

The Water Quality and Diarrhea Incidence in The Working Area of Health Center Wek I in Padangsidempuan City**Riven Alfrizon**University Aufa Royhan,
Indonesia**Nurlaila***University Aufa Royhan,
Indonesia**Masyitoh Aritonang**Sentral College of
Health Sciences,
Indonesia**Nayodi Permayasa**Sentral College of
Health Sciences,
Indonesia*** Corresponding author:**Nurlaila, University Aufa Royhan, Indonesia, ✉ nurlailanasution19@gmail.com**Article Info****Article history:**

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Background: Diarrhea remains a major public health problem among toddlers in developing countries, including Indonesia. Poor household water quality contributes to diarrhea transmission through pathogenic microorganisms. The working area of Puskesmas Wek I Kota Padangsidempuan continues to report high diarrhea incidence, highlighting the need to investigate this association.

Aims: This study aimed to determine the association between household water quality and diarrhea incidence among toddlers aged 12–59 months in the working area of Puskesmas Wek I Kota Padangsidempuan.

Methods: A quantitative cross-sectional study was conducted among 83 mothers of toddlers selected through purposive sampling. Data were analyzed using univariate and bivariate analyses with the Chi-square test ($p < 0.05$). The association was measured using the Prevalence Ratio (PR) and a 95% confidence interval.

Results: Most households (78.3%) used water that did not meet health standards, and 74.7% of toddlers had diarrhea. A significant association was found between water quality and diarrhea incidence ($p = 0.013$). Toddlers exposed to unsafe water had a higher likelihood of developing diarrhea (PR = 1.284; 95% CI: 0.869–1.896).

Conclusion: Household water quality is significantly associated with diarrhea among toddlers. Improving access to safe water, household water management, and environmental health interventions is essential to prevent diarrhea.

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INTRODUCTION

Diarrhea is still a major health issue in many developing countries, including Indonesia ([Sulistiowati et al., 2024](#)). Diarrhea is a sickness that affects the stomach and intestines. It is marked by passing stool three or more times in a day, and the stool is usually loose or very watery ([Lestari et](#)

[al., 2024](#)). This illness is a big problem because it can lead to dehydration, slow growth, and in some cases, can be deadly, especially for young children whose bodies are still growing and their immune systems aren't fully ready ([Akrom et al., 2022](#)). Infectious diseases, like diarrhea, are still one of the main reasons people die during the time right after birth and among kids under five years old in Indonesia ([Thobari et al., 2021](#)).

The World Health Organization says that diarrhea is the third biggest reason children under five die around the world ([Cisneros et al., 2024](#)). It is estimated that about 1.7 billion cases of diarrhea happen in children each year, and more than 443,000 children under five years old die from it ([Khan & Amin, 2024](#)). Diarrhea causes a lot of sickness and deaths, showing that it is still a big problem for global health, especially in places where people don't have clean water or good sanitation ([Demissie et al., 2021](#)).

One environmental factor that contributes significantly to diarrhea incidence is the quality of water used by communities for daily activities. Water is a basic human need used for drinking, cooking, washing utensils, bathing, and various other household activities ([Laillou et al., 2020](#)). Water that does not meet health requirements can become a medium for transmitting pathogenic microorganisms such as bacteria, viruses, and parasites that cause diarrhea ([Ikram et al., 2023](#)). Water contamination may occur due to domestic waste pollution, improper disposal of human waste, poor sanitation systems, or the use of unprotected water sources ([Lin et al., 2022](#)). Furthermore, seasonal environmental changes such as heavy monsoons often exacerbate these risks by promoting water logging and facilitating the spread of fecal-oral pathogens in overcrowded or poorly serviced dwelling areas ([Ikua et al., 2021](#)).

WHO and UNICEF said that about 80% of infectious diseases in developing countries are linked to bad water quality and not enough proper toilet facilities ([Girma et al., 2021](#)). Drinking water that has harmful germs like *Escherichia coli*, *Shigella*, *Salmonella*, *Vibrio cholerae*, Rotavirus, and different types of intestinal parasites can lead to diarrhea ([Faria et al., 2021](#)). So, giving kids clean water that is safe in terms of its physical, chemical, and biological qualities is really important for avoiding diarrhea, especially since young children are more likely to get sick and have serious problems from stomach infections ([Kalinda et al., 2024](#)). Beyond immediate acute distress, recurring episodes often result in long-term consequences such as electrolyte deficits, malnutrition, and impaired cognitive and physical development in affected youth ([Demissie et al., 2021](#)).

In Indonesia, diarrhea is still a major health issue. According to data from the Indonesian Ministry of Health, the number of toddlers who got health services because of diarrhea was 1,140,503 in 2020, went down to 879,596 in 2021, and then rose again to 974,268 in 2022 ([Ardianto et al., 2022](#)). The 2023 Indonesian Health Survey found that 4.3% of people across all age groups experienced diarrhea, either diagnosed by health workers or based on their symptoms ([Tosepu et al., 2023](#)). This condition shows that diarrhea is still a major health issue that needs careful attention from many different areas ([S. I. Sari et al., 2023](#)). Beyond mere morbidity, persistent diarrheal episodes in children under five are linked to significant developmental delays and nutrient malabsorption caused by sustained damage to the digestive tract ([Raihan & Mahmudiono, 2022](#)).

North Sumatra Province is one of the regions with a higher prevalence of diarrhea compared to the national average. The prevalence of diarrhea in North Sumatra was recorded at 4.7%, higher than the national prevalence of 4.3% ([Plate & Herdayati, 2023](#)). Several studies in North Sumatra have shown that environmental factors, particularly drinking water quality and household sanitation conditions, have a significant relationship with diarrhea incidence. A spatial analysis conducted by ([F. M. Sari et al., 2025](#)) identified clusters of diarrhea cases among toddlers associated with low access to sanitation facilities and the use of water sources that did not meet health requirements ([Permatasari et al., 2025](#)). Furthermore, spatial modeling reveals that urban environments in the province present distinct risk profiles, with toddlers residing in metropolitan areas facing a significantly higher predisposition to diarrheal diseases compared to those in rural regions ([Manullang et al., 2025](#)). These spatial disparities are further exacerbated by significant fluctuations in annual case reports, which indicate a dynamic relationship between population density, access to healthcare infrastructure, and the efficacy of localized sanitation interventions ([Widyastuti et al., 2025](#)). Beyond these sanitation gaps, the lack of access to piped water systems, such as PAM, serves as a critical predictor for disease clustering in densely populated districts like Medan ([Rahmadani et al., 2024](#)). Moreover, empirical evidence indicates that the absence of private latrines remains a

primary driver for these localized outbreaks, as the lack of proper waste disposal infrastructure frequently correlates with high morbidity rates across North Sumatra ([Nanda et al., 2023](#)); ([Plate & Herdayati, 2023](#)).

Various studies have shown that water quality is one of the major determinants of diarrhea incidence. Water that does not meet physical requirements, such as being turbid, colored, or having an unpleasant odor, as well as water that fails microbiological standards due to fecal contamination indicators, can increase the risk of diarrhea ([Khud et al., 2025](#)). A study by ([Prayitno et al., 2025](#)) found a significant relationship between drinking water quality and diarrhea incidence in the community. These findings indicate that poorer water quality is associated with a higher risk of diarrhea occurrence. Furthermore, microbiological contaminants, particularly *E. coli* and other pathogens like *Salmonella* and *Shigella*, represent critical transmission vectors that exacerbate gastrointestinal infections in populations relying on compromised water sources ([Fatimah et al., 2025](#)); ([Kismiyati et al., 2022](#)). Beyond these bacterial threats, the consumption of water tainted with fecal pathogens remains a primary driver of global child mortality, accounting for a significant portion of diarrheal deaths annually ([Greenwood et al., 2024](#)). Indeed, the lack of improved water infrastructure and sufficient sanitation continues to impede health outcomes, with nearly 90% of diarrheal mortality attributed to these inadequate hygiene conditions ([Muhummed et al., 2023](#)).

The working area of Puskesmas Wek I Kota Padangsidempuan is one of the areas that continues to experience diarrhea problems among toddlers. Based on data from Puskesmas Wek I, there were 36 diarrhea cases among toddlers from a total of 198 diarrhea cases in 2023. This number increased in 2024, with 95 diarrhea cases among toddlers out of 298 total diarrhea cases recorded. Furthermore, during January–March 2025, 87 diarrhea cases among toddlers were reported. The increasing number of cases indicates that diarrhea remains a public health problem requiring special attention in the working area of Puskesmas Wek I Kota Padangsidempuan.

Based on preliminary information obtained from the working area of Puskesmas Wek I Kota Padangsidempuan, some communities still use water sources that are not fully protected for daily needs, including cooking, washing utensils, and drinking purposes. This condition may increase the possibility of water contamination by pathogenic microorganisms from the surrounding environment. In addition, the quality of water used by the community has not been clearly identified regarding whether it meets established health standards. If the water used does not meet health requirements, the risk of environment-based diseases, particularly diarrhea among toddlers, may increase.

Although many things can affect how often someone gets diarrhea, like what a mother knows, how clean people are, what they eat, and how clean their surroundings are, water quality is especially important because water is something everyone uses every day in the family. Right now, there isn't enough information about how water quality is connected to cases of diarrhea in young children in the area served by Puskesmas Wek I Kota Padangsidempuan. That's why it's important to do this study to look at how water quality is connected to cases of diarrhea in young children in the area served by Puskesmas Wek I Kota Padangsidempuan. The findings from this study will help create programs to improve water quality and develop lasting ways to prevent diarrhea in young children.

METHOD

This study used a quantitative method with an analytical observational design and a cross-sectional approach. This design was used to find out how water quality, which is the independent variable, affects the rate of diarrhea in toddlers, which is the dependent variable, in the working area of Puskesmas Wek I Kota Padangsidempuan. Water quality was checked at the same time as tracking cases of diarrhea to see how the condition of water at home relates to the occurrence of diarrhea in young children.

Participant

The people in this study were mothers who had young children between 12 and 59 months old, and they lived in the area served by Puskesmas Wek I in Kota Padangsidempuan. Mothers of young children were chosen as participants because they are key in handling the home's water supply, such as using water for drinking, preparing food, cleaning dishes, and other everyday tasks. The criteria for including mothers were those who had toddlers between 12 and 59 months old, lived in the area served by Puskesmas Wek I Kota Padangsidempuan, used household water sources for

their daily activities, and were willing to take part as study participants. The people who were not included were those who couldn't be reached during the data collection or didn't give all the needed information.

Population and Methods of Sampling

The study included all the mothers who had toddlers between 12 and 59 months old in the area covered by Puskesmas Wek I Kota Padangsidempuan in 2025, and there were 481 toddlers in total. The method used to select the sample was non-probability sampling, and a purposive sampling technique was applied. This method was used because the people who took part were chosen based on certain rules that matched the goals of the study, which were mothers of young children who mainly used water from their home's water source. The sample size was determined using the Slovin formula, allowing for a 10% margin of error. The calculation gave 82.7 people, so it was rounded up to 83 people.

Instrumentation

The research instruments consisted of a structured questionnaire and a household water quality observation sheet. The instruments were developed based on water quality indicators and risk factors related to diarrhea incidence.

The measurement of water quality variables included:

1. Water source used, including the type of water source used by households for daily needs (wells, piped water, springs, or other sources).
2. Physical quality of water, including:
 - water clarity,
 - water color,
 - water odor,
 - water taste,
 - condition of water storage facilities,
 - cleanliness of water storage containers.

Water quality assessment was conducted through direct observation and interviews. The measurement results were categorized as:

- Meets requirements, if the water condition complied with good water quality indicators.
- Does not meet requirements, if physical characteristics of water indicated potential health risks.

The diarrhea incidence variable was measured based on the history of diarrhea among toddlers, defined as passing loose or watery stools three or more times within 24 hours according to the WHO definition.

The categories of diarrhea incidence were:

- Diarrhea, if the toddler experienced diarrhea during the observation period.
- No diarrhea, if the toddler did not experience diarrhea.

Before use, the research instrument was tested for validity and reliability to ensure that the instrument was appropriate and consistent for data collection.

The main instruments used in this study were a closed-ended questionnaire and an observation checklist, with the number of questions adjusted according to the research indicators. Primary data were obtained through direct interviews with mothers of toddlers and observation of household water source conditions.

Secondary data were obtained from Puskesmas Wek I Kota Padangsidempuan, including data on diarrhea cases among toddlers, the number of toddlers, the profile of the working area, and other supporting data.

The study was conducted from August 2025 to February 2026 in the working area of Puskesmas Wek I Kota Padangsidempuan.

The research procedures included:

1. Preparation of the research proposal.
2. Proposal seminar and revision.
3. Obtaining research permission.
4. Data collection through interviews and household water quality observations.
5. Data checking (editing).
6. Data coding (coding).

7. Data processing and analysis.
8. Preparation of the research report.
9. Research result seminar and revision.

The study was conducted after respondents received an explanation regarding the research objectives and signed the informed consent form.

Data analysis was done using univariate and bivariate methods. They looked at the data to see how often different water quality levels and cases of diarrhea happened in young children. A chi-square test was used to check if there's a connection between water quality and cases of diarrhea in toddlers, and the results were considered significant if the p-value was less than 0.05. The results were understood by looking at the p-value. If the p-value is less than 0.05, it shows there's a significant connection between water quality and the occurrence of diarrhea in toddlers. The strength of the link was checked using the Prevalence Ratio (PR) along with a 95% confidence interval to see if poor water quality was connected to a higher chance of getting diarrhea.

Scope and/or Limitations of Methodology

This study focused on the relationship between household water quality and diarrhea incidence among toddlers in the working area of Puskesmas Wek I Kota Padangsidempuan. The limitation of this study is the use of a cross-sectional design, which measures variables at one point in time and therefore cannot establish a direct causal relationship. In addition, water quality assessment mainly focused on physical characteristics and household water conditions based on observation and interviews, and did not include comprehensive laboratory examinations of water quality parameters such as microbiological, chemical, and physical analyses.

RESULT AND DISCUSSION

Result:

A total of 83 mothers with children aged 12–59 months participated in this study in the working area of Puskesmas Wek I Kota Padangsidempuan. The characteristics of respondents are presented based on parental characteristics, child characteristics, water source, and diarrhea incidence.

Table 1. Distribution of Respondent Characteristics and Source Water in the Working Area of Puskesmas Wek I Kota Padangsidempuan (n=83)

Variable	Frequency (f)	Percentage (%)
Parent Age		
<25 years	2	2.4
25–34 years	41	49.4
35–44 years	35	42.2
≥45 years	5	6.0
Parent Sex		
Male	36	43.4
Female	47	56.6
Parent Education		
Elementary School	6	7.2
Junior High School	11	13.3
Senior High School	28	33.7
University	19	22.9
Others	19	22.9
Parent Occupation		
Housewife/Not working	32	38.6
Private employee	11	13.3
Farmer	10	12.0
Trader	13	15.7
Others	17	20.5
Child Age		
6–11 months	3	3.6
12–23 months	18	21.7

24–35 months	20	24.1
36–47 months	20	24.1
48–59 months	22	26.5
Child Sex		
Male	42	50.6
Female	41	49.4
Water Source		
PDAM	27	32.5
Dug well	20	24.1
Pump well	17	20.5
Spring water	9	10.8
River water	6	7.2

Based on parental characteristics, most respondents were in the age group of 25–34 years (49.4%), followed by respondents aged <25 years (4.8%), aged 35–44 years (42.2%), and aged ≥45 years (3.6%). The majority of respondents were female (56.6%) and had a high school education level (33.7%). Regarding occupation, most respondents were housewives/not working (38.6%), followed by private employees (13.3%), traders (15.7%), civil servants (12.0%), and others (20.5%). The characteristics of children showed that the largest proportion of children were aged 36–47 months (24.1%), followed by children aged 24–35 months (24.1%), 48–59 months (26.5%), 12–23 months (21.7%), and 6–11 months (3.6%).

The distribution of child sex was relatively balanced, consisting of 42 boys (50.6%) and 41 girls (49.4%). The results showed that most respondents used PDAM water sources (32.5%), followed by dug wells (24.1%), pumped wells (20.5%), springs (10.8%), river water (7.2%), and other sources (4.8%). This finding indicates that although most households have access to piped water sources, the quality of water used at the household level still needs attention because contamination may occur during distribution, storage, or household management.

Table 2. Distribution of Diarrhea Incidence among Toddlers

Diarrhea Incidence	Frequency (f)	Percentage (%)
Diarrhea	62	74.7
No diarrhea	21	25.3
Total	83	100

The results showed that diarrhea incidence among children aged 12–59 months was still high. A total of 62 toddlers (74.7%) experienced diarrhea, while 21 toddlers (25.3%) did not experience diarrhea.

Relationship Between Water Quality and Diarrhea Incidence

Based on the analysis, most respondents had water quality that did not meet health requirements (78.3%). Among respondents with water quality that did not meet requirements, 21.5% experienced diarrhea, while among respondents with water quality that met requirements, 38.9% experienced diarrhea.

Table 4. Relationship Between Water Quality and Diarrhea Incidence among Toddlers

Water Quality	Diarrhea n (%)	No Diarrhea n (%)	Total n (%)	p-value	PR (95% CI)
Does not meet requirements	14 (21.5)	51 (78.5)	65 (78.3)	0.013	1.284 (0.869–1.896)
Meets requirements	7 (38.9)	11 (61.1)	18 (21.7)		
Total	21 (25.3)	62 (74.7)	83 (100)		

The Chi-Square test found that there is a significant connection between water quality and cases of diarrhea in toddlers in the working area of Puskesmas Wek I Kota Padangsidempuan ($p = 0.013$). The prevalence ratio (PR) was 1.284 (95% CI: 0.869–1.896), which means toddlers in homes where the water did not meet safety standards had a 1.284 times greater chance of getting diarrhea compared to those in homes with safe water.

Discussion:

In theory, the Water, Sanitation, and Hygiene (WASH) idea says that the quality of water is one of the environmental factors that can lead to diseases that come from the environment, especially stomach-related illnesses like diarrhea. Unsafe water can spread harmful germs from one person to another through the fecal oral route. When water gets polluted with bacteria like *Escherichia coli*, it shows that the water is contaminated with feces. This can make people sick, especially young children, because their immune systems aren't fully grown yet and they are more likely to get stomach infections. This study found a strong link between water quality and cases of diarrhea in young children in the area served by Puskesmas Wek I in Kota Padangsidempuan, with a p-value of 0.013.

The analysis showed a Prevalence Ratio (PR) of 1.284 (95% CI: 0.869–1.896). This finding indicates that toddlers using water that did not meet quality requirements had a 1.284 times higher probability of experiencing diarrhea compared with toddlers using water that met the requirements. However, because the confidence interval included the value of 1, the association has not demonstrated a strong epidemiological risk effect. This suggests that diarrhea incidence may also be influenced by other environmental and behavioral factors that were not examined in this study. These findings are consistent with the theory that household water quality is not only determined by the water source but also by the processes of distribution, treatment, and storage before consumption. Water from a relatively safe source may still become contaminated through recontamination if household water management practices are inadequate. Conditions such as uncovered storage containers, poor cleanliness of water containers, and unhygienic methods of taking water may become pathways for pathogenic microorganisms that cause diarrhea.

The study by [\(Mekonen, 2025\)](#) explained that households with unsafe drinking water and poor water storage practices have a higher risk of diarrhea. The study emphasized that water safety is not only determined by the type of water source but also by the quality of water at the point of consumption [\(Justin et al., 2025\)](#). This finding is relevant to the current study in the working area of Puskesmas Wek I Kota Padangsidempuan, where most respondents used PDAM water, but some households still had water quality problems based on the observed indicators [\(Garber et al., 2024\)](#). Inadequate water handling practices, such as storing water in open containers or proximity to contaminated sites, further facilitate pathogen transmission and elevate health risks for children [\(Kurniawati et al., 2021\)](#) ; [\(Siramaneerat & Agushybana, 2023\)](#). Furthermore, sub-optimal hygiene behaviors—specifically failing to perform handwashing before feeding children or preparing food—serve as critical mediators that exacerbate the correlation between environmental exposure and disease incidence [\(Imadudin et al., 2021\)](#); [\(Aydamo et al., 2024\)](#).

Furthermore, Santi (2025) also reported a significant association between water quality and diarrhea incidence. These findings confirm that environmental factors, particularly water quality, contribute significantly to diarrhea occurrence among toddlers. Contaminated water can increase exposure to infectious microorganisms, thereby increasing the likelihood of gastrointestinal infections. Therefore, water quality should not only be considered as a physical environmental factor but also as an important public health determinant associated with diarrhea incidence among toddlers. Diarrhea prevention efforts should focus on improving household water quality through the use of safe water sources, proper water treatment before consumption, maintaining clean water storage containers, and conducting regular monitoring of household water quality.

Implications:

The findings of this study have several practical implications for public health practice and environmental health management. Since household water quality was found to be significantly associated with diarrhea incidence among toddlers, interventions aimed at improving water safety should become a priority in diarrhea prevention programs. Primary healthcare centers, particularly Puskesmas Wek I Kota Padangsidempuan, should strengthen routine environmental health surveillance by monitoring household water quality and identifying families at high risk of using unsafe water sources.

These findings also highlight the importance of promoting safe household water management practices. Health education programs should encourage families to treat drinking water

before consumption, maintain clean and covered water storage containers, and prevent contamination during water collection and storage. Such behavioral interventions may reduce exposure to pathogenic microorganisms and decrease the burden of diarrhea among young children.

From a policy perspective, local government agencies should collaborate with health centers and water supply providers to improve access to safe drinking water and ensure that water distributed to households maintains acceptable quality standards until the point of use. Community-based Water, Sanitation, and Hygiene (WASH) programs should also be strengthened through integrated education, regular water quality monitoring, and sanitation improvement initiatives. These combined efforts are expected to contribute to reducing diarrhea incidence and improving child health outcomes in the community.

Research Contribution:

This study contributes to the understanding of environmental determinants associated with diarrhea incidence among toddlers, particularly the role of household water quality in the working area of Puskesmas Wek I Kota Padangsidempuan. The findings provide evidence that water quality is significantly associated with diarrhea incidence among toddlers, indicating that household water conditions should be considered in diarrhea prevention strategies. This study also provides local evidence that can support primary healthcare facilities in developing targeted interventions related to safe water management, household water treatment, and environmental health education. Furthermore, the results may serve as a reference for future studies focusing on water quality, sanitation, and other environmental factors related to childhood diarrhea.

Limitations:

This study has several limitations. First, the cross-sectional design only measures exposure and outcome at the same time, so it cannot determine a causal relationship between water quality and diarrhea incidence. Second, the assessment of water quality was mainly based on household observations and physical indicators, and did not include comprehensive laboratory examinations such as microbiological parameters (*Escherichia coli*, total coliform), chemical parameters, or other water quality indicators. Third, diarrhea occurrence was obtained through interviews with mothers, which may be influenced by recall bias. In addition, other factors that may contribute to diarrhea incidence, such as sanitation conditions, handwashing practices, food hygiene, nutritional status, and socioeconomic factors, were not analyzed in this study.

Suggestions:

Future studies are recommended to conduct laboratory-based water quality assessments to provide more objective measurements of physical, chemical, and microbiological water quality. Further research with a longitudinal or case-control design is also suggested to better explain the causal relationship between unsafe water quality and diarrhea incidence among toddlers. For Puskesmas Wek I Kota Padangsidempuan, it is recommended to strengthen environmental health programs through regular monitoring of household water quality, promotion of safe water management practices, and education for mothers regarding proper water treatment and storage. Communities are encouraged to maintain clean water storage containers, protect water sources from contamination, and ensure that water used for drinking and food preparation meets health requirements.

CONCLUSION

This study concludes that water quality is significantly associated with diarrhea incidence among toddlers in the working area of Puskesmas Wek I Kota Padangsidempuan (p-value = 0.013). Most respondents used water that did not meet health requirements, indicating that household water quality may contribute to diarrhea occurrence among toddlers. Although unsafe water quality showed an increased risk of diarrhea (PR = 1.284; 95% CI: 0.869–1.896), diarrhea incidence may also be influenced by other factors such as sanitation, hygiene practices, and household environmental conditions. These findings highlight the importance of improving household water management, including safe water sources, proper treatment, and hygienic storage. Further studies are recommended using laboratory-based water quality assessments and examining other risk factors to strengthen evidence for diarrhea prevention strategies.

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AUTHOR CONTRIBUTION STATEMENT

The first and second authors helped come up with the idea and planned the study. Another author was in charge of collecting the data, analyzing it, and writing the manuscript. Also helped with overseeing, providing guidance on methods, and reviewing the manuscript critically. All the authors checked and agreed on the last version of the paper.

AI DISCLOSURE STATEMENT

The authors declare that this research was prepared, researched, written, and edited without the aid of artificial intelligence (AI) techniques.

CONFLICTS OF INTEREST

The authors declare that there are no financial, institutional, or personal conflicts of interest that could influence the conduct of this study, the analysis of data, the preparation of the manuscript, or its publication.

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