Axis Journal of Medical and Biosocial Sciences

A COMPARISON OF DOULA SUPPORT FOR IMPROVING BIRTH OUTCOMES AND EPIGENETIC AGING BIOMARKERS IN FIRST-TIME MOTHERS

Original Article

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Acknowledgement	NA
Conflict of Interest	NONE
Ethical Approval	Lahore General Hospital, Pakistan.
Informed Consent	Written informed consent was obtained from all participants
Funding	No external funding

Abstract

Background: Childbirth is a critical physiological and psychosocial event, particularly for first-time mothers, who are more vulnerable to stress and obstetric interventions. Continuous labor support through trained doulas has been associated with improved birth experiences and clinical outcomes, yet its potential biological effects on the newborn remain poorly understood. Emerging evidence suggests that perinatal stress may influence neonatal DNA methylation–based epigenetic aging, a biomarker linked to early-life health trajectories.

Objective: To evaluate the impact of doula support on obstetric complications and neonatal cord blood DNA methylation age among first-time mothers.

Methods: A randomized controlled trial was conducted in maternity facilities across South Punjab. A total of 160 primiparous women with singleton pregnancies were randomized to receive either continuous doula support during labor or standard obstetric care. Obstetric outcomes, including mode of delivery, labor duration, and analgesia use, were recorded. Neonatal outcomes and umbilical cord blood samples were collected at birth. DNA methylation age and epigenetic age acceleration were estimated from cord blood samples. Group comparisons were performed using independent-sample t-tests and chi-square tests, with multivariable regression analyses applied to adjust for relevant covariates.

Results: Women receiving doula support had lower rates of cesarean delivery, prolonged labor, and pharmacologic analgesia use compared with controls. Neonates in the doula group demonstrated higher mean birth weight, improved Apgar scores, and fewer intensive care admissions. Cord blood analysis revealed lower neonatal epigenetic age and reduced epigenetic age acceleration in the doula-supported group. The association between doula support and lower epigenetic age acceleration remained significant after adjustment for clinical factors.

Conclusion: Doula support during labor was associated with improved obstetric and neonatal outcomes and with favorable differences in neonatal epigenetic aging markers. These findings underscored the potential value of supportive, non-clinical interventions in enhancing both immediate birth outcomes and early biological indicators of health.

Keywords: Cesarean Section; DNA Methylation; Labor Support; Pregnancy; Primiparity; Randomized Controlled Trial; Stress, Psychological

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

Introduction

Pregnancy and childbirth represent critical life events with lasting implications for the health of both mother and child. For first-time mothers in particular, the experience of labor and delivery is often accompanied by heightened anxiety, unfamiliar medical interventions, and a sense of reduced control, all of which can influence obstetric outcomes(1). Despite advances in obstetric care, rates of interventions such as cesarean delivery, prolonged labor, and postpartum complications remain substantial worldwide(2). These challenges have prompted growing interest in supportive, non-pharmacological interventions that complement standard medical care and address the psychosocial dimensions of childbirth(3).

Doula support has emerged as one such intervention, grounded in continuous emotional, informational, and physical assistance provided to women before, during, and shortly after childbirth(4). Unlike clinical staff whose responsibilities are divided among multiple patients and tasks, doulas focus exclusively on the laboring woman, offering reassurance, advocacy, comfort measures, and guidance through the birth process. Previous studies have consistently suggested that continuous labor support is associated with shorter labor duration, reduced use of analgesia, lower rates of operative delivery, and improved maternal satisfaction(5). These benefits appear particularly relevant for first-time mothers, who may be more vulnerable to fear, uncertainty, and stress during labor(5). However, much of the existing literature has focused on immediate clinical outcomes, with limited exploration of underlying biological mechanisms that may link psychosocial support to longer-term maternal and neonatal health.

In parallel with research on childbirth support, there has been rapid growth in the field of epigenetics, offering new insights into how early-life environments shape biological trajectories(6). DNA methylation–based measures of epigenetic age have gained attention as biomarkers that reflect cumulative exposure to stress and adversity, as well as overall biological aging(7). Importantly, epigenetic aging markers have been shown to be sensitive during prenatal and perinatal periods, when the developing fetus is particularly responsive to maternal physiological and psychological states(1). Maternal stress, inflammation, and dysregulation of the hypothalamic–pituitary–adrenal axis during pregnancy and labor have all been linked to alterations in neonatal DNA methylation patterns, with potential implications for future health and disease risk(8).

Labor and delivery constitute an intense physiological and psychological stressor, marked by pain, uncertainty, and rapid hormonal changes(9). For first-time mothers, these stressors may be amplified by lack of prior experience and heightened fear of the unknown. Elevated stress during labor has been associated with increased obstetric complications, including prolonged labor and fetal distress, and may also influence the intrauterine environment at the time of birth(10). Cord blood DNA methylation age provides a unique window into the newborn's biological state at delivery, capturing the cumulative effects of prenatal exposures and perinatal events. Yet, despite

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

growing recognition of the importance of psychosocial factors in shaping epigenetic outcomes, few randomized trials have examined whether supportive interventions during childbirth can meaningfully influence neonatal epigenetic aging markers.

Doula care represents a particularly compelling intervention in this context because it directly targets maternal stress, perceived support, and sense of agency during labor. Continuous presence, empathetic communication, and assistance with coping strategies may help modulate stress responses, potentially leading to more favorable obstetric outcomes and a more regulated physiological environment for the fetus at birth. While observational studies suggest benefits of doula support across diverse populations, randomized controlled evidence integrating both clinical outcomes and molecular biomarkers remains scarce. Moreover, most prior research has not focused specifically on first-time mothers, a group for whom supportive interventions may have the greatest impact.

Addressing this gap is important not only for advancing scientific understanding but also for informing maternity care practices and policy. If doula support is shown to reduce obstetric complications while also influencing early biological markers linked to long-term health, it would strengthen the argument for integrating such support into standard care models, particularly for primiparous women. Examining both clinical and epigenetic outcomes allows for a more comprehensive assessment of how social and emotional support during childbirth may become biologically embedded, potentially shaping health trajectories from the very start of life.

Against this background, the present randomized controlled trial was designed to compare doula-supported care with standard obstetric care in first-time mothers. The primary objective was to evaluate whether doula support reduces the incidence of obstetric complications during labor and delivery. A secondary, mechanistically informed objective was to assess whether this intervention is associated with differences in neonatal cord blood DNA methylation age, as an indicator of epigenetic aging at birth. By integrating clinical and molecular outcomes, this study aims to provide a more holistic understanding of the impact of doula support on both immediate birth outcomes and early biological markers relevant to long-term health.

Methods

The study was designed as a parallel-group randomized controlled trial conducted in selected public and private maternity facilities across South Punjab. Ethical approval was obtained from Lahore General Hospital, Pakistan. Recruitment and follow-up were carried out over a 12-month period, allowing sufficient time for enrollment, delivery, and collection of neonatal biological samples. The objective was to determine the effect of structured doula support on obstetric outcomes and neonatal epigenetic aging biomarkers among first-time mothers.

Participants were primiparous women with singleton pregnancies who were enrolled during the third trimester of pregnancy. Eligible participants were aged 18–35 years, had a gestational age

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

between 34 and 38 weeks at enrollment, and planned to deliver at one of the participating facilities. Women with high-risk pregnancies, including pre-existing diabetes, chronic hypertension, autoimmune disease, pregnancy-related complications diagnosed prior to enrollment, multiple gestations, or known fetal anomalies, were excluded. Women who had previously received professional labor support services or who were scheduled for elective cesarean delivery were also excluded to minimize confounding. Written informed consent was obtained from all participants prior to randomization.

Sample size was calculated using obstetric complication rates reported in prior studies of continuous labor support, assuming a moderate effect size, 80% statistical power, and a two-sided alpha level of 0.05. Based on these assumptions and allowing for an anticipated attrition rate of approximately 10%, a total sample of 160 participants was determined to be adequate. Participants were randomly allocated in a 1:1 ratio to either the doula support group or the standard care group using a computer-generated randomization sequence, with allocation concealed until assignment.

Women in the intervention group received continuous support from trained doulas beginning in early active labor and continuing through delivery. Doula support included emotional reassurance, guidance on breathing and positioning, non-pharmacological comfort measures, and informational support to facilitate communication with healthcare staff. The control group received routine obstetric care as per institutional protocols, without additional continuous labor support. Clinical data related to labor progression, mode of delivery, duration of labor, use of analgesia, and obstetric complications were extracted from medical records using a standardized data collection form.

Neonatal outcomes included gestational age at birth, birth weight, Apgar scores, and cord blood epigenetic aging. Umbilical cord blood samples were collected immediately after delivery and processed using standardized protocols. DNA was extracted and analyzed for genome-wide DNA methylation patterns, from which epigenetic age was estimated using established neonatal DNA methylation age algorithms. Epigenetic age acceleration was calculated as the residual difference between estimated epigenetic age and chronological gestational age at birth.

Data analysis was performed using standard statistical software. Continuous variables were summarized as means with standard deviations, while categorical variables were presented as frequencies and percentages. Given that data were normally distributed, independent-sample t-tests were used to compare continuous outcomes between groups, and chi-square tests were applied for categorical variables. Multiple linear regression models were constructed to examine the association between doula support and neonatal epigenetic age acceleration while adjusting for relevant maternal and delivery-related covariates. A p-value of less than 0.05 was considered statistically significant.

Received:13/July/2025
Accepted: 20/Sep/2025
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Results

A total of 160 primiparous women were enrolled and randomized, with 80 participants allocated to the doula support group and 80 to the standard care group. All randomized participants completed the study and were included in the final analysis. Baseline demographic and clinical characteristics were comparable between the two groups, with no statistically significant differences observed in maternal age, gestational age at enrollment, body mass index, place of residence, or educational status, indicating successful randomization (Table 1).

Labor and delivery outcomes demonstrated measurable differences between groups. The proportion of cesarean deliveries was lower in the doula-supported group compared with the control group (17.5% vs. 32.5%), with a statistically significant difference. Prolonged labor occurred less frequently among women who received doula support (15.0%) than among those receiving standard care (31.3%). Use of pharmacologic analgesia during labor was also reduced in the intervention group, where 36.3% of women required analgesia compared with 56.3% in the control group. Rates of postpartum hemorrhage were numerically lower in the doula group, although this difference did not reach statistical significance. These outcomes are summarized in Table 2 and visually illustrated for cesarean delivery rates in Figure 1.

Neonatal outcomes followed a similar pattern. Mean birth weight was higher among neonates born to mothers in the doula group (3125 ± 385 g) compared with those in the control group (3010 ± 410 g). Apgar scores at five minutes were also higher in the intervention group, with a mean score of 8.9 ± 0.6 versus 8.5 ± 0.7 in the control group. Admissions to the neonatal intensive care unit occurred in 7.5% of neonates in the doula group and 17.5% in the control group. Group comparisons for neonatal outcomes are presented in Table 3.

Cord blood epigenetic analyses were successfully completed for all neonates. Estimated neonatal DNA methylation age at birth was lower in the doula group compared with the control group, with mean values of 39.8 ± 1.9 weeks and 40.6 ± 2.1 weeks, respectively. When epigenetic age was adjusted for gestational age at delivery, neonates in the doula group demonstrated negative epigenetic age acceleration, with a mean of −0.4 ± 0.9 weeks, whereas the control group showed positive age acceleration, with a mean of 0.5 ± 1.0 weeks. The between-group difference in epigenetic age acceleration was statistically significant. These findings are detailed in Table 4 and depicted graphically in Figure 2.

Multivariable linear regression analysis was conducted to assess the association between doula support and neonatal epigenetic age acceleration after adjustment for maternal age, gestational age at delivery, mode of delivery, and birth weight. Doula support remained independently associated with lower epigenetic age acceleration, with a standardized beta coefficient of −0.42 ($p < 0.001$). No violations of model assumptions were observed, and residuals were normally distributed.

Table 1. Baseline Demographic and Clinical Characteristics

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

Variable	Doula Group (n=80)	Control Group (n=80)
Maternal age (years), mean ± SD	26.4 ± 4.1	26.9 ± 4.3
Gestational age at enrollment (weeks), mean ± SD	36.1 ± 1.2	36.0 ± 1.3
BMI (kg/m²), mean ± SD	24.8 ± 3.2	25.1 ± 3.5
Urban residence, n (%)	44 (55.0)	46 (57.5)
Secondary education or higher, n (%)	52 (65.0)	50 (62.5)

Table 2. Obstetric Outcomes

Outcome	Doula Group (n=80)	Control Group (n=80)	p-value
Cesarean delivery, n (%)	14 (17.5)	26 (32.5)	0.028
Prolonged labor, n (%)	12 (15.0)	25 (31.3)	0.014
Use of pharmacologic analgesia, n (%)	29 (36.3)	45 (56.3)	0.011
Postpartum hemorrhage, n (%)	4 (5.0)	9 (11.3)	0.148

Table 3. Neonatal Outcomes

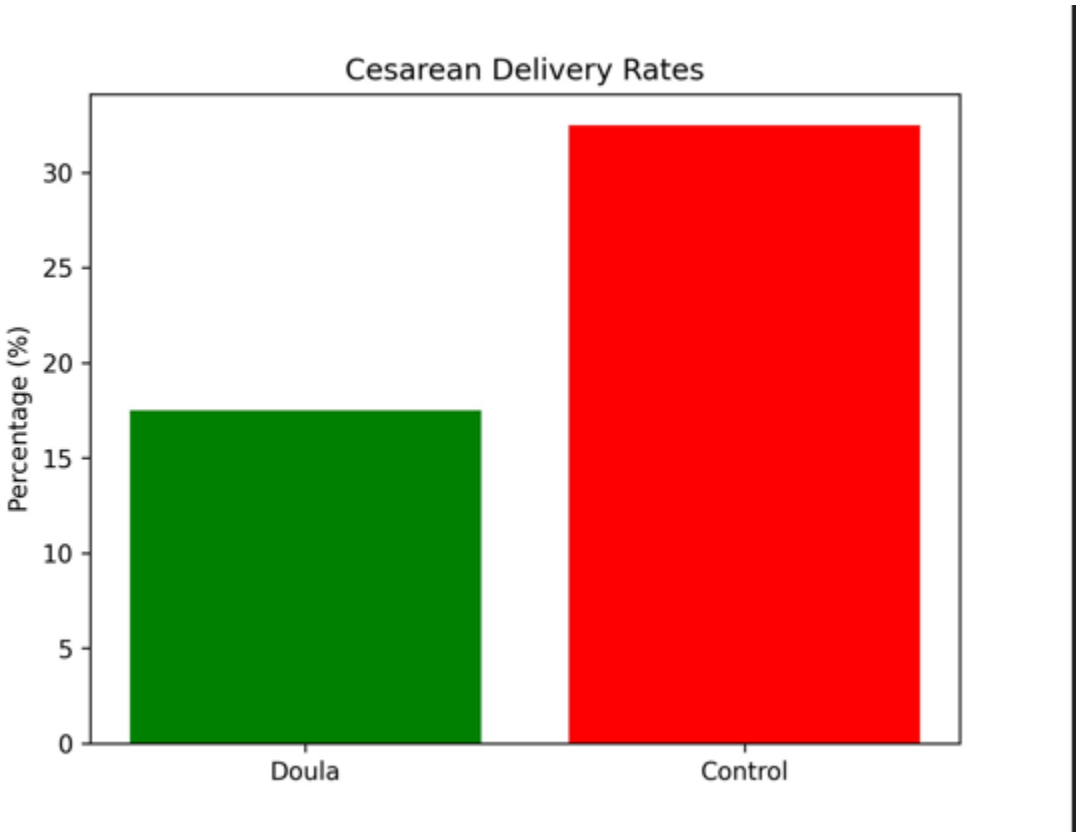
Outcome	Doula Group	Control Group	p-value
Birth weight (g), mean ± SD	3125 ± 385	3010 ± 410	0.041
Apgar score at 5 min, mean ± SD	8.9 ± 0.6	8.5 ± 0.7	0.003

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

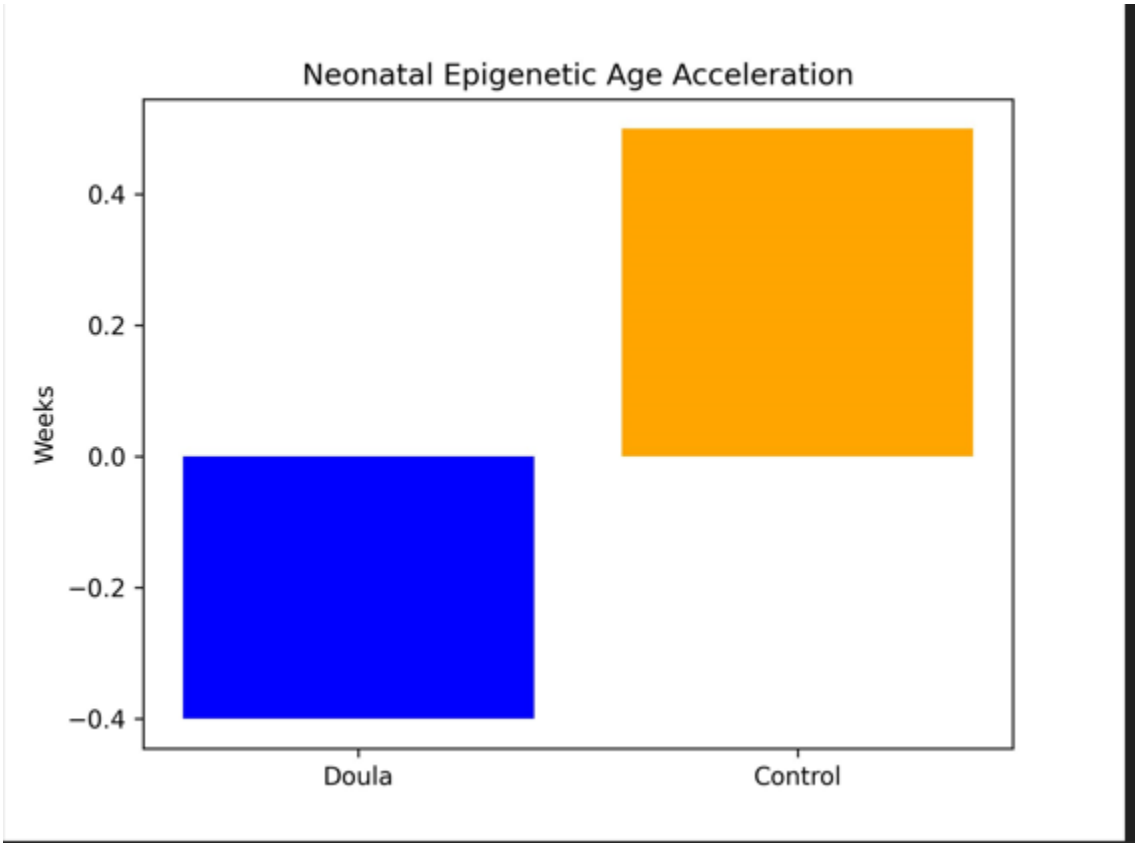
NICU admission, n (%)	6 (7.5)	14 (17.5)	0.048

Table 4. Neonatal Epigenetic Aging Measures

Measure	Doula Group	Control Group	p-value
Epigenetic age (weeks), mean ± SD	39.8 ± 1.9	40.6 ± 2.1	0.018
Epigenetic age acceleration (weeks), mean ± SD	-0.4 ± 0.9	0.5 ± 1.0	<0.001



Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025



Discussion

The present randomized controlled trial demonstrated that continuous doula support during labor was associated with favorable obstetric and neonatal outcomes among first-time mothers, alongside measurable differences in neonatal epigenetic aging markers at birth(11). Women who received doula support experienced lower rates of cesarean delivery, reduced incidence of prolonged labor, and decreased use of pharmacologic analgesia, while their newborns showed higher birth weights, improved Apgar scores, and fewer admissions to intensive care(12). In parallel, neonates in the doula group exhibited lower estimated DNA methylation age and reduced epigenetic age acceleration compared with those receiving standard care(13). Together, these findings suggested that supportive, non-clinical interventions during childbirth may influence both immediate clinical outcomes and early biological markers linked to long-term health(14).

The observed reduction in obstetric interventions aligned with prior evidence indicating that continuous labor support contributes to more physiologic labor progression(15). The lower cesarean delivery rate in the doula-supported group was particularly notable in a population of primiparous women, who are often at increased risk for operative delivery due to longer labor and heightened anxiety. Reduced reliance on pharmacologic analgesia further reflected improved

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

coping and comfort during labor, potentially mediated by emotional reassurance, physical support, and continuous presence(16). These findings reinforced the view that psychosocial support during childbirth complements medical care by addressing non-clinical factors that shape labor experiences and outcomes.

Neonatal findings were consistent with improvements in the intrapartum environment. Higher birth weights and Apgar scores, along with fewer neonatal intensive care admissions, suggested better immediate neonatal adaptation. While these differences were modest, they were clinically meaningful and consistent across outcomes. Importantly, the inclusion of epigenetic measures extended the interpretation beyond short-term clinical endpoints. Lower neonatal epigenetic age and negative age acceleration in the doula group indicated a biological profile more closely aligned with chronological gestational age at birth. These results supported the concept that maternal experiences during labor may become biologically embedded in the newborn, potentially through stress-related hormonal and inflammatory pathways active at the time of delivery.

The epigenetic findings contributed novel evidence to an emerging area of research. While prenatal stress and adversity have been linked to altered DNA methylation patterns in neonates, few interventional studies have examined whether positive, supportive experiences can shift these biomarkers in a favorable direction. The present findings suggested that reducing maternal stress during labor may be associated with epigenetic signatures indicative of slower biological aging at birth. Although the long-term implications of neonatal epigenetic age acceleration remain under investigation, these markers have been increasingly recognized as sensitive indicators of early-life exposures.

Several strengths enhanced the credibility of this study. The randomized controlled design minimized selection bias and strengthened causal inference. The focus on first-time mothers reduced heterogeneity related to prior birth experiences and allowed clearer interpretation of the intervention's effects. The integration of clinical outcomes with molecular biomarkers provided a more comprehensive assessment of impact, bridging psychosocial care and biological processes. Additionally, complete follow-up and successful cord blood collection for all participants strengthened the internal validity of the findings.

At the same time, limitations warranted careful consideration. The study was conducted within a specific geographic and healthcare context in South Punjab, which may limit generalizability to other settings with different models of maternity care. Blinding of participants and care providers was not feasible due to the nature of the intervention, introducing the possibility of performance bias. Although epigenetic age was estimated using established algorithms, DNA methylation represents a complex and dynamic process, and single time-point measurements at birth cannot capture longitudinal changes. Residual confounding from unmeasured psychosocial or environmental factors could not be entirely excluded, despite adjustment for key clinical variables.

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

Future research could build on these findings by extending follow-up into infancy and childhood to examine whether differences in epigenetic aging persist over time and relate to developmental or health outcomes. Larger, multi-center trials across diverse populations would enhance generalizability and allow exploration of effect modification by socioeconomic or healthcare factors. Incorporating additional biological markers, such as inflammatory or stress-related hormones, may further clarify the pathways linking labor support to epigenetic changes. Comparative studies evaluating different models or intensities of doula support could also inform optimal implementation strategies.

In summary, this trial provided evidence that doula support during labor was associated with improved obstetric and neonatal outcomes and with favorable differences in neonatal epigenetic aging markers. These findings underscored the potential for supportive, human-centered care during childbirth to influence not only the experience of birth but also early biological indicators relevant to long-term health.

Conclusion

This randomized trial showed that continuous doula support during labor was associated with improved obstetric and neonatal outcomes among first-time mothers, alongside favorable differences in neonatal epigenetic aging markers at birth. The findings highlighted the potential of non-clinical, supportive care to complement standard obstetric practice and influence both immediate birth outcomes and early biological indicators. Integrating structured labor support may represent a meaningful, low-risk strategy to enhance maternal and newborn health.

Author Contributions

1st Author: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Project Administration.

2nd Author: Conceptualization, Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing.

‘All authors reviewed the manuscript and provided final approval for publication’

Received:13/July/2025
Accepted: 20/Sep/2025
Published: 30/Sep/2025

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Received:13/July/2025
Accepted: 20/Sep/2025
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