



## Comparative Assessment of Weed Control Methods and Their Impact on Rice Yield in Eastern Terai, Nepal

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### ABSTRACT

Rice (*Oryza sativa* L.) is the most important cereal crop in Nepal, but its production is greatly challenged by weed infestation. Weed infestation is one of the major constraints to rice productivity in South Asia, including Nepal. This study evaluated the comparative performance of chemical and mechanical weed control methods in rice cultivation in Kamal area of Jhapa district, Eastern Terai, Nepal. A field-based socio-economic survey was conducted during the 2018 rice growing season using simple random sampling. A total of 37 rice-growing households were selected, and data were collected through household surveys, interviews, and focus group discussions. Data were analyzed using descriptive statistics including frequency and percentage analysis. Results showed that chemical weed control was the dominant method adopted by farmers, mainly due to labor scarcity and ease of application. Major weeds identified included *Cyperus rotundus*, *Fimbristylis miliacea*, *Monochoria vaginalis*, and *Echinochloa colona*. The average cost of cultivation was lower under chemical weed control (Rs 1968 kattha<sup>-1</sup>) compared to mechanical weed control (Rs 2218 kattha<sup>-1</sup>). However, average yield and gross return were similar under both methods (1.4 Qt kattha<sup>-1</sup> and Rs 3150 kattha<sup>-1</sup>, respectively). The benefit-cost ratio was higher for chemical weed control (1.6) compared to mechanical control (1.4). The findings indicate that chemical weed control currently provides higher economic efficiency under local farming conditions. However, long-term sustainability, environmental safety, and integrated weed management approaches should be emphasized. This study provides baseline information for extension programs and policy interventions aimed at improving rice productivity and profitability in Eastern Nepal.

**Keywords:** Rice, Weed management, Weed intensity, Benefit–cost ratio, Nepal

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## INTRODUCTION

Rice is the primary staple and a major contributor to food security and agricultural GDP in Nepal, cultivated across diverse agro-ecological zones from the lowland Terai (59 m asl) to high-altitude Jumla (3050 m asl) (Paudel 2013). Rice is number one staple crop in Nepal and it contributes livelihoods of majority of people in Nepal. Nepal Agricultural Research Council (NARC) has been playing a significant role to improve the rice productivity in the country (Shrestha et al 2021). Rice production in Nepal is constrained by many biotic factors, particularly weed infestation, which reduces rice yield by 20–40% if unmanaged (De Datta and Baltazar 1996).

Weed infestation being one of the most important cause rice yield to frequently fall short of its potential. Ineffective management of weeds can result in large yield losses because they compete with rice for light, nutrients, and water. A range of weed control techniques, such as mechanical, chemical, and integrated methods, have been used to reduce yield losses. Chemical herbicides are frequently employed because of their effectiveness and labour-saving benefits, but issues with cost, herbicide resistance, and environmental safety continue to exist. Different types of herbicides have been used in rice to control weeds. Pendimethalin is the effective and economically feasible option for weeds management in dry direct seeded rice (Bhurer et al 2013). Although chemical uses are time-consuming and labour-intensive, mechanical techniques like mechanical tillage and hand weeding are safe for the environment. A sustainable strategy to balance effectiveness, cost, and environmental impact is integrated weed management, which combines mechanical and chemical methods. Several studies related to different weed management practices in rice have been carried out by previous researchers (Dangol et al 2020, Antralina et al 2015, Manisankar et al 2022, Duary et al 2021, Parameswari and Srinivas 2017).

Furthermore, socioeconomic factors like labor availability, input affordability, farmer knowledge, risk perception, and access to extension services and agro-input markets have a significant impact on the adoption of weed management technology. Designing focused extension interventions and policy frameworks that support

environmentally responsible, economically feasible, and sustainable weed management in rice-based production systems requires a deeper comprehension of how these factors influence farmers' management decisions. The study is limited by small sample size and short-term observation, which potentially mask yield variability or long-term effects. Larger sample sizes and longitudinal designs over time should be used to assess integrated weed management approaches that optimize profitability while also reducing the ecological footprint. This study aimed to evaluate the adoption, effectiveness, cost, yield, and profitability of chemical versus mechanical weed control methods in rice cultivation.

## METHODOLOGY

### Study Area

The study was conducted in five wards of Kamal, Jhapa district (Eastern Terai), Nepal, covering 1,606 km<sup>2</sup> with a population of 812,650 (2011 Census). The region has a humid subtropical climate with high rainfall during the monsoon (June–September).

### Weed management practices

Farmers used combined, chemical, and manual weed management methods. Environmentally viable but labor-intensive manual control methods included hand weeding or basic mechanical instruments (such as hoes and cono weeders). Chemical control made use of pre- and post-emergence herbicides, and farmer knowledge, availability, and cost all had an impact on acceptance. Adaptive tactics depending on labor availability, economic capacity, and input access were reflected in mixed techniques, which coupled partial herbicide spraying with delayed hand weeding.

**Sampling and Data Collection:** A total of 37 rice-growing households were selected using simple random sampling. Data were collected through household surveys and semi-structured questionnaires, Key informant interview and focus group discussions

Data included socio-demography, seed sources, weed infestation, control methods, labor and input costs, yield, and gross income. Secondary data were collected from government and institutional reports.

### Data Analysis

were analyzed using descriptive statistics (frequency, percentage, mean, and range) using SPSS v26. Benefit–cost (B/C) ratios were calculated as:

$B/C \text{ ratio} = \text{Gross Return (Rs)} / \text{Total Cost of Production (Rs)}$ .

A B/C ratio >1 indicated profitability, while <1 reflected economic loss.

## RESULTS

### Socio-demographic Characteristics

The socio-demographic characteristics of the respondents revealed that rice cultivation in the study area is predominantly managed by male farmers, who constituted 62% of the total respondents, while female farmers accounted for 38%. Age distribution analysis indicated that the majority of farmers belonged to the middle to older age groups, with the highest proportion observed in the 55–60 years category, followed by the 35–55 years group. Very few farmers were found in the younger (25–35 years) and older (>60 years) age categories, suggesting that rice farming is largely practiced by experienced and economically active populations (Table 1).

**Table 1. Socio-demographic characteristics of rice-growing households (n = 37)**

Characteristics	Category	Frequency (n)	Percentage (%)	Cumulative (%)
Gender	Male	23	62.2	62.2
	Female	14	37.8	100
Age Group (years)	25–35	2	5.4	5.4
	35–55	15	40.5	45.9
	55–60	17	45.9	91.8
	Above 60	3	8.2	100
Education Level	Illiterate	15	40.5	40.5
	Primary	8	21.6	62.1
	Secondary	9	24.3	86.4
	Higher Secondary	6	16.2	102.6*
	University	1	2.7	105.3*

Source: Field Survey 2018

Regarding educational status, a considerable proportion of respondents were found to be illiterate (40.54%), followed by secondary level education (24.32%), primary education (21.62%), and higher secondary education (16.21%). Only a small percentage (2.7%) of farmers had attained university-level education (Table 1). Although most farmers were literate, limited access to extension services and technical training contributed to lower

knowledge levels regarding improved weed management practices in rice cultivation.

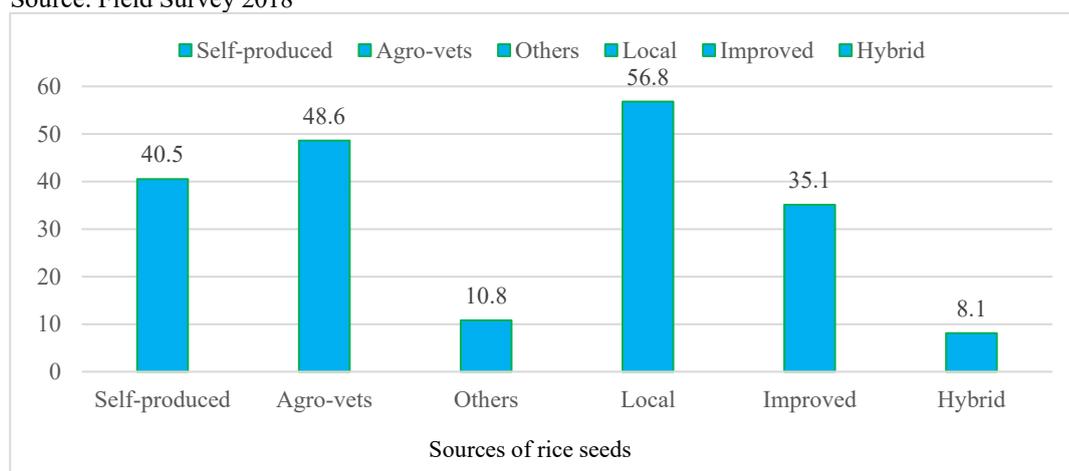
### Adoption and Usage Patterns of Rice Seeds

Seed is a critical input in rice cultivation, directly influencing crop yield, quality, and farmers' income. Understanding farmers' preferences for seed sources and types provides valuable insights for agricultural planning and extension services. The study revealed that farmers in Eastern Nepal obtain rice seeds from multiple sources. Among the respondents, 48.64% reported purchasing seeds from agro-vets, 40.54% produced seeds themselves, and 10.81% used seeds from other sources (Table 2, Fig.1). Regarding the type of seed mostly used, more than half of the farmers (56.75%) cultivated local varieties, followed by 35.13% using improved varieties, and only 8.10% adopting hybrid seeds (Table 2, Fig. 1). These results indicate that while improved seeds are gaining popularity, local varieties remain dominant due to their adaptability, familiarity, and availability within the farming community. The preference for self-produced seeds also highlights the reliance on traditional practices and the importance of accessible seed supply systems. Studying these patterns helps identify the adoption level of improved technologies and highlights areas where farmers may require support in accessing quality seeds. This study aimed to assess the sources and types of rice seeds most commonly used by farmers in the region, providing a foundation for improving seed distribution and adoption strategies.

**Table 2. Adoption and usage patterns of rice seeds (n = 37)**

Category	Type/Source	Frequency (n)	Percentage (%)	Cumulative (%)
Source of Seed	Self-produced	15	40.5	40.5
	Agro-vets	18	48.6	89.1
	Others	4	10.8	100
Mostly Used Seed	Local	21	56.8	56.8
	Improved	13	35.1	91.9
	Hybrid	3	8.1	100
Total Respondents	—	37	100	—

Source: Field Survey 2018



**Fig. 1. Adoption or use pattern of rice seeds derived from different sources by respondents**

### Weed Infestation and Management Practices

A survey conducted among 37 rice farmers in Eastern Nepal revealed that weed infestation varied across fields, with 25 farmers (67.56%) reporting dense weed growth and 12 farmers (32.43%) reporting light infestation (Table 3).

**Table 3. Weed infestation and management practices among rice-growing households (n = 37)**

Parameter	Method	Frequency (n)	Percentage (%)	Cumulative (%)
Weed Intensity	Dense	25	67.6	67.6
	Light	12	32.4	100
Weed Control Method	Chemical only	30	81.1	81.1
	Both Chemical & Mechanical	6	16.2	97.3
	Mechanical only	1	2.7	100
Total Respondents	—	37	100	—

Source: Field Survey 2018

When it came to weed management practices, chemical methods were the most widely adopted, with 30

farmers (80%) using herbicides due to their ease of application and the limited availability of labor during peak periods. A smaller proportion of farmers, 6 respondents (17%), employed a combination of chemical and mechanical methods, while only 1 farmer (3%) relied solely on mechanical control (Table 3). These results highlight the predominant use of chemical weed management and underscore the need to explore integrated approaches to ensure sustainable rice production.

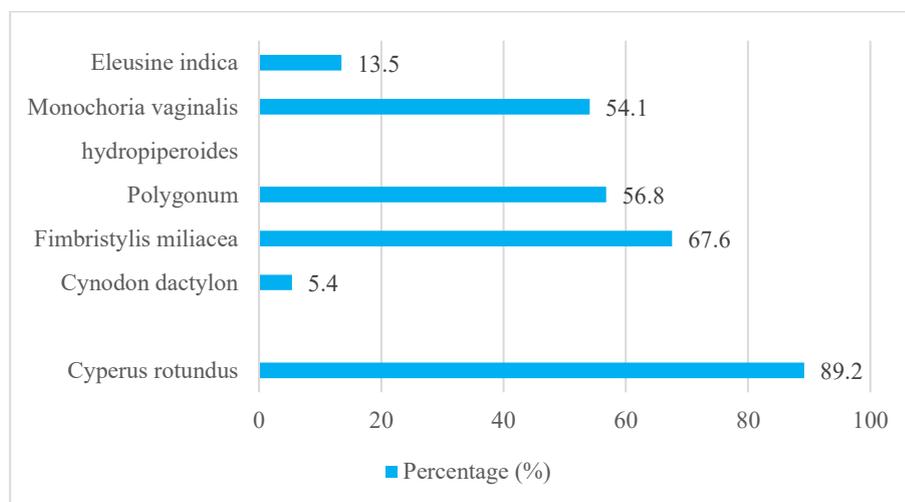
### Weed Flora and Weed Intensity

During the course of the study, an attempt was made to identify the major weed species present in rice fields of the study area based on farmers' responses. The results presented in Table 4 show that among the 37 respondents, 33 farmers (89.19%) identified mothe jhar (*Cyperus rotundus*) as the major weed in their rice fields, while only 2 respondents (5.41%) reported dubo (*Cynodon dactylon*) as a minor weed problem. Similarly, 25 respondents (67.57%) reported jwane (*Fimbristylis miliacea*) as a major weed problem, whereas pire jhar (*Polygonum hydropiperoides*) was reported by 21 respondents (56.76%). Karkale jhar was identified by 20 respondents (54.05%), and kode jhar was reported by 5 respondents (13.51%) in their rice fields (Table 4, Fig 2). Field observations further revealed that mothe jhar and sama jhar were the major weed problems in unirrigated areas, whereas karkale jhar showed higher dominance in irrigated rice fields. These findings indicate that weed composition and dominance varied depending on irrigation conditions in the study area.

**Table 4. Distribution of major weed species in rice fields based on farmers' responses (n = 37)**

S.N.	Local Name	Scientific Name	Frequency (n)	Percentage (%)	Field Condition / Remarks
1	Mothe jhar	<i>Cyperus rotundus</i>	33	89.2	Major weed; dominant in unirrigated areas
2	Dubo	<i>Cynodon dactylon</i>	2	5.4	Minor weed problem
3	Jwane	<i>Fimbristylis miliacea</i>	25	67.6	Major weed problem
4	Pire jhar	<i>Polygonum hydropiperoides</i>	21	56.8	Common weed problem
5	Karkale jhar	<i>Monochoria vaginalis</i>	20	54.1	Dominant in irrigated areas
6	Kode jhar	<i>Eleusine indica</i>	5	13.5	Less common weed

Source: Field Survey 2018



**Fig. 2. Percentage of occurrence of different weeds as reported by respondents**

### Cost of Cultivation

A comparative cost analysis of chemical and mechanical weed control methods in rice cultivation is presented in Table 5. The results indicate that the total cost of production was lower in the chemical weed control method (Rs. 1968 kattha<sup>-1</sup>) compared to the mechanical weed control method (Rs. 2218 kattha<sup>-1</sup>). The cost of land preparation, seed/sett, farmyard manure (FYM), fertilizer, and general labor remained similar under both methods. However, a significant difference was observed in herbicide and weeding labor costs, where the chemical method required only Rs. 50 kattha<sup>-1</sup> for herbicides, whereas the mechanical method required Rs. 300 kattha<sup>-1</sup> for manual weeding labor. The higher labor requirement in mechanical weed control contributed to the increased total cost of production. These findings suggest that chemical weed control is more cost-effective compared to mechanical weed control under the existing labor scarcity and farming conditions of the study area.

**Table 5. Comparative cost analysis of chemical and mechanical weed control methods in rice (Rs kattha<sup>-1</sup>)**

Particulars	Chemical Weed Control (Rs kattha <sup>-1</sup> )	Mechanical Weed Control (Rs kattha <sup>-1</sup> )	Difference (Mechanical – Chemical)
Land preparation	300	300	0
Sett	60	60	0
FYM cost	340	340	0
Fertilizer	318	318	0
Herbicides / Labor	50	300	250
Labor cost	900	900	0
Total Cost	1968	2218	250
Mean Cost per Item	328	369.7	41.7.
Range	50 – 900	60 – 900	0 – 250

Source: Field Survey 2018

**Average yield and Gross income**

The average yield and income obtained from rice cultivation under chemical and mechanical weed control methods are presented in Table 6. The findings indicate that both weed control methods produced similar yield levels, with an average yield of 1.4 Qt kattha<sup>-1</sup>, ranging from a minimum of 1.2 Qt to a maximum of 1.6 Qt kattha<sup>-1</sup>. Likewise, the average income generated from rice cultivation was found to be Rs. 3150 kattha<sup>-1</sup> under both chemical and mechanical weed management practices. This suggests that although the cost of weed control methods may differ, the yield and income outcomes remained comparable under the prevailing farming conditions of the study area. The data presented are based on the field survey conducted in 2018.

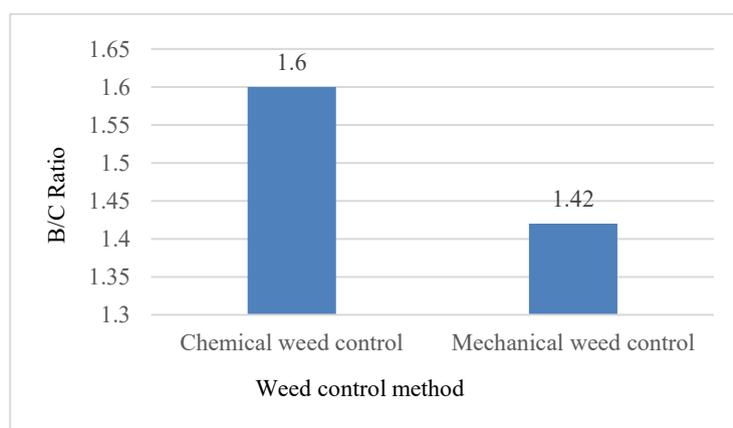
**Table 6. Average yield and income from rice under different weed control methods (n = 37)**

Method	Average Yield (Qt kattha <sup>-1</sup> )	Minimum Yield (Qt kattha <sup>-1</sup> )	Maximum Yield (Qt kattha <sup>-1</sup> )	Yield Range (Qt kattha <sup>-1</sup> )	Average Income (Rs kattha <sup>-1</sup> )	Income Difference (Rs)
Chemical weed control	1.4	1.2	1.6	0.4	3150	0
Mechanical weed control	1.4	1.2	1.6	0.4	3150	0

Source: Field Survey 2018

**Benefit Cost Ratio**

The benefit–cost (B/C) ratio of rice cultivation under different weed management methods is presented in Table 7. The results show that the chemical weed control method had a higher economic return compared to the mechanical method. The average cost incurred under the chemical method was Rs. 1968, with an average return of Rs. 3150, resulting in a B/C ratio of 1.6. In contrast, the mechanical weed control method involved a higher average production cost of Rs. 2218 kattha<sup>-1</sup>, while the average return remained the same at Rs. 3150 kattha<sup>-1</sup>, leading to a comparatively lower B/C ratio of 1.4. These findings indicate that the chemical weed control method was more economically efficient than the mechanical method under the conditions of the study area. The data were obtained from the field survey conducted in 2018.

**Fig. 3. Benefit cost ratio of different weed control method as reported by respondents.**

**Table 7. Benefit–Cost (B/C) ratio of rice under different weed control methods (n = 37)**

Method	Average Cost Incurred (Rs kattha <sup>-1</sup> )	Average Return (Rs kattha <sup>-1</sup> )	B/C Ratio	Cost Difference (Rs)	Return Difference (Rs)	B/C Difference
Chemical	1968	3150	1.60	–	–	–
weed control						
Mechanical	2218	3150	1.42	250	0	-0.18
weed control						

Source: Field Survey 2018

## DISCUSSION

In this study we did assessment of different weed management practices on rice. This study's findings highlight critical interactions between seed sourcing, varietal choice, weed pressure, and the economics of weed management. Almost 50% of the respondents purchased their seed from agro-vets suppliers (48.6%), but a significant amount also used self-produced seed (40.5%), which suggests a semi-market system combining modern market-based inputs and traditional practices. This trend indicates that farmers weigh cost, availability and risk when choosing inputs. The high percentage of local seed types (56.8%) in comparison to improved (35.1%), and hybrid types (8.1%) (Table 2) supports this interpretation, with local varieties typically being favored because of their ability to adapt, affordability and reliability under varying conditions.

Weed infestation level reported as dense by most of the farmers (67.6%) revealed that weeds are a major production constraint due to competition. CVIs (chemical value interests) accounted for 81.1% (Table 3), with use of mechanical methods as individual approaches being seldom applied. The preference is perhaps so strong because of labor-saving and cost considerations, especially in contexts where manual labor is costly or difficult to find. Economic analysis confirms this preference. Substantial savings were noted in weed control expenses leading to lower total cost for chemical weed management (Rs 1968 per kattha) compared to mechanical methods (Rs 2218). Although the average cost of production was lower in the chemical control method, where both methods gave equal yields (1.4 Qt per kattha) and incomes (Rs 3150), hence: Chemical control is more profitable rather than higher yield. The higher benefit–cost ratio for chemical methods (1.6 vs. 1.42) (Table 7). Adhikary et al (2020) found that application of herbicide in rice is economic viable and profitable weed management practice in rainfed rice ecosystem. Khaliq et al (2012) found that the application of herbicides was an efficient and cost-effective method for weed control in rice. This suggests that farmers care more about cost efficiency than methods of weed control. Using or overusing herbicides could develop long-term adverse issues such as environmental impact and the establishment of resistant targets. Chemical or integrated procedures are gradually replacing labor-intensive mechanical methods. Similar weed ecology found in lowland rice fields in South Asia was reflected in the dominance of *Cyperus rotundus* and *Fimbristylis miliacea*. This findings was similar to Jamaludheen et al (2025) who mentioned *Cyperus rotundus* as one of notorious weeds in rice field. Reduced labor costs for manual weeding under chemical control are the main cause of the lower cost, which is consistent with earlier research showing herbicides are cost-effective in labor-constrained situations.

Higher profitability without sacrificing yield was shown by the B/C ratio, which supported studies conducted in Nepal and Eastern India. Rice yield did not change significantly between chemical and mechanical approaches, despite cost differences. This is in line with studies indicating early- season herbicide use efficiently minimizes weed competition. This implies that the choice of approach and proper timing are more important than the type of weed control used alone. In order to reduce threats to the environment and human health, integrated weed management (IWM) is necessary for long-term sustainability, even though chemical weed treatment is more cost-effective. Soil health can be preserved, herbicide dependence can be decreased, and resilience may be increased through farmer education and the use of mechanical–chemical combinations. For the management of perennial weeds that cannot be effectively controlled by a single technique, the IWM strategy is crucial (Bridgemohan et al 1991, Alagbo and Akinyemiju 2018)

Socio-economic factors such as labor migration, increasing wage rates, and time constraints during peak agricultural operations have strongly influenced farmers' preference toward chemical weed control in many developing countries. However, long-term sustainability requires balancing economic benefits with environmental safety. Integrated weed management approaches combining preventive, cultural, mechanical, biological, and chemical methods are increasingly recommended for sustainable rice production systems. Therefore, promoting farmer awareness, strengthening extension services, and encouraging participatory research at the local level are essential for sustainable weed management. Policy support for safe herbicide use, training on proper dose and timing, and promotion of eco-friendly weed control technologies will help maintain productivity while safeguarding environmental and human health. Adoption of site-specific weed management using farmer knowledge and local weed ecology can further enhance control efficiency while reducing

unnecessary herbicide application.

## CONCLUSION

The findings of the study revealed that farmers predominantly rely on chemical and, to a lesser extent, mechanical methods for weed management in rice cultivation. Although herbicide use is associated with potential risks to soil health and human safety, a large proportion of farmers prefer chemical weed control due to its ease of application, time efficiency, and the shortage of labor during critical crop growth stages. In addition, the increasing cost of manual labor further encourages farmers to adopt chemical methods over purely mechanical approaches. The study also indicated that while yield levels were comparable between methods, chemical weed control was more economically beneficial due to lower production costs, which influences farmers' decision-making in weed management practices. Promotion of integrated weed management, farmer training, and safe herbicide practices is essential to ensure sustainable, high-yielding rice production in the region.

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## AUTHOR'S CONTRIBUTION

Sabina Rai conceptualized the study, designed the survey, conducted field data collection, and analyzed the data. She also drafted and finalized the manuscript.

## CONFLICT OF INTEREST

The author declares no conflict of interest related to this study.

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