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Trend of Rainfall Pattern in Palembang for 20 Years and Link to El-niño Southern Oscillation (ENSO)

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ABSTRACT

One factor that significantly affects rainfall in Indonesia, especially in Palembang City, is *the El-Niño Southern Oscillation* (ENSO). This study aims to determine how big the correlation is and when the highest correlation occurs between the Niño 3.4 Index and rainfall during the 2001-2020 period. The stages of analysis carried out to carry out this study are as follows: 1) downloading daily rainfall data for 20 years, 2) processing the raw data to make it homogeneous, and 3) correlation analysis to find out when the highest correlation occurs between rainfall and the Niño 3.4 Index. The results show that the highest correlation occurs in September at -0.524, August at -0.481, and October at -0.439. The influence of the Niño 3.4 Index produces a negative relationship. If the Niño 3.4 Index increases, it will affect the maximum temperature at the sea surface so that rainfall will decrease and cause drought. The results obtained can also be used as a prediction or forecast of the inflow of rainfall and the length of the rainy season.

INTRODUCTION

Indonesia is a country Island with a climate which very dynamic and complex. One factor affecting Indonesia's weather and climate is the monsoon (Ariska et al., 2022a). The most dominant monsoon cycles are the Asian and Australian monsoons (Kajita et al., 2022; Pachauri et al., 2014). Monsoons occur periodically, but the beginning of the rainy season and seasondrought are not always the same throughout the year (Pachauri et al., 2014) because the seasons in Indonesia are influenced by global phenomena such as El Niño, La Niña, Southern Oscillation, and Dipole Mode Events (DME) or Indian Ocean Dipole (IODs). The territory of Indonesia, which includes the Monsunal region, is the Southern Part of Sumatra, Central and South Kalimantan, Java, Bali, Nusa Tenggara, and parts of Papua (Aldrian, 2001; Aldrian & Susanto, 2003; Hermawan, 2010). Kindly general, El Niño triggers happening condition drought prolonged in the territory of Indonesia and can cause a drop in the temperature advance sea in the region waters Indonesia whereas La Niña tends to increase sea surface temperature in Indonesian waters (Iskandar et al., 2008; Kutzbach, 1967; Luhwahyudin & Citrosiswoyo, 2012). This condition occurs repeatedly for 3 - 8 years and is usually related to the index Oscillation south of one negative value (Handoko et al., 2019).

Many previous studies have shown that the occurrence of the El Niño phenomenon has a major impact on climate conditions in the

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world, including Indonesia (Aldrian, 2001; Aldrian & Susanto, 2003; Dewanti et al., 2018; Iskandar, 2010). However, this study analyzes rainfall patterns in Palembang City by correlating the ENSO phenomenon in the Pacific Ocean with rainfall data for the last 20 years (2001-2020). The diversity of climate in Palembang City, which is increasingly fluctuating day by day, motivates researchers to see that the climate trend in Palembang City is already heading towards extreme climate change in anticipation of the threat of hydrometeorological disasters in Palembang City, such as forest and land fires. Therefore, research on climate patterns in Palembang City must be updated occasionally. This study explains the trend of changing rainfall patterns in Palembang City for the last 20 years, from 2001-2020, and links its relation to the ENSO phenomenon. The decrease or increase in rainfall due to the ongoing El Niño phenomenon has caused Indonesia to experience a longer dry season than normal.

Palembang City is located between 1 °37′27″- 4°55′17″ South latitude and between 102 °3′54″and 106°13′26″ East longitude with an area of 91,806.36 km^2. In terms of climatology, southern Sumatra has a tropical and wet climate with variations in rainfall per day of 61.0-634.4 mm throughout the year. It has temperatures that tend to be hot, ranging from 26.4 ℃ to 27.8 ℃ with an average air temperature of around 26.8 ℃ (Molle & Larasati, 2020; Pandia et al., 2019; Swenson & Grotjahn, 2019). Geographical, topographical, and climatological conditions make the southern part of Sumatra prone to floods, landslides, abrasion, and climate change. Climate change, including rainfall, impacts many things, such as water resources, agriculture, and health. In this study, an analysis will be carried out to determine how big the correlation is ENSO, especially the Niño 3.4 Index with rainfall in the Southern Sumatra region during the last 20 years. Therefore, this research aims to predict and predict the inflow of rainfall and the length of the rainy season that will occur in the city of Palembang.

METHOD

In this study, the daily rainfall data was obtained from one of the rain observation posts in Palembang, the Palembang Climatology Station. The comparison data used is an anomaly of sea surface temperature *Niño 3.4 (SST Index Niño 3.4*) taken from the NOAA website *https://psl.noaa.gov/gcos_wgsp/Timeseries/ Niño34/*. The data obtained is in the form of raw data in *Excel form*, which will be processed utilizing data homogenization. Data homogenization is checking back the data that will be used manually using filters in Excel to group data. Data with a value of 8888 is changed to zero to normalize the data obtained. Data that is empty per month is complemented by looking at data from the website *http://www.meteomanz.com/* and for missing or empty data, justification is carried out by averaging the data on the day before with the data on the day after taking into account the months in the seasonal patterns that often occur (Akhsan et al., 2022; Novi et al., 2018).

Rainfall data and sea surface temperature index Niño 3.4 are searched for on average each month and grouped for each month each year from 2001-2020, which will become 20 data. Correlation analysis is calculated between the average Niño 3.4 Index and the average monthly rainfall 12 months in 20 years. The results of the correlation analysis will produce a correlation coefficient indicating the high degree of relationship between the Niño 3.4 Index and rainfall. The correlation value is calculated using Pearson's correlation in Microsoft Excel.

Pearson correlation is a simple correlation involving only one dependent variable and one independent variable, measuring the strength of the linear relationship between the two variables. The formula for the Pearson product moment correlation coefficient (Bhatti et al., 2020; Zhan et al., 2017), **r** is;

$$r_{yx_i} = \frac{n\sum X_i Y - (\sum X_i)(\sum Y)}{\sqrt{n\sum X_i^2 - \sum X_i^2 \;\; n\sum Y^2 - \sum Y^2}} \quad (1)$$

With:

r_{yx_i}: The correlation coefficient between Y and X

X : Independent variable (independent)

Y : Dependent variable (dependent)

n : Total data

The independent variable (*independent)* is the monthly average of the Niño 3.4 index each year from 2001-2020 in 20 years, and the dependent variable (the *dependent)* is the monthly average of rainfall every month from the rain observation post. *Pearson's Product Moment* correlation formula has an r table to determine the significance level, a measure of validity according to the amount of research data, and the percentage of error rate values (Simanjuntak et al., 2020). Correlation is a statistical technique used to measure or see the closeness of the relationship (correlation) between two variables. The measure that states the closeness of the relationship is called the correlation coefficient (Misnawati & Perdanawanti, 2019). If the value of r count > r table, it means that there is a correlation between the connected variables. If r count <r table, then there is no correlation between the connected variables. The level of significance can be seen in the table of values for the correlation coefficient "r" (Cavazos, 2000; Emery & Thomson, 2016).

Table 1. Table of R Critical of Pearson One-tail Correlation

df=N-2	0.1	0.05	0.025	0.01
18	0.299	0.3783	0.4438	0.5155
20	0.284	0.3598	0.4227	0.4921
34	0.233	0.2785	0.3291	0.3862
35	0.216	0.2746	0.3246	0.381
37	0.216	0.2673	0.316	0.3712
38	0.216	0.2638	0.312	0.3665

RESULTS AND DISCUSSION

The territory of Indonesia, especially southern Sumatra with coordinates 1-4 °LS and 102-196 °E, from 2015 to early 2016 felt the impact of the strong El Niño phenomenon, which caused forest and land fires and was followed by the La Niña phenomenon in mid-2016 which resulted in an increase in rainfall up to 200 percent (wet-dry). The El Niño phenomenon is characterized by an SST anomaly with a positive value of more than 0.5 $°C$ (if the SST anomaly value is greater than +1.5 °, it means that El Niño is strong), and the La Niña phenomenon is characterized by a negative SST anomaly of less than -0.5 °C.

The correlation analysis shows that the Niño 3.4 index significantly affects rainfall only during the ASON transition season. These results indicate that only the August-November rainfall has a real correlation with the Niño 3.4 index (Kajita et al., 2022; Novi et al., 2018).

Table 2. The Correlation between the Niño 3.4 Index and Rainfall

Month	Correlation
January	0.150228138
February	0.205584027
March	-0.0443131
April	-0.14591507
May	0.16545433
June	0.0269082
July	-0.02251121
August	-0.48133269
September	-0.524873723
October	-0.439591199
November	-0.387599009
December	-0.019333

Based on the correlation results obtained at 12 months in 20 years between the Niño 3.4 index and rainfall, the highest correlation was obtained in several ASON periods, specifically in September at -0.5248 with a significance of 1%, in August at -0.4813 with a significance of 2%, in October at -0.439

with a significance of 5%, and in November at -0.387 with a significance of 5% (Table 2). Meanwhile, the lowest correlation was in December.

The correlation value obtained is in the form of a negative correlation which indicates that the relationship is inverse between rainfall and the Niño 3.4 index. If the Niño 3.4 index increases, rainfall will decrease, whereas if the Niño 3.4 index decreases, rainfall will increase. In general, the relationship between the Niño 3.4 index with rainfall is negative because if the Niño 3.4 index is positive, it will affect the maximum temperature, causing heat or dryness, which means rainfall will decrease, resulting in drought. From these results, it can also be seen that the lowest significance occurs in December. January and February are where this is because, in those months, there is an apparent sun movement in the Southern Hemisphere (BBS) so that the wind blows from North to South, better known as the West Monsoon, and causes a wet month in these three months. The remaining months are a transitional period (the transition from the dry season to the rainy season and the transition from the rainy season to the dry season) with results that are close to significance. Based on the results of the correlation test that has been carried out, a significant relationship is obtained between Niño 3.4 and rainfall in Palembang City, so significant results are obtained in August, September, October, and November. This trend can be observed in Figure 1- 4.

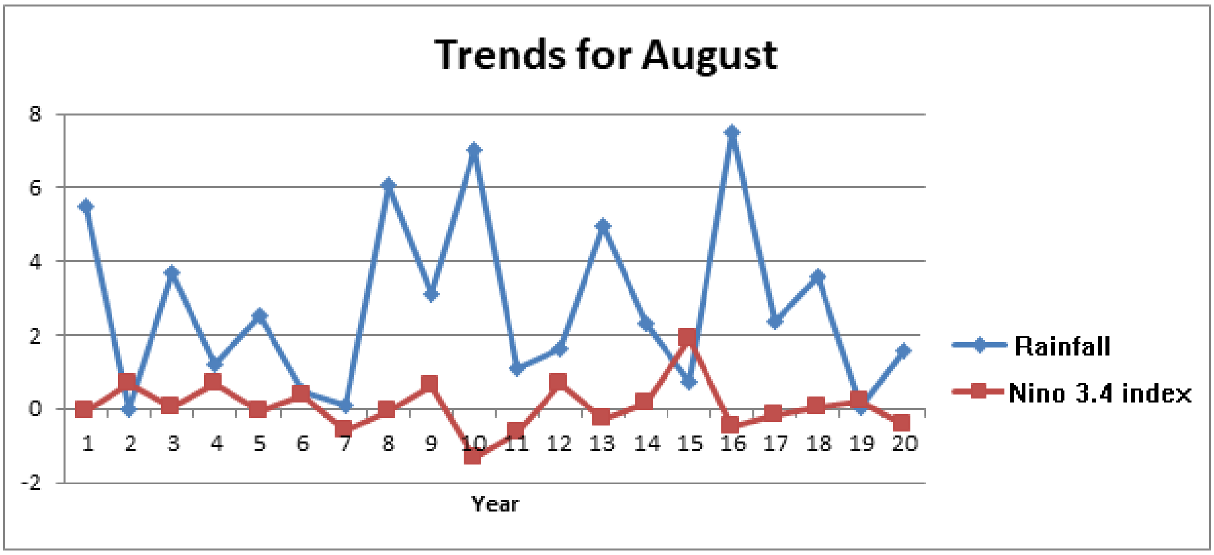


Figure 1. Rainfall Trend in August in 20 Years

Based on the trend between the Niño 3.4 Index and rainfall, a negative correlation value was obtained in 2015 and 2016 to show an inverse relationship between the average rainfall and the Niño 3.4 Index. In 2015 it can be seen that rainfall decreased while the Niño 3.4 Index increased conversely in 2016. The rainfall has increased dramatically, and the Niño 3.4 Index has decreased. When rainfall increases, there is a La Niña period. When rainfall decreases, drought occurs during the El Niño period. La Niña also occurred in 2010 and 2011.

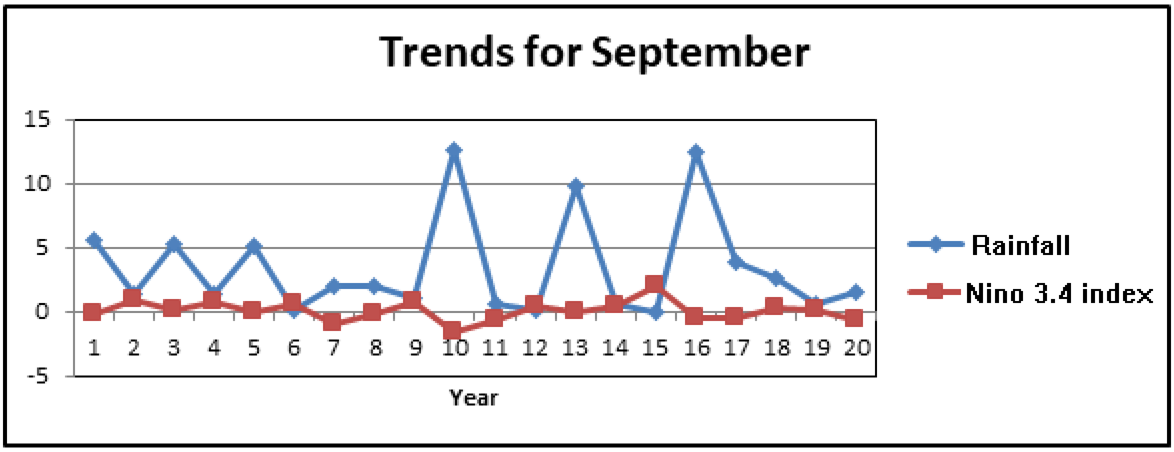


Figure 2. Rainfall Trend in September in 20 Years

The results in September in 20 years clearly show that in 2010, 2013, and 2016 there was an increase in rainfall, so a strong correlation was obtained with a negative correlation value.

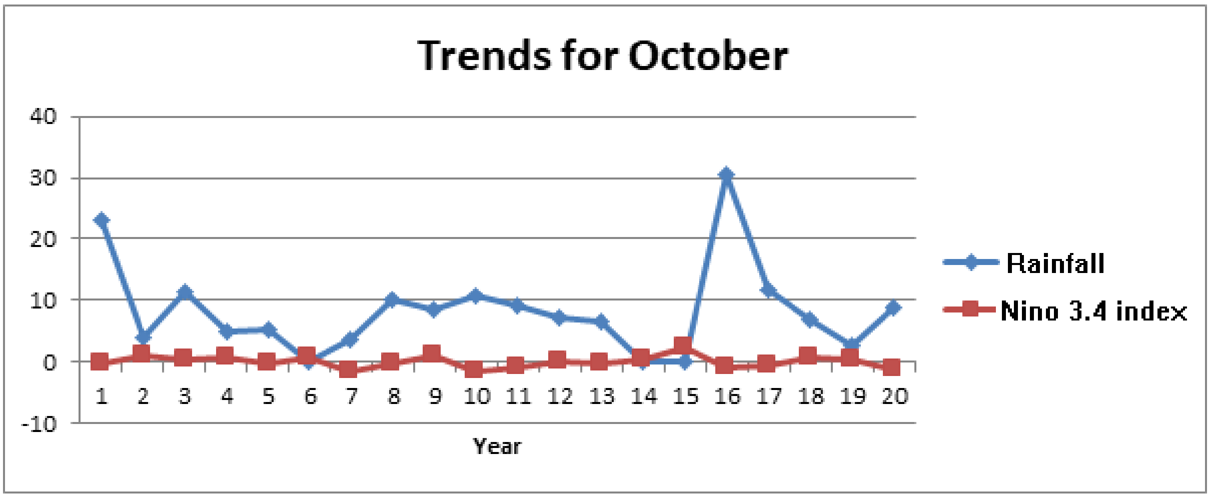


Figure 3. Rainfall Trend in October in 20 Years

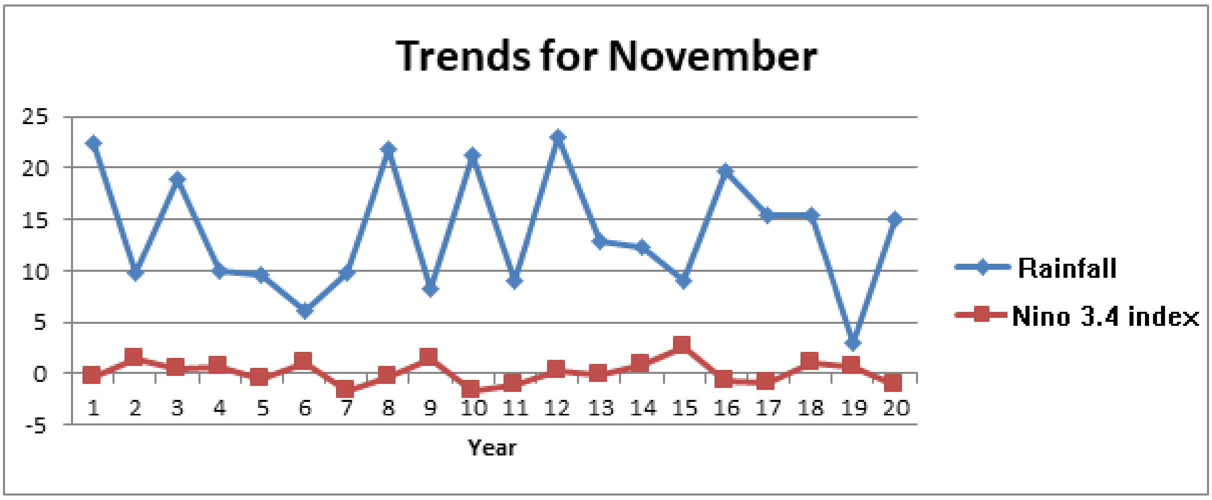
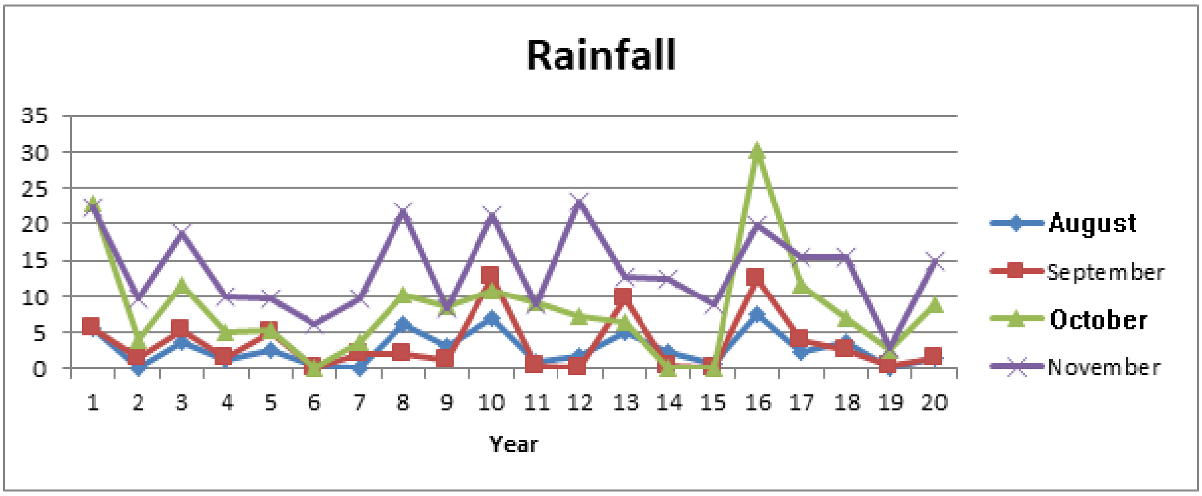
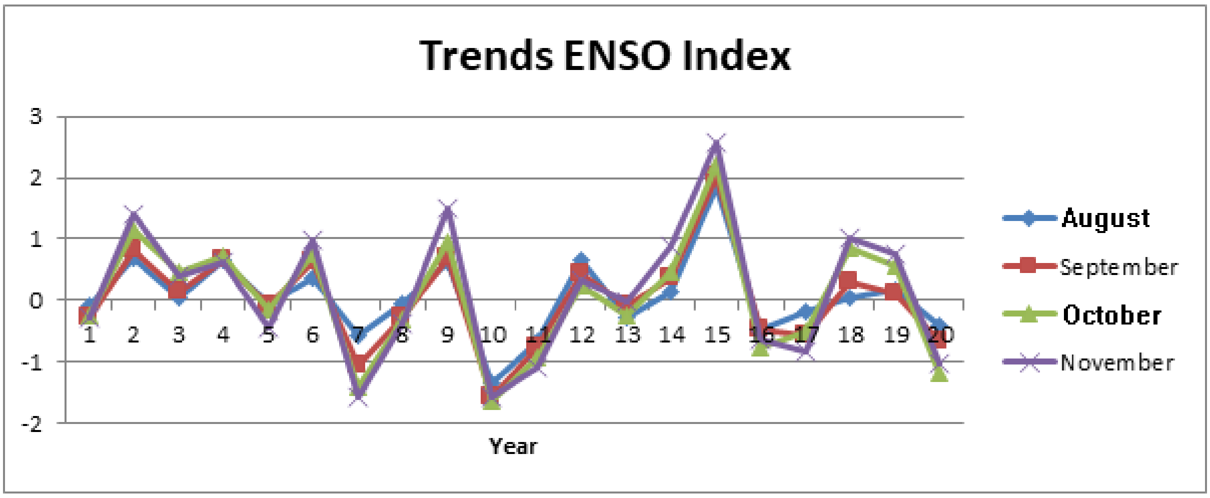


Figure 4. Rainfall Trend in November in 20 Years



(a)



(b)

Figure 5. (a) Rainfall Trend (b) Niño 3.4 Index Trend for 20 Years

When the four data obtained in August, September, October, and November are compared, the rainfall experienced the highest increase in 2016. The decrease in rainfall, with the highest Niño 3.4 Index, occurred in 2015. The correlation coefficient for the following four months is the strongest, with a negative correlation. In months other than the ASON transition period, there is no significant correlation between rainfall and Niño 3.4 Index (Rouw et al., 2014; Lyons, 1982).

These results follow the results of a study by (Hafizhurrahman et al. 2015; Kutzbach, 1967; Misnawati & Perdanawanti, 2019; Pourasghar et al., 2012), which shows that the transition season has a high level of predictability while the green season has a low level of predictability (Ariska et al., 2022b). The greater the value of the sea surface temperature anomaly (the more positive or El Niño occurs), the more negative the rainfall data (Bhatti et al., 2020; Tavakol et al., 2020).

The Impact of El Niño and La Niña Events in Southern Sumatra

The results showed that the correlation between the Niño 3.4 Index and rainfall reached a correlation value of 0.38 – 0.52 with high significance. However, this also indicates that other factors besides Niño 3.4

affect rainfall in the Southern Sumatra (Aldrian & Susanto, 2003; Ramage, 1968). The Niño index of 3.4 has more influence on sea surface temperature so that it can cause El Niño to occur, which causes drought and rainfall trends to be below normal. El Niño and La Niña have far-reaching impacts on many sectors, including agriculture, health, climate, and disasters. Several factors influence the occurrence of El Niño. Depending on the intensity of strong/weak El Niño, the factors are local (geographical location, topography, and others) and the season and the ongoing period (month/time) (Brandes et al., 2002; Dewanti et al., 2018).

CONCLUSION

The effect of the Niño 3.4 Index on rainfall in the southern part of Sumatra is only significant during the transition season in August-November, while for other months, it is not significant. The correlation between Niño 3.4 and rainfall shows a negative correlation, so an increase in sea surface temperature (Niño 3.4) will cause a decrease in rainfall and a shift in climate. The impact of El Niño has a wider effect on agriculture, health, water resources, drought, and forest fires.

AUTHOR CONTRIBUTIONS

MA as coordinator of data processing and checking the accuracy of research results. FP reviewed the literature, edited the manuscript, and made the programming code. HA edited the data and checked the manuscript. All authors read and agreed on the final script.

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