primary school girls had that kind of low income per year. More distinctively, 100% of the families of the 10-year-old age group earned less than 3,000 USD per year.

Table 2. Prevalence rate of pediculosis among different age groups of kindergarten and primary schoolgirls in Ladkrabang district, Bangkok

Student	**The 1st semester**		**The 2nd semester**	
(n=3,461)	**% (Positive)**	**% (Negative)**	**% (Positive)**	**% (Negative)**
Kindergarten girls				
5-year-old	33.8 (200/592)	66.2 (392/592)	29.6 (175/592)	70.4 (417/592)
6-year-old	32.4 (179/552)	67.6 (373/552)	30.8 (170/552)	69.2 (382/552)
mean	33.1 (379/1,144)	66.9 (765/1,144)	30.2 (345/1,144)	69.8 (799/1,144)
Primary schoolgirls				
7-year-old	66.7 (280/420)	33.3 (140/420)	65.5 (275/420)	34.5 (145/420)
8-year-old	61.5 (240/390)	38.5 (150/390)	59.2 (231/390)	40.8 (159/390)
9-year-old	58.3 (266/456)	41.7 (190/456)	54.2 (247/456)	45.8 (209/456)
10-year-old	50.0 (185/370)	50.0 (185/370)	43.8 (162/370)	56.2 (208/370)
11-year-old	45.5 (150/330)	54.5 (180/330)	41.8 (138/330)	58.2 (192/330)
12-year-old	46.4 (163/351)	53.6 (188/351)	41.9 (147/351)	58.1 (204/351)
mean	55.4 (1,284/2,317)	44.6 (1,033/2,317)	51.8 (1,200/2,317)	48.2 (1,117/2,317)
Total	48.1 (1,663/3,461)	51.9 (1,798/3,461)	44.6 (1,545/3,461)	55.4 (1,916/3,461)

Table 3. Family income of infested kindergarten and primary school girls in Ladkrabang district, Bangkok

Student (n=3,461)	Family income per year			
	The 1st semester		The 2nd semester	
	% (< 3,000 USD)	% (> 3,000 USD)	% (< 3,000 USD)	% (> 3,000 USD)
Kindergarten girls				
5-year-old	79.0 (158/200)	21.0 (42/200)	90.3 (158/175)	9.7 (17/175)
6-year-old	78.8 (141/179)	21.2 (38/179)	78.8 (141/170)	17.1 (29/170)
Primary schoolgirls				
7-year-old	91.4 (256/280)	8.6 (24/280)	93.1 (256/275)	6.9 (19/275)
8-year-old	92.9 (223/240)	7.1 (17/240)	96.5 (223/231)	3.5 (8/231)
9-year-old	91.5 (226/247)	8.5 (21/247)	91.5 (226/247)	8.5 (21/247)
10-year-old	87.6 (162/185)	12.4 (23/185)	100 (162/162)	0 (0/162)
11-year-old	85.3 (128/150)	14.7 (22/150)	82.8 (128/138)	7.2 (10/138)
12-year-old	86.5 (141/163)	13.5 (22/163)	95.9 (141/147)	4.1 (6/147)
Total	86.3 (1,435/1,663)	13.7 (228/1,663)	92.9 (1,435/1,545)	7.1 (110/1,545)

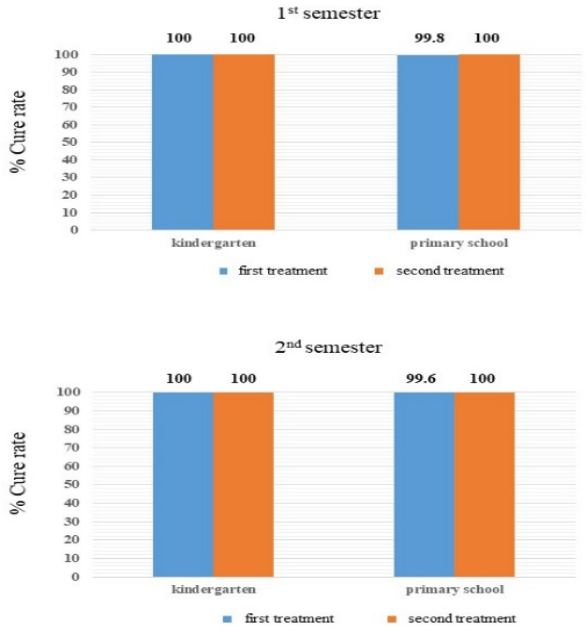

Figure 3. Percentage cure rates after the 1st and 2nd Zingiberaceae treatment in the 1st and 2nd semesters of academic year 2022

The results of head lice treatment with Zingiberaceae essential oil and Zingiberaceae shampoo on the infested girls are presented in Figure 3. For

infested kindergarten girls, the Zingiberaceae essential oil and shampoo were highly effective, providing 100% cure rate after the treatments in the 1st and 2nd semesters. Almost identically, the results for the infested primary school girls showed that the treatments were highly effective at almost 100% (99.6% to 99.8% cure rate) after the 1st treatment in both semesters and 100% after the 2nd treatment.

Discussion

Globally, *Pediculus humanus capitis* infestation is a severe public health problem for girls 5-12 years of age. Most infested girls live under a poor hygienic condition in low-income areas of the country (Gunathilaka *et al*., 2019; Moshki *et al*., 2019; Leung *et al*., 2021). On May 2022, Thai government announced that the students should return to onsite classes after the COVID-19 pandemic. Our results revealed that the prevalence rates of head lice infestation among kindergarten and primary school girls were 33.1, 55.4% in the 1st semester (May-September 2022) and 30.2, 51.8% in the 2nd semester (November 2022-March 2023). This result was a lower prevalence of head lice infestation during the COVID-19 lockdown in Pathum Thani Province, Thailand at 68.7% (Kitvatanachai *et al*., 2023). The prevalence rate of head lice infestation during May to September, a rainy season, was higher than during November to March probably because the girls were staying inside the house most of the time and they might have frequent, close head-to-head contact, or share some personal articles (towel, comb, brush, and shower cap) with other people and when Thai students go back to school in May, some of them may be infested with lice from their siblings and parents. Thus, the lice are likely to spread out to their classmates. This result showed that the outbreak of COVID-19 did not reduce the lice problem when the situation returned to normal.

Transmission of pediculosis occurs by direct contact. The main form of transmission of this disease is through direct head-to-head contact. Many researchers reported several factors associated with a high level of head lice infestation. Temperature, humidity, and odor may influence transmission (Valero *et al*., 2024). Additionally, the climate, geographical environment, health conditions, income, and family size are important factors affecting the prevalence of head lice (Adham *et al*., 2020). For instance, most infested girls came from a low living-standard house and lived under a poor hygienic condition (small house with over-crowed members; many members living in the same room; lack of bathing facilities in the house), widespread sharing of towel, cloth, or some personal articles, low frequency of hair and clothes washing, and frequent contact with infected person (Soleiman-Ahmad *et al*., 2017; Gunathilaka *et al*., 2019).

The highest prevalence rate in this study was 66.1-60.4% in the 7-to-8-year-old girl group. These results are fully supported by reports from other researchers (Kitvatanachai *et al*., 2023; Liao *et al*., 2019). A high infestation rate of 82.4% was reported in 7-to-10-year-old group of primary school girls in Pathum Thani, Thailand (Kitvatanachai *et al*., 2023), 76.4 to 81.4% in a 9-to-10-year-old group of primary school girls in southeast Iran (Soleiman-Ahmad *et al*., 2017), 57.1 to 58.8% in a 7-to-8-year-old group of schoolchildren in Battambang, Cambodia (Liao *et al*. , 2019), 57.2% in a 9-to-11-year-old group of schoolchildren in Woreta town, northwest Ethiopia (Dagne *et al*., 2019), and 51.8% in a 9.5-to-10.5-year-old group of kindergarten and primary school children in Kuwait (Henedi *et al*., 2019). Girls in the age group of 7-10 years get into more close physical contact during their playing with infested siblings and mother as well as sharing some personal articles with family members or classmates, increasing the chance of direct, close contact, and thus this girl group usually had a high prevalence rate (Nategh *et al*., 2018).

One of Thailand's government policies regarding the poverty of the people states that a family is considered to be in poverty if its income is less than 3,000 USD per year. Our results showed 86.3 to 92.2% of the infested girls came from a family with a low-income of less than 3,000 USD per year. Therefore, almost all of the infested girls were living in a poor family with a poor living standard. Most of their parents were farmers in Ladkrabang district, suburban Bangkok, Thailand. The results were similar to many results reported from Southeast Iran (Soleiman-Ahmad *et al.*, 2017), northwest Ethiopia (Dagne *et al.*, 2019), Kuwait (Henedi *et al*., 2019), rural Honduras (Jamani *et al*., 2019), western Sri Lanka (Gunathilaka *et al*., 2019). More importantly, many researchers reported that the infestation rate decreased with better living standard, hygiene, health, and educational program for infested girls (Yingklang *et al*., 2018).

Regarding head lice treatment, the Zingiberaceae essential oil and Zingiberaceae shampoo were highly effective as demonstrated by the 100% cure rate for all infested girls after the 2nd treatment in both the 1st and 2nd semesters. None of the examined girls reported any side effects (such as headache, fever, vomit, squeamish, red spot, irritation of the scalp, and scalp wound) after the head lice treatment. These results are supported by the findings by other researchers and one of our previous studies which reported the high efficacy of some plant essential oils and herbal shampoos for head lice treatment (Gutiérrez *et al*., 2016; Sittichok and Soonwera, 2018; Sittichok *et al*., 2018a,b). Generally, constituents of *C. zedoaria* and *Z. cassumunar* contains various compounds such as curcuminoids, sesquiterpenoids, terpenes and terpenoids. Many papers have pointed that terpenes and terpenoids caused mortality of insects by inhibiting the activity of acetylcholinesterase enzyme in the nervous system of insects (El-

Wakeil, 2013). Other researchers reported that the cuticle of a head lice egg is hydrophobic, hence Zingiberaceae essential oil can penetrate through the cuticle of a head lice egg and block the aeropyles of the egg, causing the egg not to hatch and die. In addition, even though the cuticles of nymph and adult head lice are hydrophilic, the Zingiberaceae shampoo was an aqueous formulation that can penetrate through them, causing damages to their respiratory system, circulatory system, and nervous system and causing mortality of both stages of head lice (Akkad *et al*., 2016; Soonwera *et al*., 2018). Thus, the combination of Zingiberaceae essential oil and Zingiberaceae shampoo treatments was the best alternative to chemical pediculocides for head lice treatment. On top of that, the treatments are inexpensive and safe for infested girls that came from a low-income family.

This study concludes that head louse (*P. humanus capitis*) infestation is a serious problem, and there was a high prevalence rate among Thai girls 5-12 years of age in Ladkrabang district, Bangkok, Thailand. The best strategy for reducing the prevalence rate was to improve their living standard, promote a health education program, and enact an eradication program with native plant products like Zingiberaceae plants (*Curcuma zedoaria* and *Zingiber cassumunar*) for girls and their parents. These programs should be led by the hygiene teachers in the school.

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Conflicts of interest

The authors declare no conflict of interest.

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