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Analysis of The Heavy Metal Cd Content in Ricefield Eel from Rawa Taliwang Lake, West Sumbawa Regency

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Abstract: It is important to carry out research on heavy metal in fish body. The specific aims and targets of this research are: Want to know the metal content of Cadmium (Cd) in Ricefield eels (*Monopterus albus*) which comes from Rawa Taliwang Lake. The specific benefit is to protect consumers who consume fish from heavy metal contamination. The research was carried out at Rawa Taliwang Lake, namely in an area that is submerged in water. There are 2 research stations, namely in the eastern and western parts of the lake. Data collection method was carried out using traps (Bubu). Four Ricefield eel samples were taken at each station. Next, the rice eel samples were put into a plastic bag and then stored in *a sample box*. The research samples were then analyzed at the Mataram Uviversity analytical laboratory and at Environmental Laboratory of the Environmental and forestry services West Nusa Tenggara Province. The data analysis method is carried out by taking the tissues from the Ricefield eel muscles, and then analyzed for Cd heavy metal content by using Atomic *Absorption Spectrophotometer*. Measurement of heavy metals in Ricefield eel tissue was carried out by adding concentrated HNO_3 and $HClO_4$, heated at a temperature of 60-70^oC for 2-3 hours until the solution was clear. Samples are ready to be measured with AAS using an air-acetylene flame. The conclusion of this research is that the content of Cd heavy metal in Ricefield Eels (*Monopterus albus*) originating from Rawa Taliwang Lake ranges from 2.55 - 4.01 mg/kg (ppm).

Keywords: Cadmium (Cd); Ricefield eels; Taliwang Rawa Lake

Introduction

Aquatic ecosystems are habitats for aquatic organisms. Ricefield eel is a species of fish. Fish is one of the species that depends on aquatic ecosystems for life. Rawa Taliwang Lake as a freshwater ecosystem has a role as a place where biological processes take place for various types of aquatic organisms. The total area of Rawa Taliwang Lake is 819.20 ha consist of freshwater. This lake located in West Sumbawa Regency. This area was once designated as a Natural Tourism Park based on the Regulation of the Minister of Forestry and Plantation No. 418/Kpts- II/1999 dated 15 June 1999 covering an area of 1,406 ha. However, the Ministerial regulation has been revoked and replaced with Ministerial regulation No. 589/Menhut-II/2009 concerning the determination of Forest Areas and Water Conservation Areas in West Nusa Tenggara Province on 2 October 2009 (BKSDA, 2015; Kawirian et al., 2018). Taliwang swamp lake is a body of water that has a diversity of fish species. Ricefield eel (*Monopterus albus*) is a species of fish found in the lake of Rawa Taliwang. These fish can become bioindicators for existing ecosystems.

The location of the lake of Rawa Taliwang consist of two subdistrict, namely Taliwang subdistrict (including Seloto, Pakirum and Sampir Village) and Seteluk subdistrict, especially Meraran Village. Geographically,

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Rawa Taliwang Lake or Lake Lebo is located between latitudes 8 º 34'0" S and 116 º 13'0" E with regosol and lithosol soil types and hilly to mountainous topography with a height of 200-400 m above sea level (BKSDA, 2015). Rawa Taliwang Lake has high natural resource potential, which can play a role in improving the economy of the surrounding community, including as an area for catching and cultivating freshwater fish. The other function of this lake are a water source for agricultural irrigation, a source of raw household water. This lake area has potential for ecotourism and also plays a role as flood control for Taliwang City. In the dry season the lake water decreases until some areas of the lake become dry (BKSDA, 2015).

In connection with the area for catching and cultivating freshwater fish, and community agricultural activities that use insecticides, herbicides, fungicides and fertilizers, there is a chance that the water and organisms in Rawa Taliwang Lake will be polluted by heavy metals like Cadmium (Cd), mercury (Hg), and others. Considering that Cd can harm bone growth, this research is important to be done. People consume fish from the Taliwang swamp lake every day, so finding Cd in fish bodies is important to protect people from the negative effects of heavy metals.

The increasing condition of the heavy metal Cadmium (Cd), in waters such as lakes, especially at the beginning of the rainy season, needs to be controlled because according to Riani et al. (2017) heavy metals that enter the waters will spread and accumulate in sediment, which will then accumulate in the bodies of aquatic organisms such as fish. Aquaculture systems have contaminated by heavy metals through various sources, for examples atmosphere and agricultural activities (El Bahgy et al., 2021). Apart from this, Cd is persisten heavy metal in the environment, and it will harm for the bodies of contaminated organism. If humans consume contaminated fish with Cadmium (Cd), it can accumulate, toxic, damage bones and it is very dangerous for humans organs. Humans who consume contaminated fish with Cadmium (Cd) heavy metal, will accumulate in tissues, very dangerous, toxic, and can make human bones damaged (Amriarni et al., 2012).

Increasing of heavy metals or accumulation of heavy metals in the fish's body follows water temperature. Increasing water temperature tends to increase the accumulation and toxicity of Cd heavy metals. Soraya et al. (2012) said that exposed fish by Cu and Cd heavy metals tend to accumulate more when the temperature is 30 ^{o}C when compared to room temperature. This can occur due to an increase in the metabolic rate of aquatic organisms (Sitorus, 2004). Heavy metal contamination of fish such as ricefield eels (*Monopterus albus*) will easily occur in lake waters. Fish that live in limited habitats, for example rivers and lakes, are more easily contaminated with heavy metals compared to fish that live in open waters. The accumulation of Cd metal in fish tissue occurs after adsorption of Cd from water or through feed or food such as contaminated algae (Ratnawati et al., 2008).

Water bodies such as lakes can easily be polluted by many kinds of heavy metals like cadmium (Cd) (Widowati et al., 2008; Bakrie, 2008). The Contamineted water and soil can be easily come from rubbish, liquid waste and other pollutants such as from detergents, fertilizers, and pesticides (Notohadiprawiro, 2006). The results of researchers' observations show that farmers around Lake Rawa Taliwang still use fertilizer in their rice fields in order to fertilize plants, for example rice plants (Khairuddin et al., 2022).

Various plant species grow in Rawa Taliwang Lake. The plant has the ability to act as a biofilter, namely the ability to filter, bind and trap pollution in the wild in the form of excess sediment, rubbish and other household waste. This function plays an important role in improving the quality of water (Gunarto, 2004). Various types of plants can become a natural bioremediation agent called biosorption because it can absorb heavy metals in nature such as Cu, Mn, Cr, Co, Fe, Ni, Pb, Cd and Zn (Hastuti et al., 2013). Rawa Taliwang Lake receives water and sediment sources from various surrounding water flows which enter the lake. Many kinds of pollution has been studied in bodies of water in Indonesia, as informed by the results of research by Rochyatun et al. (2010) which shows that the levels of heavy metals / pollutants in sediments and the body of water at the mouth of the Cisadane river show that the levels of heavy metals (Cu, Zn, Ni and Pb , and Cd) in sea water in estuarine waters ranges from Cu $\leq$ 0.001-0.001 ppm, Zn $\leq$ 0.001 ppm, Ni $\leq$ 0.001-0.003 ppm, Pb $\leq$ 0.001-0.005 ppm, and Cd $\leq$ 0.001-0.001 ppm.

Various research results show that Snakehead fish (*Channa striata*) and Ricefield eels (*Monopterus albus*) have been contaminated by heavy metals such as Cd, Cu and Pb. The results of research by Murtini & Rachmawati (2007) found that Snakehead fish contained by heavy metals Hg 6.68 ppb, Cd 2.32 ppb, Cu 24.50 ppb and Pb 1.60 ppb. Other research shows that the Pb content in Snakehead fish is 11.01 ppm and in Mozambique Tilapia is 10.83 ppm (Prastari et al., 2017). Zahro & Suprapto (2015) reported that snakehead fish contained Cd content of 0.16 ppm, Cu 0.79 ppm and Pb 0.22 ppm. Accumulation of Cu metal was detected in the gills and liver of Snakehead fish (*Channa striata*) (Yoga & Sadi, 2016; Moodley et al., 2021).

In Ricefield eels (*Monopterus albus*) heavy metals were also found. The research results show that the Cd content in Climbing perch (*Anabas testudienus*) is 84 ppb (Budiman et al., 2012). Apart from Climbing perch and snakehead fish, the results of analysis of Beloso fish meat found lead (Pb) content of 0.005 mg/kg (ppm), copper (Cu) 0.293 mg/kg, and Cadmium (Cd) 0.032 mg/kg. This description shows that fish tissue is able to accumulate various types of heavy metals.

The main cause of heavy metals becoming dangerous pollutants is that heavy metals cannot be destroyed (*non-degradable*) by living organisms and then it will be accumulated in the environment, especially settling at the bottom of waters (Rochyatun & Rozak, 2010). Considering the existence of heavy metals in aquatic organisms and as material for study and determining development policies and enriching the material for Environmental Knowledge courses, the author is interested in conducting research on the analysis of the heavy metal Cd content in Ricefield eels originating from Rawa Lake Taliwang West Sumbawa Regency.

The results of observations made by the author show that the water body in Rawa Taliwang Lake receives water from the surrounding area which passes through agricultural areas that use fertilizers, herbicides, fungicides, insecticides and passes through community mining processing areas, so that the water body in the lake receives the burden of pollution. Heavy metals can be accumulated by algae which is in the water and at the bottom of the water, follows the food chain, enters the fish's body and accumulates. For this reason, research has been carried out to determine the heavy metal content in fish. This research tries to analyze the Cd metal content in Ricefield eels (*Monopterus albus*) originating from Lake Rawa Taliwang.

Methods

The research was carried out at Rawa Taliwang Lake, namely in an area that is always submerged in water or in a body of water. There were 2 stations representing the Lake area, namely station 1 on the east side and station 2 on the west side, according to topographic considerations. Catching Ricefield eels (*Monopterus albus*) is done using traditional traps (Bubu). Four Ricefield eel samples were taken at each station. Next, the sample of Ricefield eels (*Monopterus albus*) is put in a plastic bag and then stored in *a sample box*. The research samples were then analyzed at the Mataram Uviversity analytical laboratory and at Environmental Laboratory of the Environmental and forestry services West Nusa Tenggara Province.

Muscles tissues from Ricefield eels (*Monopterus albus*) were analyzed for Cadmium (Cd) content using an Atomic *Absorption Spectrophotometer (AAS)*. The analysis begins with destroying the fish body and then analyzing it using AAS. Measurement of heavy metals in fish muscle tissue was carried out by adding concentrated $HClO_4$ and HNO_3, heating at a temperature of 60-70°C as long as 2-3 hours until the solution was clear. Samples are ready to be measured with AAS using an air-acetylene flame.

Results and Discussion

From 2 research locations, an analysis of Cadmium (Cd) content in Ricefield eels (*Monopterus albus*) originating from Lake Rawa Taliwang can be presented as follows.

Table 1. Results of laboratory analysis of Cadmium (Cd) content in Ricefield eel (*Monopterus albus*) tissue from Rawa Taliwang Lake

Fish Species	Sample / Replication Locations	Cd content mg/kg (ppm)
Ricefield Eel	East Side	
	Location 1 (1)	4.01
	Location 1 (2)	4.01
Ricefield Eel	West Side	
	Location 2 (1)	2.55
	Location 2 (2)	2.55

The content of Cadmium (Cd) in Ricefield eels originating from the lake of Rawa Taliwang, West Sumbawa Regency is at a concentration of 2.55 – 4.02 ppm. Ricefield eels usually live in swamp waters and lakes so they can be bioindicators in lakes. The Cd metal content has exceeded the threshold in accordance with the provisions of Food and Drug Supervisory Agency Regulation Number 9 of 2022 concerning Requirements for Heavy Metal Contamination in Processed Food, namely 0.3 mg/Kg (ppm) for processed fish products.

The high concentration of the heavy metal Cadmium (Cd) in Ricefield eels originating from Lake Rawa Taliwang, West Sumbawa Regency, indicates that the waters of Lake Rawa Taliwang have been contaminated by the Cadmium heavy metal. This heavy metal Cd is predicted come from agricultural and aquaculture activities because the research location is surrounded by rice fields. The source of this Cd is caused by the use of fertilizer by farmers. Cd heavy metal also came from Pospat fertilizer (Riani et al., 2017; Khairuddin et al., 2021). When food and water are consumed by Ricefield eel, next heavy metals enter the aquatic food chain directly through the gastrointestinal tract of eel (Magna et al., 2021). If humans consume Ricefield eels which contain high levels of Cd, and then it can accumulate, dangerous, and make human bones damaged. Because the research results show that the Cd content is very high, based on this Cd standard, Ricefield eels originating from Rawa Taliwang Lake, West

Sumbawa Regency are no longer safe for consumption. If Ricefield eel is consumed, it can have negative impacts that affect human health.

The content of the heavy metal Cd found in Ricefield eels originating from Lake Rawa Taliwang, West Sumbawa Regency in this study was very high. The heavy metal content Cd is at the level of 2.55 ppm – 4.01 ppm. The Cd metal content is far above the threshold (0.3 mg/Kg) in accordance with Food and Drug Supervisory Agency Regulation Number 9 of 2022 concerning Requirements for Heavy Metal Contamination in Processed Food, namely for processed fish products.

Accumulation of heavy metals can occur in the body of fish such as Ricefield eels. Research results by Murtini & Rachmawati (2007) reported that the heavy metal content in fish in the Saguling reservoir is, Cd between 1.89 - 66.57 ppb, Cu between 0.29- 247.40 ppb and Pb around 1.60 – 40.32 ppb. The results of this study strengthen the findings in this study, especially for the heavy metal Cadmium (Cd). Pb levels were also found at 0.48 mg/kg, and Hg at 1.26 mg/kg in Tilapia fish. Research results also show that carnivorous fish contain higher levels of heavy metals compared to omnivore and herbivorous fish (Hossain et al., 2022). Meanwhile, the heavy metal Cd has also been found in Pomfret fish at less than 1 mg/kg (Moodley et al., 2021). Cd was found too on the fish muscle (Ture et al., 2021). Heavy metal accumulation in each target organ of organism can be various, for example in Parastromateus niger fish in liver ranged from 0.03-89.98 mg/kg, gills ranged from 0.004-49.94 mg/kg and meat ranged from 0.00-35.68 mg/kg (Pertiwi et al., 2021). High heavy metal concentrations of 6.7 mg/L were obtained for Cd (Mokarram et al., 2021), and Cd concentrations were detected ranging from 0.005 to 0.008 mg/L (Astuti et al., 2021). Cadmium (Cd) level in milkfish (*Chanos chanos* Forsk) from Palibelo Bima, Indonesia, was found to be an average of 0.006 percent or 6 ppm in milkfish tissue (Khairuddin et al., 2023). The concentration of estradiol in several fishes was reported to decrease when exposed to heavy metals including Cd. Heavy metal Cd were determined 0,2 – 0,5 mg/Kg in the muscle tissues of consumed fish species (Köker et al., 2021). Cd heavy metal contents range in the tissue from some species of organism like roach, pike, and perch 0.0014–0.0095, 0.0010–0.0015, and 0.0020 mg kg−1, respectively (Chałabis-Mazurek et al., 2021).

Ricefield eels are organisms that are capable of accumulating heavy metals in their bodies because they are influenced by environmental factors, for example increasing environmental temperature. Rising water temperatures will cause an increased accumulation of heavy metals in the fish's body. The accumulation and toxicity of heavy metals is influenced by rising water temperatures. Temperature can directly affect fish metabolism (Alshkarchy et al., 2021). Heavy metals that accumulate due to increasing temperatures include Cadmium (Cd) and Mercury (Hg). Ricefield eels can be exposed to many kinds of heavy metals. Fish exposed to heavy metals such as Cd will tend to accumulate more heavy metals at a temperature of 30 ^{0} C when compared to room temperature. In case of increasing water temperature, the metabolic rate of aquatic organisms such as fish will increase (Sitorus, 2004; Soraya et al., 2012; Murtini & Rachmawati, 2007; Khairuddin et al., 2021).

Freshwater fish are all capable of accumulating heavy metals. The research result (Zulfiah, et al, 2017) show that the average level of Pb metal in samples of milkfish (*Chanos chanos* Forsk) is 0.0392 mg/kg, and the average level of Cu metal is 0.0882 mg/kg. Cu metal in Rejung fish (*Sillago sihama*) was found to be 2.24 mg/kg (Solgi & Mirmohammadvali, 2021). Other research shows the presence of the Cadmium heavy metal in milkfish tissue (Purnomo & Muchyiddin, 2007).

Cd can affect human bones condition. If humans often consume fish that have been exposed to Cd, it can endanger health. Increasing Cd levels too high can make a negative impact on humans and animals because it can damage bones and easily accumulate in body tissues and organs (Notohadiprawiro, 2006; Rochyatun & Rozak, 2010; Rochyatun et al., 2010). Environmental changes can also have a real impact on phytoplankton such as algae and other plant species, because algae as plants are organisms that have the fastest response to environmental changes. Plants are more sensitive compared to animals and humans (Widowati et al., 2008; Khairuddin et al., 2021).

Heavy metals are *nondegradable material* by living organisms in ecosystem, which is the main reason why heavy metals become harmfull pollutants to various organisms. As a result, these metals accumulate in the environment and settle to the bottom of the waters to form a new complex compounds with organic and inorganic materials. These heavy metals can be taken up by algae, eaten by small fish and then entered into food chains and food webs.

In sediments, heavy metals are usually found. These metals can be taken up by phytoplankton which is food for fish. These heavy metals can come from agricultural activities carried by water through rivers. Next, various types of heavy metals that can dissolve in river water are adsorbed by fine particles (*suspended solid*) and carried to the estuary by the water in the river. At the mouth of the river, river water and tidal currents can meet to each other, so that fine particles containing heavy metals can settle in the estuary. The consequences of these events can make heavy metal levels in estuary sediments higher than in the open sea. In general, river estuaries a sedimentation process occur, where metals that are difficult to dissolve in the water column, then fall to the bottom of the waters and settle in the sediment, so that the sediment always contains heavy metals (Rochyatun et al., 2010; Russell et al., 2012; Khairuddin et al., 2021).

The aquatic environment is often contaminated with heavy metals, like the waters of Kendari Bay (Amriarni et al., 2012). Community and industrial wastes as sources of water pollution should make a consideration in order to reduce the burden of waste entering the water so that the impact on organisms can be minimized (Riani et al., 2017), because based on the results of this research, Cd levels have been detected in fish tissue. The Cadmium (Cd) content found in the tissues of Milkfish, Tilapia and Snakehead fish was also reported by Khairuddin et al. (2021). Cd in Climbing perch and Snakehead fish in Rawa Taliwang Lake was found to range between 0.011 ppm to 0.016 ppm. Meanwhile, according to Food and Drug Monitoring Agency (BPOM) regulation Number 5 of 2018 concerning the Maximum Limit for Heavy Metal Contamination in Processed Food, the maximum limit for Cd content in fish and fishery products is 0.10 mg/Kg or the equivalent of 0.1 ppm. This means that the Cd levels in fish have almost reached the upper limit allowed.

Cadmium can accumulate in the bodies of animals through the food chain, which ultimately reaches humans (Herman, 2016). Cadmium (Cd) is a metal that can be carried by water from sources of contamination such as those originating from agricultural activities that use fertilizer. Cd in Ricefield eel is predicted come from agricultural areas around Lake Rawa Taliwang. Cadmium is easily absorbed by organic substances in the soil and becomes very dangerous if It is absorbed through food chain. This phenomenon can happen because soil containing Cd will be absorbed by plants and then eaten by herbivorous animals which always depend on plants (Gunarto, 2004).

Sources of heavy metal pollution such as Cd in plants can come from fertilizers, pesticides, irrigation water, or even from the surrounding air (Agustina, 2014). There is still a lot of use of organic (cythetic) fertilizers that contain the heavy metal cadmium (Cd), even though the amount is not large, if the soil is routinely given fertilizer containing Cd, it can cause the heavy metal Cd to accumulate and be absorbed by vegetables growing on local agricultural land. Cadmium in aquatic ecosystems can accumulate in various organisms such as squid, fish, oysters and shrimp. Sensitivity to Cadmium can vary greatly between aquatic organisms. Organisms that live in salt water are known to be more resistant to poisoning of Cd than organisms that live in fresh water.

Several studies show that Cadmium (Cd) is found in water bodies and sediments. The content Cd found in the Cisadane river was < 0.001 ppm. Heavy metal levels in the sediment of several locations that have not been polluted have been reported to have Cd content in the range of 0.020-0.070 ppm (Rochyatun et al., 2010). At certain concentrations, cadmium (Cd) can kill sperm cells in men. This is the basis that exposure to cadmium (Cd) metal vapor can result in impotence. The toxic power of cadmium (Cd) also affects the bones, kidneys, lungs, reproductive system and organs (Widowati et al., 2008).

Cd can also be carried from various wastes, for example liquid waste from industry and disposal of used lubricating oil containing Cd can be carried into sea waters as well as residues from burning fuel which are released into the atmosphere and then fall into the sea. Cd levels in unpolluted seawater are at a concentration of less than 1 mg/l or less than 1 mg/kg of marine sediment (1 ppm). Various records show that Cadmium (Cd) has been used in various industries such as dyeing, lubricating oil, metal coating, metal smelting, batteries, and fuel, especially fossil fuels. The Cd content in super phosphate fertilizer can reach 170 ppm, fuel and lubricating oils contain up to 0.5 ppm of Cd, and coal contains up to 2 ppm of Cd (Syukur, 2018; Agustina, 2014).

Cadmium (Cd) metal can harm to the human body because it can accumulate in the body when it enters through contaminated food or drink. This low sea water temperature causes the cadmium not to melt, but its molecules remain intact and sink, mixing with the mud at the bottom of the sea. Cd metal can enter waters due to the discharge of sediment and waste containing Cd into the environment. The overflow of rivers contaminated with Cd elements and inundating areas such as bays and rice fields will continue with the absorption of these elements by plants such as mangroves or other plants around these areas.

Poisoning by the heavy metal Cd has been reported in Japan, which causes lumbago disease which progresses to bone damage resulting in softening and cracking of the bones (O'Neill, 2004). The body organs targeted for Cd poisoning are the kidneys and liver, if the content reaches 200 μg Cd/gram (wet weight) in the kidney *cortex* which will result in kidney failure and end in death. The accumulation of Cd in the body increases with age, namely half-life in the body is in the range of 20 - 30 years (Yoga & Sadi, 2016).

Cadmium that is absorbed by the human body enters the body through food and can be excreted through feces, but a small portion enters the kidneys and is excreted in urine. The heavy metal Cadmium (Cd) in the kidneys can accumulate with proteins in the kidneys so that it can cause interference with enzyme activity. If you eat foods that contain Cadmium (Cd) for a long time, it will result in chronic poisoning. Symptoms will occur after a long time and are chronic, such as; poisoning of the kidney nephrons is known as nephrotoxicity. Another impact of chronic Cadmium (Cd) poisoning is that it can cause cardiovascular disorders, namely circulatory failure which is characterized by decreased blood pressure or increased blood pressure (hypertension) . Accumulation in the body mainly occurs in the organs of the liver and kidneys. The effect of acute poisoning is disruption of the digestive tract. Meanwhile, chronic effects, after long-term exposure to cadmium, especially impaired kidney function (Widowati et al., 2008; Zahro & Suprapto, 2015).

Water and sediment can contain heavy metals, such as the results of research by Rochyatun et al. (2010) which shows that heavy metal levels in sea water at the mouth of the Cisadane River in July 2005 ranged from Pb ≤ 0.001 0.005 ppm, Cd ≤ 0.001-0.001 ppm, Cu ≤ 0.001-0.001 ppm, Zn ≤ 0.001 ppm and Ni ≤ 0.001-0.003 ppm. The heavy metal levels (Pb, Cd, Cu, Zn and Ni) in sea water at the mouth of the Cisadane River which were quite high in July 2005 were Pb metal, followed by Ni, Cu, Zn and Cd metals.

Conclusion

From the previous description and discussion, a conclusion can be drawn from this research, namely that the content of the heavy metal Cadmium (Cd) in Ricefield Eels (*Monopterus albus*) originating from Rawa Taliwang Lake ranges from 2.55 ppm to 4.01 ppm.

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Author Contributions
Khairuddin as the main author, writing original draft, Yamin was involved in the methodology and discussion and Kusmiyati was also involved in writing the draft and methodology.

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Conflicts of Interest
The authors declare no conflicts of interest in preparing this research article.

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