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Research paper

Effect of Climate Change on Onion Production in Solapur District, (M.S), India

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KEYWORDS

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ABSTRACT

One of the districts in the state of Maharashtra is Solapur, which lies in a semiarid area. The changing environment of today affects people all around the world and disrupts their way of life. One of the industries most affected by climate change, patterns of precipitation, floods, droughts, and unusually high or low rainfall is agriculture. Floods and droughts are natural occurrences, but because of climate change, they can also be indicators of the state of the local climate. In the Solapur district, several farmers are considering onions as a profitable crop. For these reasons, it has grown in demand as a cash crop in recent years among smallholder farmers. The production of onions is impacted by excessive rainfall, which also has an impact on new product arrivals, increasing demand, and ultimately raising prices. In this regards, efforts are taken to check whether the climate affecting production in Solapur district or not.

1. Introduction

Maharashtra accounts for around 55-60 % of the country's Kharip production and 36- 40% of the country's Rabi production. Owing to inelastic demand and seasonal production of onion, the onion prices are not stable throughout the year. Price fluctuation creates uncertainty in the income levels of crop growers and the price paid by the consumer (Kambale and Tiwari, 2019). Extensive variability in the quantity and distribution of rainfall causes severe crop damage and economic losses to farmers (Gadage and Lawande, 2012).

The climatic changes cause disease in crops, which means more use of chemical fertilizers and insecticides which are very costly, as well as increasing temperature causes more irrigation (Agale and Thaware, 2020). Increases in temperature, rainfall, and relative humidity also affected post-storage quality causing considerable loss (Chahal and Mishra, 2021). Saline water limits the productivity of onion crops (Pessoa et al., 2019). Onion crops in Maharashtra affected by adverse climatic conditions like extremely high temperatures and excessive rainfall, found Climate change is perceived by the farmers with lack of access to information regarding climate resilient technologies, lack of knowledge about other adaptation options and their proper method of implementation, insufficient access to inputs and improper knowledge about timings and dosage of biofertilizers

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for increasing the resilience of onion crop to climatic vagaries among other constraints faced by them (Chahal and Mishra, 2021).

Climate change is the major cause of the low production of onion crops worldwide. Fog, dew, unseasonal rainfall, temperature variation, hailstorm, cloudiness, this climatic phenomenon occurs due to climate change (Agale and Thaware 2020). Thus, the overall area effect played an important role in the variation of onion production in Maharashtra during the study periods. (Baviskar et al., 2022).

Onion is one of the most water-logging sensitive crops as the severity of depleting oxygen and light supply to the developing roots are very high, thereby affecting the gas exchange process and inducing anaerobic fermentation pathways ultimately affecting plants' normal metabolic pathways in waterlogged soil (Kuruwanshi et al., 2021). The yields are significantly influenced by temperature, particularly the daily maximum temperature during the cultivation periods (Gibum et al., 2024). Onion post-harvest loss has diverse environmental effects that include resource-related, climatic, and ecological aspects (Satheesan, 2024).

2. Materials and Methods

Data on relative humidity and temperature precipitation during the previous 34 years were obtained from the Indian Meteorological Department in Pune. The existing monthly rainfall, humidity, and temperature data were converted into an annual average rainfall, annual average maximum and minimum temperature, and annual average relative humidity. The Onion production and area data of Solapur district is collected from the District Agriculture office Solapur. The Mann-Kendall trend test was used to check for positive or negative trends in data SPSS software was used for correlation, regression, and trend analysis.

3. Result and Discussion

Table 1 Mann-Kendall test observations and interpretation of the average annual temperature, rainfall, and humidity parameters of the Solapur district

Parameter	Mann Kendall's tau	P value- one tailed	Test interpretation
Average Annual maximum Temperature	0.503	3.0994e-05	Reject H_0
Average Annual minimum. temperature	0.114	0.35028	Accept H_0
Average Annual Rainfall	0.112	0.35804	Accept H_0
Average Annual Maximum Relative humidity% (Morning time)	-0.36	0.0022	Reject H_0
Average Annual Minimum Relative humidity% (Evening time)	0.0287	0.82	Accept H_0

Table 2 Correlation of production with climate variables

Variables	Correlation coefficient (r-value)	p-value	Remarks
Area	0.75	0.012	Significant
Average annual rainfall	0.63	0.048	Significant
Average annual relative humidity Morning	0.04	0.91	Not Significant
Average annual relative humidity evening	-0.093	0.79	Not Significant
Average annual minimum temperature	0.21	0.56	Not Significant
Average annual maximum temperature	-0.11	0.75	Not Significant

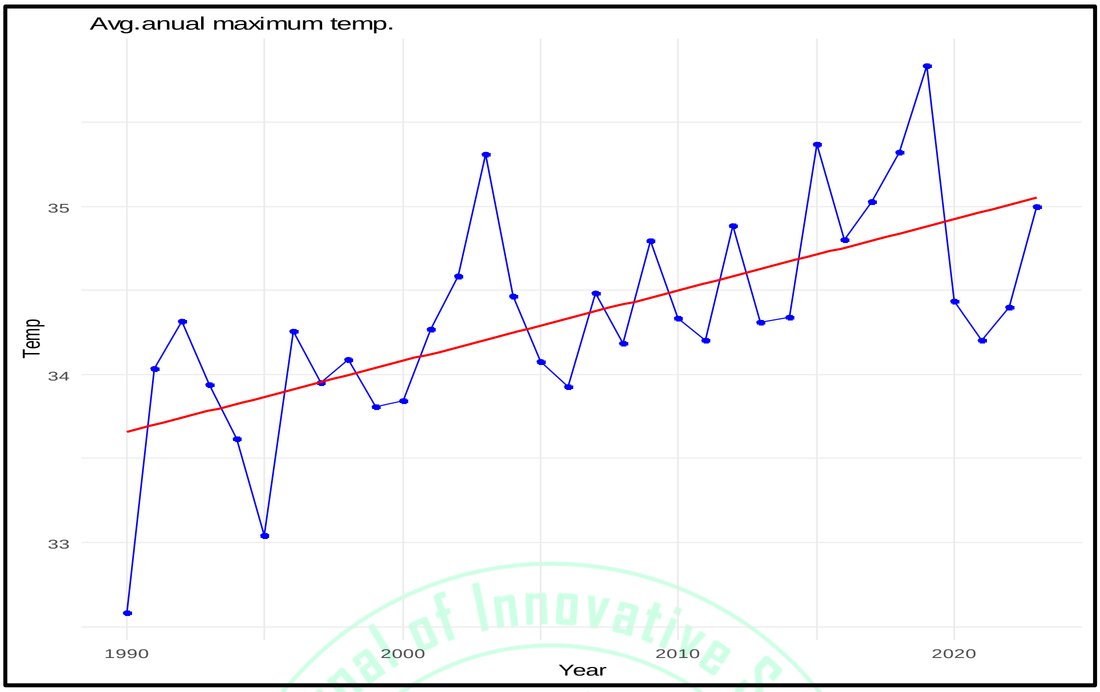

Fig. 1 Average annual maximum temperature trend of Solapur district

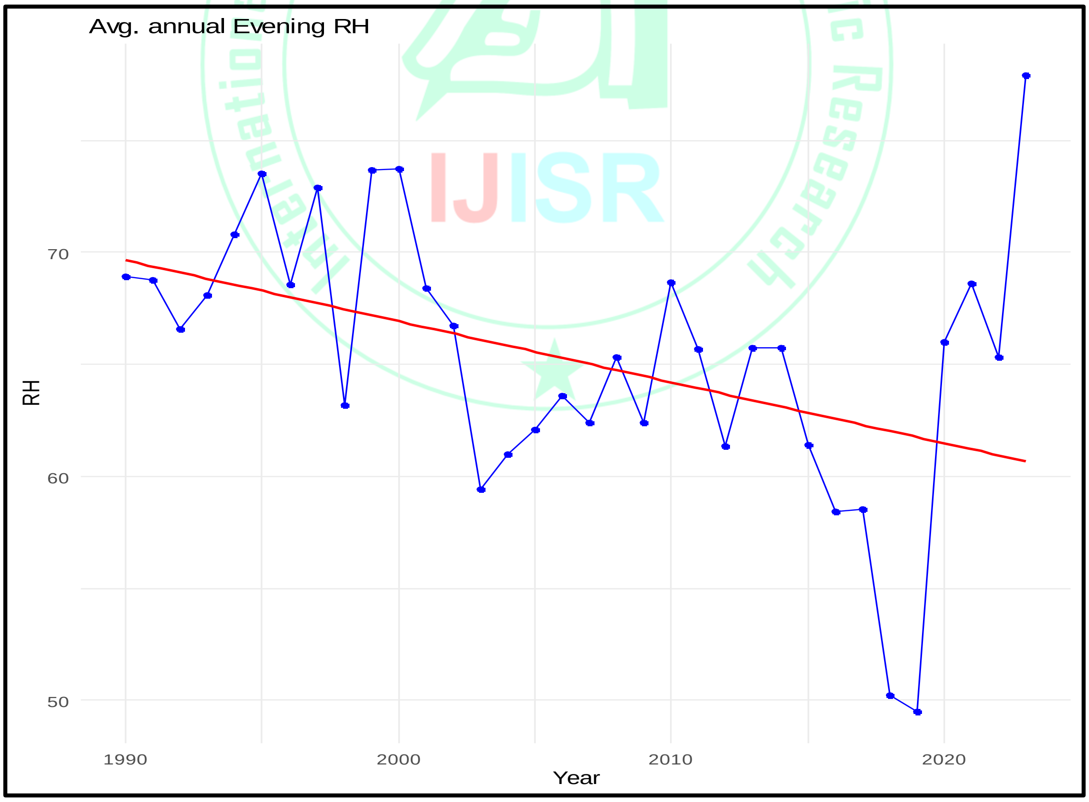

Fig. 2 Average annual maximum (Morning time) Relative humidity trend of Solapur district

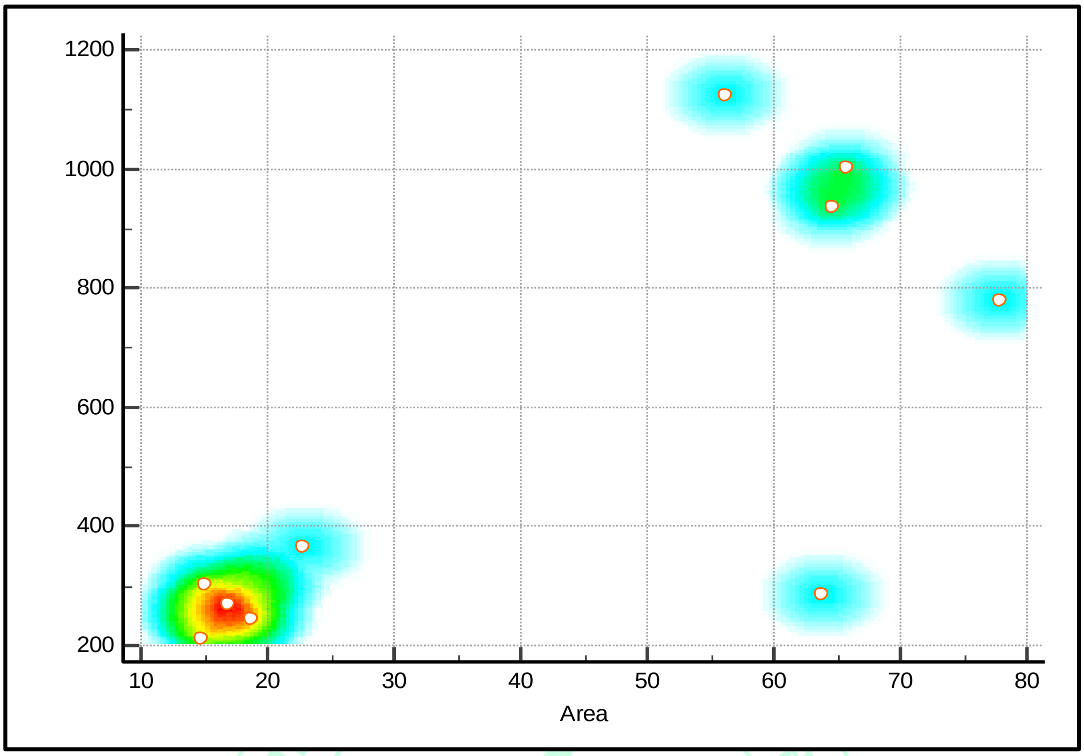

Fig. 3 Correlation between production and area

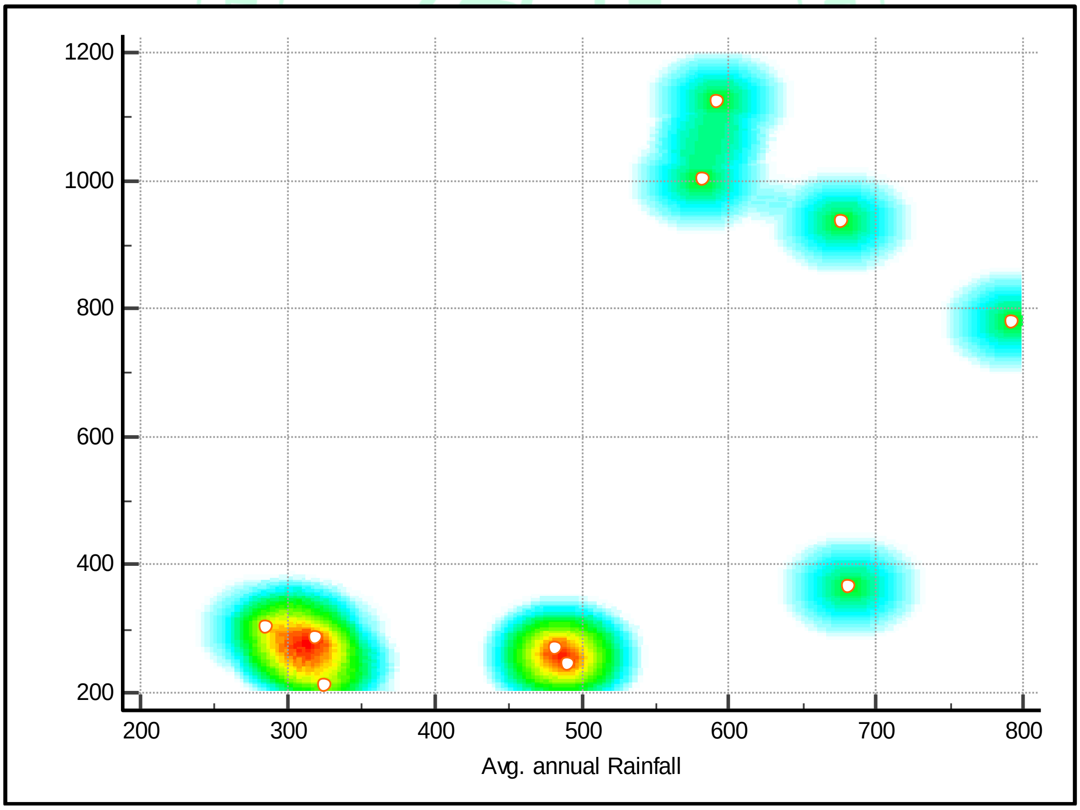

Fig. 4 Correlation between production and avg. annual rainfall

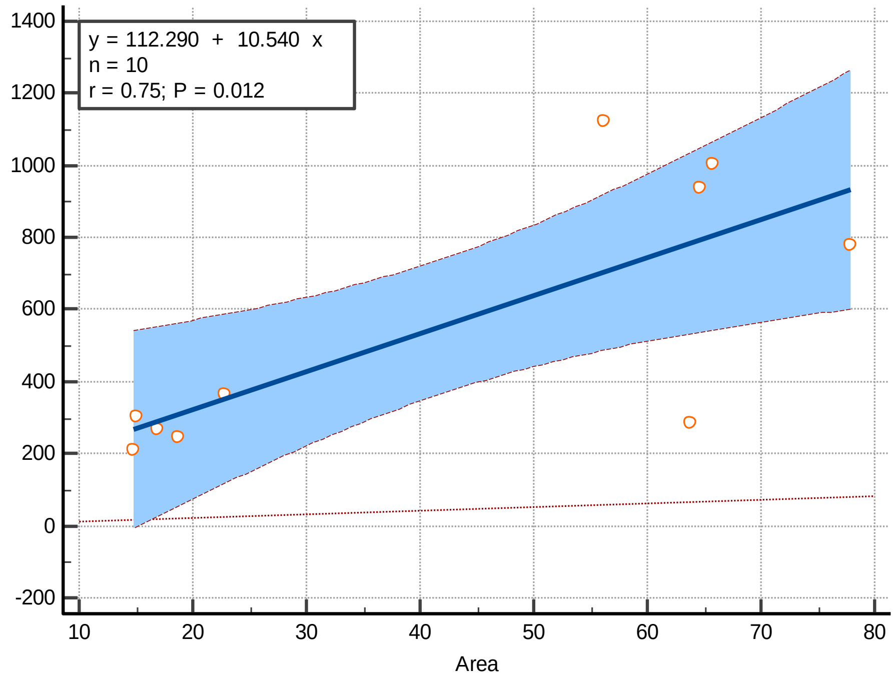

Fig. 5 Regression analysis of Area and Production

3.1 Regression Equation

y = 112.2900 + 10.5398 x

3.2 Regression Analysis

Parameter	Coefficient	Std. Error	95% CI	t	P
Intercept	112.2900	158.2920	-252.7320 to 477.3119	0.7094	0.4982
Slope	10.5398	3.2728	2.9926 to 18.0870	3.2204	0.0122

3.3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square
Regression	1	670886.61018	670886.61018
Residual	8	517517.92075	64689.74009

F-ratio	10.37083
Significance level	P=0.0122

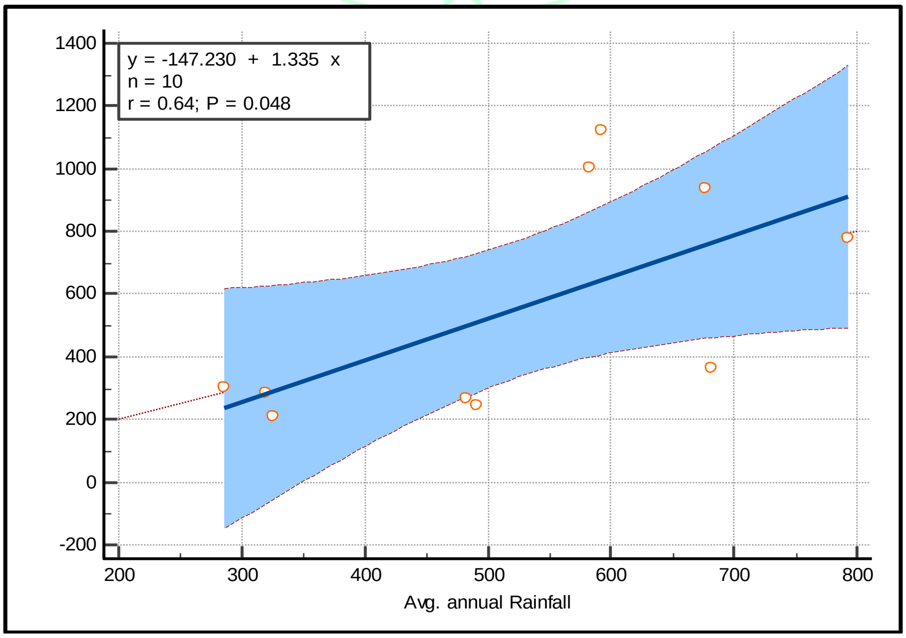

Fig. 6 Regression analysis of Avg. annual rainfall and Production

3.4 Regression Equation

$y = -147.2297 + 1.3354\ x$

3.5 Regression Analysis

Parameter	Coefficient	Std. Error	95% CI	t	P
Intercept	-147.2297	314.4801	-872.4220 to 577.9626	-0.4682	0.6522
Slope	1.3354	0.5736	0.01263 to 2.6581	2.3280	0.0483

3.6 Analysis of Variance

Source	DF	Sum of Squares	Mean Square
Regression	1	479951.66083	479951.66083
Residual	8	708452.87010	88556.60876

F-ratio	5.41972
Significance level	P=0.0483

The regression equation is

$$\text{Production} = -145.4021 + 8.0846 \times (\text{Area}) + 0.6881 \times (\text{Avg. Annual Rainfall})$$

The multiple regression model explains 64.11% of the variance in production, with the overall model being statistically significant ($F = 6.25$, $p = 0.0277$). While Area shows a borderline significant effect on production, suggesting that larger areas contribute to higher production, though the effect is not strongly confirmed ($p = 0.0685$). In contrast, the effect of Avg. Annual Rainfall does not significant impact on production ($p = 0.2611$), indicating the predictors do not overlap in their contributions. Thus, Area appears to be a more influential predictor of production.

A value of 0.503 indicates a moderate to strong positive trend, meaning there is a noticeable increasing tendency in the Avg. annual maximum temp over time (Table 1). This indicates that the observed trend is statistically significant. There is strong evidence to reject the null hypothesis. The Mann-Kendall test results suggest a moderate to strong positive trend in the climate data of Avg. annual maximum temp, and this trend is statistically significant. Therefore, we can confidently conclude that there is a meaningful increasing trend in the data over the years fig.1 shows trend of increasing average annual maximum temperature during study period.

A value of -0.36 indicates a weak negative trend, meaning there is a noticeable decreasing tendency in the Avg. annual Morning RH data over time (Table 1). The Mann-Kendall test results suggest a weak negative trend in the Avg. annual Morning RH, but this trend is statistically significant. Fig.2 shows negative trend of average annual maximum (morning time) relative humidity during study period.

The regression analysis shows that there is a statistically significant linear relationship between the area variable and the production variable, as evidenced by the significant slope ($p=0.0122$) fig.3 and 5 (Table 2). The model's overall significance is supported by the ANOVA results (F-ratio = 10.37083, $p=0.0122$). However, the intercept is not statistically significant ($p=0.4982$), indicating that the expected value of the dependent variable when the independent variable is zero is not reliably different from zero.

The regression analysis reveals a statistically significant linear relationship between the avg. The annual rainfall variable and the production variable, are indicated by the significant slope ($p=0.0483$) fig.4 and 6 (Table 2). The model's overall significance is confirmed by the ANOVA results (F-ratio = 5.41972, $p=0.0483$). However, the intercept is not statistically significant ($p=0.6522$), suggesting that the expected value of the dependent variable when the independent variable is zero is not reliably different from zero.

4. Conclusion

The present study will focus on findings on the impacts of climate change on onion production conducted in Solapur district (Maharashtra) during 1990-2024. The research includes the study of climate change in Solapur district by using trend analysis and regression analysis and trend analysis of Average annual Maximum and minimum temperature, rainfall, and morning and evening time relative humidity revealing that there is an increasing trend in average annual maximum temperature and average annual morning time relative humidity with no significant trend in average annual rainfall, average annual minimum temperature, and average annual evening time relative humidity.

Studies so far focus on single parameters like only temperature rainfall or humidity or in dual combinations. Similar results are found and mentioned in the Climate Action Plan by Solapur Municipal Corporation (2024). Patil and Toradmal (2020) studied the Rainfall trend of the Solapur district for the years 2000-2019 and found a slightly decreased rate of mean annual rainfall. Joshi et al (2019) found a similar trend in the average annual rainfall of the Solapur district for the years 1961-2017. In present research gives an idea of the latest trend in the Average annual rainfall of the Solapur district.

The correlation regression analysis between climate variables and onion production in Solapur district shows there is a linear and positive correlation between area and production of onion i.e. area under onion cultivation affects onion production in Solapur district. On the other hand, climate variables average annual rainfall, maximum and minimum temperature, and morning and evening time RH do not affect the annual production of onion in the Solapur district. Thus, Area appears to be a more influential predictor of production. Dasagiri et al (2014) revealed that area instability is a major reason for the instability of Onion production in a study of Maharashtra's Onion growth and instability.

Thus, in areas affecting Onion production, similar results are revealed by Sharma et al. (2017) in research on the effect of area on the yield of onion in Rajasthan. Choubey (2014) found a positive correlation between yield per hectare and area in India. Current research gives a clear idea about the relationship between climate variables and Onion Production in the Solapur district.

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Authorship Confirmation/Contribution Statement (CRediT Format)

- Conceptualization-author 1
- Methodology -author 1
- Data curation-author 1
- Formal analysis -author 1
- Investigation -author 1
- Writing-author 1
- Writing-review and editing-author 2
- Funding acquisitions -author 1
- Supervision-author 2

All authors have read and agreed to the published version of the manuscript.

Author(s') Disclosure (Conflict of Interest) Statement

The authors declare no conflict of interest related to this research.

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