### **ORIGINAL RESEARCH ARTICLE**

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# Cerebral palsy risk in relation to parental age: insights from a matched case-control study

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#### Abstract

**Background** Cerebral palsy, a prevalent childhood physical disability, exhibits complex multifactorial causes. This case-control study explores the role of parental age in cerebral palsy risk and associated patterns.

**Methods** A case-control study comparing children with cerebral palsy at ages 3 months to 3 years with agematched healthy control subjects was conducted between January 2022 and August 2023 at Federal Medical Centre, Abeokuta, Nigeria. Cases were recruited from the pediatric physiotherapy outpatient clinic, while controls were selected from pediatric and children emergency wards. Data were collected retrospectively from electronic medical records. Risk factors were evaluated using conditional logistic regression models.

**Results** We studied 134 subjects with cerebral palsy and 134 age-matched control subjects. Significant risk factors for cerebral palsy included the maternal age 35–39 years (odds ratio 2.16, P < 0.005), maternal age  $\geq 40$  years (odds ratio 3.83, P < 0.005), paternal age 41–45 (odds ratio 2.00, P < 0.05), paternal age  $\geq 46$  (odds ratio 6.80, P < 0.05), primiparous (odds ratio 2.2, P < 0.05), paternal low income (odds ratio 2.49, P < 0.05), paternal primary education (odds ratio 2.46, P < 0.05), and maternal primary education (odds ratio 2.39, P < 0.05).

**Conclusions** This research contributes to our understanding of parental age as risk factors associated with cerebral palsy in children. The results also underscore the importance of demographic and socioeconomic factors, especially father's level of income, maternal parity, and parental education. These findings can guide future research and public health interventions aimed at reducing the burden of cerebral palsy.

Keywords Parental age, Cerebral palsy, Case control, Risk factors

#### Introduction

Cerebral palsy (CP) is the most common physical disability in childhood, with a prevalence of around 2.11 per 1000 live births globally [1]. The causes of CP are

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<sup>2</sup> Department of Epidemiology and Medical Statistics, Faculty

<sup>3</sup> Department of Physiotherapy, North Devon District Hospital, Room 4, Flat 5, Chichester House, Upper Raleigh Road, EX314JB, Barnstaple, UK complex and multifactorial, with genetic and environmental factors playing a role. CP is a group of permanent movement disorders that affects a person's ability to move and maintain balance and posture. CP is caused by damage to the developing brain, which may occur before, during, or shortly after birth. This syndrome is the first cause of motor disability and the second cause of neurodevelopmental abnormalities in children after intellectual disability [1]. The exact causes of CP are still unknown, but research suggests that environmental and genetic factors may play a role. One of the potential environmental factors that have been linked to CP is parental age at the time of conception [2, 3]. There is increasing evidence to suggest



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that advanced parental age, particularly maternal age, is associated with an increased risk of CP in offspring. However, the relationship between parental age at conception and CP risk is not well understood, and few studies have explored the potential role of parental age patterns, which considers the age of both parents at the time of conception [4].

Parental age is a well-established risk factor for several adverse outcomes, including birth defects, intellectual disability, and autism spectrum disorders [5, 6]. It has been shown to have a significant impact on child health outcomes, including CP. Some studies have reported an increased risk of CP in children born to older parents [4, 7-9], while others have found no association [10]. However, the relationship between parental age patterns and CP risk remains unclear. Understanding these associations can provide valuable insights for both clinicians and researchers seeking to better identify risk factors and enhance prevention and management strategies for CP. This case-control study, which matches cases of CP with suitable controls, sets out to explore the patterns of parental age concerning the risk of CP. By scrutinizing data from individuals with CP and comparing it to data from matched individuals without the condition, we aim to discern whether advanced maternal or paternal age is correlated with a higher risk of CP. Additionally, we seek to ascertain if there are specific age thresholds at which this risk is more pronounced. The study's intent is to contribute to the broader understanding of risk factors for CP, offering insights that can guide families and healthcare providers in counseling and prevention strategies.

#### Methods

#### Study setting design

This study was conducted at the Federal Medical Centre, Abeokuta, Nigeria (FMCA), in its pediatric physiotherapy outpatient clinic, covering the period from January 2022 to August 2023. As the largest tertiary hospital in Ogun State, FMCA plays a crucial role in providing healthcare services to patients from neighboring towns in the region. The study's ethical considerations were thoroughly addressed, as it was officially approved by the Research Ethics Committee of the Federal Medical Center, Abeokuta, Nigeria (FMCA/470/HREC). Utilizing a matched case-control study design, we aimed to investigate the potential relationship between parental age and the risk of CP. The study participants were selected from our extensive electronic medical records system (EMR), which allowed for a comprehensive and retrospective identification of both cases, consisting of pediatric patients with CP, and control subjects, all meeting the specific study criteria.

# Criteria for inclusion and the selection of both cases and controls

In our study, we identified cases as children with confirmed diagnoses of CP according to the International Classification of Diseases (ICD-10) (G.80.0-9) (WHO, 2016) and prior to study enrollment, while controls were selected from pediatric ward and children emergency ward. These cases were selected from the pediatric outpatient clinic within the physiotherapy department at FMCA.

#### Exclusion criteria for cases and controls

We implemented specific exclusion criteria, excluding children with postnatal CP (Fig 1). Furthermore, we excluded individuals with incomplete or unreliable medical records to maintain data accuracy.

#### Matching

This hospital-based case-control study was matched by patient's age. We employed frequency matching based on patient's age group to ensure a balanced distribution of age in both the case and control groups. Controls were meticulously selected to replicate this age distribution. Matching in case-control studies is done to reduce the potential for confounding variables, thereby strengthening the validity of study findings [11]. It ensures that cases and controls are more comparable in terms of specific characteristics, such as age, gender, or other potential confounders, which allows for a more accurate assessment of the exposure-disease relationship [12]. By matching, we enhanced the ability to detect true associations between exposures (parental age) and outcome (CP) while minimizing the influence of variables that could distort the results, leading to more reliable and interpretable research findings.

#### Sample size

The sample size calculation was based on an 18% prevalence of older women with children having cerebral palsy [13]. To achieve a statistical power of 80% for detecting an odds ratio (OR) of 2.0 with a 95% confidence interval, we adopted a 1:1 ratio of cases to controls. Consequently, the determined sample size is 268 patients, comprising 134 cases and 134 controls.

#### **Study variables**

The dependent variable in this study was the clinical diagnosis of CP, whereas the independent variables encompassed sociodemographic characteristics (such as patient's age and sex) and parental characteristics



Fig. 1 Flowchart of cases and controls

(including age, religion, level of income, and education status).

#### Statistical analysis

Data were collected, revised, coded, and entered to the Statistical Package for Social Science (IBM SPSS) version 26. The quantitative data were presented as mean and standard deviations, while qualitative variables were presented as number and percentages. The comparison between groups regarding qualitative data was done using chi-square test. The confidence interval was set to 95%, and the margin of error accepted was set to 5%. The *P*-value was considered significant as the following: *P*-value < 0.05, significant (S). In bivariate analysis, odds ratio with 95% confidence interval (CI) was calculated. Risk factors with a *P*-value of  $\leq 0.05$  in the bivariate analysis were retained in the multivariate analysis. The multivariate analysis was conducted to verify the associations between different independent variables and CP and interpreted as significant at a P-value of < 0.05 and 95% CI.

#### Results

This case-control study was conducted on two-hundred and sixty-eight (268) children. Among 134 cases and 134 controls, 167 (62.3%) were males, while 101 (37.7%) were females. There were 90 (33.6%) of the males who had CP, while only 44 (16.4%) were females. The child's age distribution among cases is in Table 1. A higher proportion of the children were first born in cases group (24.3%) and controls (20.5%).

Concerning the parental demographics, majority of the mothers (35.1%) were in the age group of 30–34 years contributing 19.4% among cases and 15.7% among controls. This study also reported a higher percentage for the fathers (32.5%) between the ages of 31–35, with 17.2% attributed to cases and 15.3% to controls. The age groups 31–35 also had 32.1% for the mean parental age which was calculated by summing up both father and mother age and divided by two. Multiparous mothers (60.8%) reported a higher frequency as compared to primiparous mothers (39.2%). More than 65% and 70% of the fathers and mothers were low-income earners respectively. Also concerning level of education, about 171 (63.8%) of the

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1       55(20,5)       65(24,3)         2       30(1,2)         3       27(10,1)       28(10,4)         4 and above       16(6,0)       14(1)         Maternal age (years)       23(8,6)       15(5,6)         20-24       23(8,6)       56(6,7)         30-34       42(15,7)       26(19,4)         35-39       28(2,2)       31(1,6)         2-40       4(15,5)       26(2,1)         8an ± 5D       21,5,2       34(1,2)         Parity       94(35,1)       69(25,7)         Primparous       94(35,1)       69(25,7)         Primiparous       94(35,1)       69(25,7)         Primparous       94(35,1)       69(25,7)         Primage       29(10,8)       11(4,1)         31-35       4(16,4)       4(15,7)         26-30       29(10,8)       11(4,1)         31-35       4(16,4)       28(2,0)         34-40       14(4,1)       28(2,2)         36-40       4(16,4)       28(2,1)         4mean ± 5D       33 ± 5.5       32 ± 5.7         Mean ± 5D       33 ± 5.5       32 ± 5.7         Mean ± 5D       39 ± 5.9       32 ± 5.7 <t< td=""><td>Child position in family</td><td></td><td></td><td>2.232</td><td>0.508</td></t<>	Child position in family			2.232	0.508
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3270.1)280.044 and above16.0011.4.1 <b>Material age (years)</b> 11.036 <b>X</b> =1-2426.0015.6.6.2-2-436.0026.07.30-3420.10.020.10.030-3420.10.020.10.030-3420.80.031.15.0Mean ± SD31.15.820.65.7.Prity9787Multiparous94.05.169.02.7.Primiparous40.14.969.25.7.25-020.08.011.4.1.25-197.00.010.3.1.26-520.08.011.4.1.27-541.05.020.20.2.26-520.08.011.4.1.26-520.08.011.4.1.26-520.08.011.4.1.26-520.08.011.4.1.26-520.08.011.4.1.26-520.08.011.4.1.26-520.08.011.4.1.27-530.3.6.530.4.2.Materia SD30.3.6.530.4.2.Materia SD30.3.6.530.4.2.Materia SD30.9.5.930.4.2.Materia SD30.9.5.930.2.1.Materia SD30.9.5.930.3.1.Multiparous60.2.7.90.7.Multiparous60.2.7.90.7.Multiparous60.2.7.90.7.Multiparous60.2.7.90.7.Multiparous60.2.7.90.7.Multiparous60.2.7.90.7.Multiparous60.2.7.90.7.Multip	2	36 (13.4)	30 (11.2)		
4 and above       16 (60)       1 (1)         Maternal age (years)       11.036 $\Delta = 2$ 23 (8.6)       5 (5.6)         2-2-9       34 (16.0)       26 (9.7)         30-34       42 (15.7)       52 (19.4)         35-39       22 (8.2)       31 (1.6) $\geq 40$ 41.5       10 (3.7)         Mean ± SD       94 (35.1)       69 (25.7)         Multiparous       94 (35.1)       69 (25.7)         Primparous       40 (1.9)       69 (25.7)         Primparous       40 (1.9)       69 (25.7)         Primiparous       94 (35.1)       69 (25.7)         Primparous       40 (1.9)       61 (3.2)         2-5       94 (35.1)       69 (25.7)         Primiparous       94 (35.1)       69 (25.7)         2-5       94 (1.9)       61 (1.2)         2-63       91 (1.9)       13.43         3-35       91 (1.1)       13.43         3-35       91 (1.6)       91 (1.9)         3-46       91 (3.1)       91 (3.1)         Mean ± SD       39 ± 5.9       32 ± 5.7         Mean ± SD       39 ± 5.9       32 ± 5.7         Mean ± SD       39 ± 5.9	3	27 (10.1)	28 (10.4)		
Maternal age (years)         11.036           20-24         23 (8.6)         15 (5.6)           25-29         43 (16.0)         26 (9.7)           30-34         42 (15.7)         52 (19.4)           35-39         22 (8.2)         31 (11.6)           ≥40         4 (15.5)         103.7)           Mean ± SD         31.1 ± 5.8         29.6 ± 5.7           Partny         9.787         9.787           Multiparous         94 (35.1)         69 (25.7)           Primiparous         40 (15.9)         69 (25.7)           Partnal age         13.243         13.243           26-30         94 (15.9)         69 (25.7)           31-35         41 (15.9)         13.243           26-30         9.0 (0.8)         11 (4.1)           31-35         41 (15.3)         46 (17.2)           36-40         41.45.9         11 (4.1)           31-35         11 (4.1)         20 (8.2)           24         5 (1.9)         9 (34)           Mean ± SD         36.3 ± 6.5         34.9 ± 6.4           Mean ± SD         30.3 ± 0.5         34.9 ± 6.4           Religion         52 (0.9 ± 0.5)         36.9 ± 0.5           Islanic	4 and above	16 (6.0)	11 (4.1)		
$20-24$ 23 (86)       15 (5.6) $25-29$ 43 (16.0)       26 (9.7) $30-34$ 42 (15.7)       52 (19.4) $35-39$ 22 (8.2)       31 (11.6) $\geq 40$ 41 (15.0)       10 (3.7)         Mean $\pm$ SD       21 (8.2)       10 (3.7)         Mean $\pm$ SD       94 (35.1)       69 (25.7)         Parity       9787       9787         Multiparous       94 (35.1)       69 (25.7)         Parity       91 (14.9)       65 (24.3)         Patemal age       13.23       3.24 $< 25^{5}$ 40 (14.9)       65 (24.3) $26-30$ 20 (10.8)       14.15 $26-30$ 41 (15.3)       46 (17.2) $36-40$ 41 (16.4)       42 (15.7) $41-45$ 11 (4.1)       22 (8.2) $246       51.90       9 (3.4)         Mean \pm SD       3.3 \pm 5.5       3.2 \pm 5.7         Religion       3.9 \pm 5.9       3.2 \pm 5.7         Mean \pm SD       3.9 \pm 5.9       3.2 \pm 5.7         Multiparous       5.0 (30.0)       1.2 \pm 1.1 \pm 1.1 \pm 1.2 $	Aaternal age (years)			11.036	0.026
25-2943 (160)26 (9,7)30-3442 (15,7)52 (194)35-3922 (8,2)31 (1.6)≥404 (1.5)10 (3.7)Mean ± 5D31 ± 5.852 (5.7)Parity94 (35.1)69 (25.7)Primiparous40 (1.9)65 (24.3)Patematage91 (1.6)69 (25.7)Patematage13 (1.6)52 (3.6)S254 (1.5)61 (3.7)31-3520 (10.8)11 (4.1)31-3520 (10.8)11 (4.1)36-4041 (15.3)46 (17.2)36-4011 (4.1)22 (8.2)41-4511 (4.1)22 (8.2)≥4651.9)93.4)Mean ± 5D63 ± 65.7)12.191Mean ± 5D3.39 ± 5.93.26 ± 5.7Religion20 (3.6)80 (31.0)Religion20 (3.6)80 (3.1)(Anity)82 (30.6)80 (3.1)(Instinativ)80 (3.6)80 (3.1)(Instinativ)60 (25.7)9.877Multiparous60 (25.7)9.877Multiparous60 (3.6)9.131(Instinativ)80 (3.6)9.97(Instinativ)80 (3.6)9.97(Instinativ)80 (3.6)9.97(Instinativ)80 (3.6)9.97(Instinativ)80 (3.6)9.97(Instinativ)80 (3.6)9.97(Instinativ)80 (3.6)9.97(Instinativ)80 (3.6)9.97(Instinativ)9.929.93(Instinativ	20–24	23 (8.6)	15 (5.6)		
$30-34$ $42$ (157) $52$ (194) $35-39$ $22$ (8.2) $31$ (11.6) $\geq 40$ $4$ (15) $10$ (3.7) $Mean \pm 5D$ $31.1 \pm 58$ $29.6 \pm 5.7$ $\mathbf{Prity}$ $\mathbf{Prity}$ $\mathbf{Prity}$ $\mathbf{Prity}$ $\mathbf{Prity}$ $\mathbf{Prity}$ $\mathbf{Pternal age}$ $4(15)$ $69 (25.7)$ $\mathbf{Pternal age}$ $114.1$ $25^{5}$ $4(15,5)$ $114.1$ $31-35$ $29 (10.8)$ $11 (4.1)$ $31-35$ $41 (15.3)$ $46 (17.2)$ $36-40$ $44 (16.4)$ $20 (15.7)$ $41-45$ $114.1$ $22 (8.2)$ $2 4 6$ $51.9$ $93.4$ $\mathbf{Mean} \pm 5D$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $39.5 \pm 5.9$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $32.9 \pm 5.9$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $39.5 \pm 5.9$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $32.9 \pm 5.9$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $39.5 \pm 5.9$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $39.9 \pm 5.9$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $39.9 \pm 5.9$ $32.6 \pm 5.7$ $\mathbf{Mean} \pm 5D$ $\mathbf{Mean} \pm 20.4$ $\mathbf{Mean} \pm 20.4$ $\mathbf{Muitiparous}$ $\mathbf{S2} (30.6)$ $\mathbf{S2} (30.6)$ $\mathbf{Muitiparous}$ $\mathbf{S2} (30.6)$ $\mathbf{S2} (30.6)$ $\mathbf{Muitiparous}$ $\mathbf{S2} (20.6)$ $\mathbf{S2} (20.6)$ $\mathbf{Muitiparous}$ </td <td>25–29</td> <td>43 (16.0)</td> <td>26 (9.7)</td> <td></td> <td></td>	25–29	43 (16.0)	26 (9.7)		
35-39       20, 20, 31, 11.6, 10, 37, 10, 10, 37, 10, 10, 37, 10, 10, 37, 10, 10, 37, 10, 10, 10, 37, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10	30–34	42 (15.7)	52 (19.4)		
$\geq 40$ 40.510.37Mean $\pm$ SD31.1 $\pm$ SA29.6 $\pm$ S7Parity9.787Multiparous9.4 (35.1)6.9 (25.7)Primiparous40 (14.9)6.5 (24.3)Paternal age13.243 $\leq 25$ 4.1 (1.5)4.1 (1.5) $\leq 26$ 2.9 (10.8)11.4.1) $31-35$ 4.1 (15.3)4.6 (17.2) $36-40$ 4.1 (16.3)2.8 (2.3) $41-45$ 11.4.1)2.2 (8.2) $\geq 46$ 5.1 (1.9)9.3.4Mean $\pm$ SD36.3 $\pm$ 6.53.9 $\pm$ 5.9Religion12.191Religion9.87Christianity8.2 (30.6)8.0 (31.0)Isamic6.9 (25.7)9.877Multiparous6.9 (25.7)9.877Multiparous6.9 (25.7)9.4 (35.1)Primiparous6.9 (25.7)9.8 (30.2)	35–39	22 (8.2)	31 (11.6)		
Mean ± SD         Nu ± 5.8         29.6 ± 7.           Parity         9.787           Multiparous         94 (35.1)         69 (25.7)           Primparous         40 (4.9)         65 (24.3)           Paternal age         13.243           \$25         4 (1.5)         4 (1.5)           26-30         29 (10.8)         11 (4.1)           31-35         41 (15.3)         46 (17.2)           36-40         44 (16.4)         42 (15.7)           41-45         11 (4.1)         22 (8.2)           246         5 (1.9)         9 (3.4)           Mean ± SD         36.3 ± 6.5         34.9 ± 6.4           Mean ± SD         30.3 ± 6.5         34.9 ± 6.4           Mean ± SD         33.9 ± 5.9         32.6 ± 5.7           Religion         20 (19.4)         30.9 ± 6.4           Kein ± SD         32.9 ± 5.9         32.6 ± 5.7           Multiparous         20 (30.6)         80 (31.0)           Islamic         82 (19.4)         60 (22.4)           Parity         9.877         9.877           Multiparous         69 (25.7)         94 (35.1)           Primiparous         69 (24.3)         40 (19.9)           Low	≥ 40	4 (1.5)	10 (3.7)		
Parity       9,087         Multiparous       94 (35.1)       69 (25.7)         Primiparous       40 (14.9)       65 (24.3)         Paternal age       13,243         ≤25       4 (1.5)       4 (1.5)         26-30       29 (10.8)       11 (4.1)         31-35       41 (15.3)       46 (17.2)         36-40       44 (16.4)       42 (15.7)         41-45       11 (4.1)       22 (8.2)         ≥46       5 (1.9)       9 (3.4)         Mean ± SD       36.3 ± 6.5       34.9 ± 6.4         Mean ± SD       30.3 ± 5.9       32.6 ± 5.7         Religion       20 (10.4)       30.9 ± 5.9         Christianity       82 (30.6)       80 (31.0)         Islamic       32 (19.4)       80 (31.0)         Islamic       52 (19.4)       9 (36.9)         Parity       9877         Multiparous       60 (25.7)       94 (35.1)         Primiparous       60 (25.7)       94 (35.1)         Parity       99 (36.9)       91 (30.2) <td>Mean ± SD</td> <td>31.1 ± 5.8</td> <td>29.6 ± 5.7</td> <td></td> <td></td>	Mean ± SD	31.1 ± 5.8	29.6 ± 5.7		
Multiparous       94 (35.1)       69 (25.7)         Primiparous       40 (14.9)       65 (24.3)         Paternal age       13.243         25       4 (15)       4 (15.)         26-30       29 (10.8)       11 (4.1)         31-35       41 (15.3)       46 (17.2)         36-40       44 (16.4)       42 (15.7)         41-45       11 (4.1)       22 (8.2)         246       5 (1.9)       9 (3.4)         Mean ± SD       36.3 ± 6.5       34.9 ± 6.4         Mean ± SD       33.9 ± 5.9       32.6 ± 5.7         Mean ± SD       39.9 ± 5.9       32.6 ± 5.7         Mean ± SD       30.9 ± 5.9       32.6 ± 5.7         Meliparous       52 (19.4)       60 (22.4)         Primiparous       52 (19.4)       60 (22.4)         Party	Parity			9.787	0.002
Primiparous         40(14)         65 (24.3)           Paternal age         13.243           \$25         4(15)         4(1.5)           26-30         29 (10.8)         11 (4.1)           31-35         41 (15.3)         46 (17.2)           36-40         44 (16.4)         42 (15.7)           41-45         11 (4.1)         22 (8.2)           ≥46         5 (1.9)         9 (3.4)           Mean ± SD         36.3 ± 6.5         34.9 ± 6.4           Mean ± SD         33.9 ± 5.9         32.6 ± 5.7           Mean ± SD         33.9 ± 5.9         32.6 ± 5.7           Mean ± SD         32.0 ± 1.0         9.802           Mean ± SD         32.0 ± 5.7         9.877           Meligion         52 (19.4)         60 (22.4)         9.877           Multiparous         69 (25.7)         94 (35.1)         9.877           Multiparous         69 (25.7)         94 (35.1)         9.876           Father's level of income         5.976         5.976	Multiparous	94 (35.1)	69 (25.7)		
Paternal age       13.243         ≤25       4 (1.5)       4 (1.5)         26-30       29 (0.8)       11 (4.1)         31-35       4 (15.3)       46 (17.2)         36-40       44 (16.4)       42 (15.7)         41-45       11 (4.1)       22 (8.2)         ≥46       5 (1.9)       9 (3.4)         Mean ± SD       363 ± 6.5       34.9 ± 6.4         Mean ± SD       33.9 ± 5.9       32.6 ± 5.7         Religion       33.9 ± 5.9       32.6 ± 5.7         Christianity       82 (30.6)       80 (31.0)         Islamic       52 (19.4)       60 (22.4)         Parity       9.877       9.877         Multiparous       69 (25.7)       94 (35.1)         Primiparous       69 (25.7)       94 (35.1)         Father's level of income       5.976         Low       99 (36.9)       81 (30.2)	Primiparous	40 (14.9)	65 (24.3)		
≤25       4(1.5)       4(1.5)         26-30       29(10.8)       11 (4.1)         31-35       41 (15.3)       46 (17.2)         36-40       44 (16.4)       42 (15.7)         41-45       11 (4.1)       22 (8.2)         ≥46       5 (1.9)       9 (3.4)         Mean ± SD       36 3 ± 6.5       34.9 ± 6.4         Mean ± SD       36.3 ± 6.5       34.9 ± 6.4         Mean ± SD       33.9 ± 5.9       32.6 ± 5.7         Religion       10.982       0.982         Christianity       82 (30.6)       80 (31.0)         Islamic       52 (19.4)       60 (22.4)         Parity       9.877       9.877         Multiparous       69 (25.7)       94 (35.1)         Primiparous       65 (24.3)       40 (4.9)         Father's level of income       5.976         Low       99 (36.9)       81 (30.2)	Paternal age			13.243	0.021
26-30     29 (10.8)     11 (4.1)       31-35     41 (15.3)     46 (17.2)       36-40     44 (16.4)     42 (15.7)       41-45     11 (4.1)     22 (8.2)       ≥ 46     5 (1.9)     9 (3.4)       Mean ± SD     36.3 ± 6.5     34.9 ± 6.4       Mean ± SD     33.9 ± 5.9     32.6 ± 5.7       Religion     12.191       Christianity     82 (30.6)     80 (31.0)       Islamic     52 (19.4)     60 (22.4)       Parity     9877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       Eatwide     50.6     50.7       Low     99 (36.9)     81 (30.2)	<25	4 (1.5)	4 (1.5)		
31-35     41 (15.3)     46 (17.2)       36-40     44 (16.4)     42 (15.7)       41-45     11 (4.1)     22 (8.2)       ≥ 46     5 (1.9)     9 (3.4)       Mean ± SD     36.3 ± 6.5     34.9 ± 6.4       Mean ± SD     33.9 ± 5.9     32.6 ± 5.7       Religion     2 (19.4)     60 (22.4)       Christianity     82 (30.6)     80 (31.0)       Islamic     52 (19.4)     60 (22.4)       Parity     9.877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       Father's level of income     5.976	26-30	29 (10.8)	11 (4.1)		
36-40     44 (16.4)     42 (15.7)       41-45     11 (4.1)     22 (8.2)       ≥ 46     5 (1.9)     9 (3.4)       Mean ± SD     36.3 ± 6.5     34.9 ± 6.4       Mean ± SD     33.9 ± 5.9     32.6 ± 5.7       Religion     0.982       Christianity     82 (30.6)     80 (31.0)       Islamic     52 (19.4)     60 (22.4)       Parity     9.877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       Father's level of income     5.976       Low     99 (36.9)     81 (30.2)	31-35	41 (15.3)	46 (17.2)		
41-45       11 (4.1)       22 (8.2)         ≥ 46       5 (1.9)       9 (3.4)         Mean ± SD       36.3 ± 6.5       34.9 ± 6.4         Mean ± SD       33.9 ± 5.9       32.6 ± 5.7         Mean ± SD       33.9 ± 5.9       32.6 ± 5.7         Religion       52 (19.4)       60 (22.4)         Christianity       82 (30.6)       80 (31.0)         Islamic       52 (19.4)       60 (22.4)         Parity       9,877         Multiparous       69 (25.7)       94 (35.1)         Primiparous       65 (24.3)       40 (14.9)         Eather's level of income       5.976         Low       99 (36.9)       81 (30.2)	36-40	44 (16.4)	42 (157)		
≥ 46       5(1.9)       9(3.4)         Mean ± SD       36.3 ± 6.5       34.9 ± 6.4         Mean parental age       12.191         Mean ± SD       33.9 ± 5.9       32.6 ± 5.7         Religion       6.982         Christianity       82 (30.6)       80 (31.0)         Islamic       52 (19.4)       60 (22.4)         Parity       9.877         Multiparous       69 (25.7)       94 (35.1)         Primiparous       65 (24.3)       40 (14.9)         Eather's level of income       5.976         Low       99 (36.9)       81 (30.2)	41-45	11 (4 1)	22 (8 2)		
Mean ± SD     36.3 ± 6.5     34.9 ± 6.4       Mean parental age     12.191       Mean ± SD     33.9 ± 5.9     32.6 ± 5.7       Religion     0.982       Christianity     82 (30.6)     80 (31.0)       Islamic     52 (19.4)     60 (22.4)       Parity     9.877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       Father's level of income     5.976       Low     99 (36.9)     81 (30.2)	> 46	5 (1 9)	9 (3 4)		
Mean parental age     12.191       Mean parental age     33.9 ± 5.9     32.6 ± 5.7       Religion     0.982       Christianity     82 (30.6)     80 (31.0)       Islamic     52 (19.4)     60 (22.4)       Parity     9.877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       Father's level of income     5.976       Low     99 (36.9)     81 (30.2)	Jean + SD	363 + 65	349+64		
Mean ± SD       33.9 ± 5.9       32.6 ± 5.7         Religion       0.982         Christianity       82 (30.6)       80 (31.0)         Islamic       52 (19.4)       60 (22.4)         Parity       9.877         Multiparous       69 (25.7)       94 (35.1)         Primiparous       65 (24.3)       40 (14.9)         Father's level of income       5.976         Low       99 (36.9)       81 (30.2)	Vean parental age		0.00 - 0.00	12 191	0.016
Religion     0.982       Christianity     82 (30.6)     80 (31.0)       Islamic     52 (19.4)     60 (22.4)       Parity     9,877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       Father's level of income     5.976       Low     99 (36.9)     81 (30.2)	Mean + SD	339 + 59	326+57	12.1.9.1	0.010
Christianity     82 (30.6)     80 (31.0)       Islamic     52 (19.4)     60 (22.4)       Parity     9.877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       5.976       Low     99 (36.9)     81 (30.2)	Religion	000 - 000	52.0 2 5.7	0.982	0 322
Islamic     52 (19.4)     60 (22.4)       Parity     9.877       Multiparous     69 (25.7)     94 (35.1)       Primiparous     65 (24.3)     40 (14.9)       Father's level of income     5.976       Low     99 (36.9)     81 (30.2)	Christianity	82 (30.6)	80 (31.0)		
Parity         9,877           Multiparous         69 (25.7)         94 (35.1)           Primiparous         65 (24.3)         40 (14.9)           Father's level of income         5.976           Low         99 (36.9)         81 (30.2)	Islamic	52 (194)	60 (224)		
Multiparous         69 (25.7)         94 (35.1)           Primiparous         65 (24.3)         40 (14.9)           Father's level of income         5.976           Low         99 (36.9)         81 (30.2)	Parity	52(1511)	00 (22.1)	9877	0.002
Primiparous         65 (24.3)         40 (14.9)           Father's level of income         5.976           Low         99 (36.9)         81 (30.2)	Multiparous	69 (25 7)	94 (35 1)	5.677	0.002
Father's level of income         5.976           Low         99 (36.9)         81 (30.2)	Primiparous	65 (24 3)	40 (14 9)		
Low 99 (36.9) 81 (30.2)	ather's level of income	00 (21.0)	10 (11.2)	5 976	0.049
	Low	99 (36 9)	81 (30.2)	3.570	0.019
Medium 31 (11.6) 44 (16.4)	Medium	31 (11.6)	44 (16.4)		
High 4 (15) 9 (3.4)	High	4 (1 5)	9 (3 4)		
Mother's level of income 3409	Mother's level of income	1 (1.3)	2 (J. I)	3.428	0 180
Interfer         5.420           Interfer         05 (35.4)         06 (35.8)		95 (35.4)	96 (35.8)	5.720	0.100
Medium 22 (8.2) 20 (10.8)	Medium	22 (82)	29 (10.8)		
High 17 (63) 0 (3.4)	High	17 (63)	Q (3 /)		

#### Table 1 Child, maternal, and parental characteristics with and without CP

Variables	Children without CP (N1 = 134) n1 (%)	Children with CP (N2 = 134) n2 (%)	χ <sup>2</sup>	<i>p</i> -value
Father's level of education			40.525	0.000
Primary	4 (1.5)	26 (9.7)		
Secondary	77 (28.7)	94 (35.1)		
Tertiary	53 (19.8)	14 (5.2)		
Mother's level of education			7.606	0.022
Primary	17 (6.3)	17 (6.3)		
Secondary	80 (29.9)	98 (36.6)		
Tertiary	37 (13.8)	19 (7.1)		

#### Table 1 (continued)

CP cerebral palsy:  $\chi^2$  chi-square: p-value level of significance; SD standard deviation

fathers and 178 (66.4%) of the mothers had secondary education respectively. These findings are summarized in Table 1.

#### **Bivariate analysis**

According to Table 1, there was statistically significant differences according to the bivariate analysis between cases and control group, in respect of maternal age (p = 0.026), parity (p = 0.002), paternal age (p = 0.021), mean parental age (p = 0.016), father's level of income (p = 0.049), father's level of education (p = 0.000), and mother's level of education (p = 0.022).

#### Univariate analysis

Table 2 shows the crude (univariate) and adjusted (multivariate) odds ratios and 95% confidence intervals for CP. Compared with offspring of mothers between 20 and 24 years age, CP risk was 7% lower among children of mothers between 25 and 29 years of age (*COR*: 0.93, 95% confidence interval (CI), 0.41 to 2.09) and 89% higher among children of mothers within the 30–34 years of age (*COR*: 1.89, 95% confidence interval (CI), 0.88 to 4.09). Also relative to mothers between 20 and 24 years of age, mothers between 35 and 39 years of age and above 40 years of age were two times and three times as likely to give birth to a child with CP respectively. Primiparous mothers were significantly more likely to give birth to a child with CP (p = 0.02).

Concerning father's age, CP risk was 62% lower among children of fathers between 26 and 30 years of age as compared to fathers less than 25 years of age. Fathers whose age fall between 31 and 35 years were 12% more likely to have children with CP, and those within 36–40 years of age were 5% less also likely. The odds of having a child with CP is higher among fathers between 41 and 45 years of age as compared to fathers less than 25 years by two times. Fathers who were greater than 46 years were 
 Table 2
 Conditional logistic regression analysis to estimate the odds (odd ratio, OR) of CP

	COR (95% C/)	AOR (95% CI)
Maternal age		
20–24	1	1
25–29	0.93 (0.41-2.09)	3.36 (0.72–15.71)*
30–34	1.89 (0.88–4.09)	8.14 (1.39–47.29)*
35–39	2.16 (0.92–5.05)*	16.66 (2.23–121.69)*
≥ 40	3.83 (1.01–14.49)*	73.33 (4.11–1307.11)
Parity		
Multiparous	1	1
Primiparous	2.2 (1.34–3.66)*	3.76 (1.81–7.81)*
Paternal age		
≤ 25	1	
26–30	0.38 (0.08–1.78)*	1.73 (0.233–12.86)
31–35	1.12 (0.26–4.78)	10.31 (1.19–88.88)*
36–40	0.95 (0.22–4.07)	5.63 (0.67–47.29)
41-45	2.00 (0.42–9.55)	6.29 (0.87–121.42)*
≥ 46	6.80 (3.31–10.52)	10.30 (0.22–171.15)
Joint age	1.04 (0.99–1.09)*	0.85 (0.72–1.01)*
Fathers level of income		
High	1	1
Medium	1.91 (0.81–4.50)	1.58 (0.69–3.59)
Low	2.49 (0.94–6.63)*	0.39 (0.14–1.13)*
Father's level of education		
Primary	24.61 (7.37-82.21)*	0.29 (0.09–0.95)*
Secondary	4.62 (2.39–8.96)*	0.1 (0.10-0.17)*
Tertiary	1	1
Mother's level of educa- tion		
Primary	2.39 (1.27–4.47)*	5.84 (3.21–9.88)
Secondary	1.95 (0.82–4.65)	1.87 (0.75–4.71)
Tertiary	1	1

*CP*, cerebral palsy; *COR*, crude odds ratio; *AOR*, adjusted odds ratio: \**p* < 0.05

six times more likely to have children with CP. This study also puts into consideration the mean of the father and mother's age (mean FM age). For a unit increase in mean FM age, the odds of CP were 1.04 times.

As regards the level of income, fathers with medium level of income were 1.91 times more likely to have children with CP as compared to those with high level of income. The odd of having children with CP was two times higher in fathers with low-income level compared to reference group. The odds of CP were higher in fathers with primary level of education (*COR*: 24.61, 95% confidence interval (CI), 7.37 to 82.21) and lesser in fathers with secondary level of education (*COR*: 4.62, 95% confidence interval (CI), 2.39 to 8.96). Mothers with secondary education were 2 times more likely to have children with CP, while those with primary education were 1.95 times more likely.

#### Multivariable analysis

In the fully adjusted model (Table 2), all maternal age groups, primiparous (*AOR*: 9.49, 95% *CI*: 1.31–68.88), unknown maternal education status (*AOR*: 18.64, 95% *CI*: 2.15–161.73), CNS infection in infancy (*AOR*: 0.02, 95% *CI*: 0.-0.58), and neonatal admission (*AOR*: 0.13, 95% *CI*: 0.03–0.61) remained statistically significant. All maternal age groups were statistically significant with an increase in gradient risk of having children with CP. Mothers with advanced age were statistically more likely to have children with CP (P < 0.05). Fathers age between 31–35 years and 41–45 years of age were also more likely to have children with CP (P < 0.05). Mothers experiencing their first childbirth (AOR: 3.76, 95% CI, 1.81 to 7.81) were also found to have an increased likelihood of having children with crebral palsy.

#### Discussion

CP is one of childhood neurological disorders that impose a significant burden on families as well as society, which needs continuous care and multiple financial resources. Paternal and maternal age have become one of the most discussed risk factors in paternal-maternal-fetal medicine, and its multidimensional impact on the developing fetus has made it one of the main topics of epidemiological research. This study aimed to evaluate the parental age patterns and risk for CP at FMCA. A hundred and thirty-four (134) children with CP as cases and 134 children without CP as controls of age up to 3 years were recruited and matched with child's age.

Among 134 cases, 65.7% of male children and 34.3% of female children were observed which shows the significant difference in the association between the genders. This implies a male predisposition among children with CP which is in congruent with other studies [14-16].

This correlation was explicitly supported in the research conducted by Hagberg et al. in 2001, which affirmed that the female gender exhibited a lower risk of developing CP compared to the male gender [16]. Likewise, a study supported this observation, revealing that the rate of CP per 1000 male births exceeds that among females by about 30% [17]. The male sex represents a risk factor for most neurodevelopmental disabilities such as intellectual disability, autism, attention deficit and hyperactivity disorder, and, mainly, CP, with males representing up to 70% of all affected children [18-20]. This biological vulnerability of the male sex in CP and other neurodevelopmental disorders has been explained by several factors such as a different brain organizations [14, 21], genetic predisposition [21, 22], and the influence of female hormones on a possible reduction of the consequences of brain damage [20]. Therefore, sex has been reported to have an effect on increasing the risk of CP [19], but it is not entirely clear whether it may also affect the severity of the outcome, the development of comorbidities, and the response to treatments. The male embryo is suggested at a greater risk of damage or death [23]. Additionally, stillbirth, premature birth, congenital deformities, perinatal brain damage, and neonatal adverse outcomes are more common in male [24].

Our study highlights the significant association between maternal age and CP, shedding light on the varying risk levels among different age groups. Among these groups, the risk is at its lowest between the ages of 25-29 and escalates dramatically for mothers aged 35 and above as compared to 20-24 years of age. This age-dependent risk factor mirrors the findings of many previous studies, affirming that maternal age plays a pivotal role in the occurrence of CP [24, 25]. The variations in CP risk among different maternal age groups can be attributed to several underlying factors. Firstly, it is well-established that as women grow older, the likelihood of experiencing various health complications during pregnancy increases [26–28]. These complications, such as gestational diabetes and hypertension, can have a direct impact on the developing fetus. Furthermore, older mothers may be more prone to certain genetic mutations that can contribute to CP in their offspring [29-31]. On the other end of the spectrum, younger mothers generally have a lower risk of CP, which can be attributed to factors such as their reduced likelihood of preexisting health conditions, lower rates of chronic diseases, and potentially healthier lifestyles. Additionally, early childbearing often coincides with a shorter reproductive history, potentially resulting in fewer opportunities for adverse events affecting fetal development [31]. The sharp increase in CP risk beyond the age of 35 is a subject of particular concern, as the biological processes in older mothers, such

as the progressive decrease in the number and quality of oocytes, along with the natural aging process of matured ova, can create an environment that is less favorable for the developing fetus [32]. The cumulative effect of these age-related factors significantly raises the likelihood of CP in babies born to mothers aged 35 and older.

Findings from the binary logistic regression also revealed that paternal age is a risk factor for CP. The findings suggest that younger fathers (26-30) might have a reduced risk, while older fathers (41–45 and  $\geq$ 46) appear to face an elevated risk. Young fathers aged 26 to 30 might experience a relatively lower risk of CP. One possible explanation for this reduced risk among younger fathers is their overall better health and potentially more robust sperm quality [33]. These factors could contribute to a healthier fetal development, which, in turn, might lower the risk of CP. Conversely, the situation appears quite different for older fathers, particularly those aged 41 to 45 and those aged 46 or above. The data point towards an elevated risk of CP in these age groups. The reasons behind this increased risk are multifaceted. Advanced paternal age has been associated with a higher likelihood of genetic mutations, as older sperm is more prone to carrying genetic abnormalities [34–36]. These mutations can be a contributing factor to the development of CP in offspring. A study revealed a direct correlation between paternal age and decreased sperm quality and testicular function [36]. Genetic abnormalities, such as DNA mutations and chromosomal aneuploidies, and epigenetic modifications, such as the silencing of essential genes, have all been linked to the father's advancing years [37]. Advanced paternal age has demonstrated an impact on reproductive and fertility results, influencing the efficacy of procedures like in vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI), as well as the incidence of preterm births [36]. A study was conducted on extensive sequencing analysis and found that germline single base-pair alterations increased at a rate of about two base pairs per year with increasing paternal age [38].

Our study also revealed that primiparous mothers were two times more likely to give birth to children with CP. This heightened risk among first-time mothers could be attributed to their relative lack of experience and understanding when it comes to child care, which frequently leads to a multitude of stressors and difficulties. As Nan et al. (2020) have noted, this lack of experience can be particularly overwhelming for first-time mothers, potentially influencing the health outcomes of their children [39]. Furthermore, the unique challenges faced by primiparous mothers may extend to various aspects of child-rearing, from prenatal care to postnatal support, ultimately impacting their children's risk of developing CP. Also, first-time mothers often lack experience in child care and may not recognize early signs of developmental issues [40]. In their early journey into parenthood, these mothers may not be as skilled at deciphering the subtle cues, which refer to the small, often nonverbal signals or hints that babies give to express their needs, feelings, or discomfort [41]. These cues can include changes in facial expressions, body movements, or sounds that experienced parents may readily understand. This lack of experience can result in delayed detection of potential issues and hinder timely interventions. Based on our research, it was evident that fathers with lower income had a twofold increased likelihood of having children with CP. This observation can be elucidated by the cultural context in many African settings, where fathers often bear the role of primary breadwinners, shouldering significant financial responsibilities, including healthcare expenses [42-44]. Consequently, this financial burden, more acutely felt by fathers with limited income, might inadvertently lead to delays in accessing quality healthcare services and timely medical interventions for their children, potentially contributing to the increased risk of CP in offspring.

The findings from our study suggest a strong association between the father's level of education and the risk of CP. Specifically, fathers with primary education had a significantly elevated risk. This observation underscores the importance of husband's education and the woman's health behavior [45-47]. This possibility is supported by the Whitehall studies in the UK, which found that a woman's health behaviors corresponded more closely to her husband's social class than to her own [48]. Fathers with higher educational attainment are often better equipped to make informed decisions regarding maternal and child health. In the United States, a father's socioeconomic information may represent the couple's social position more completely than the mother's, given the persistent gender gap in occupation and income [49], even among college graduates [50]. As a marker of relative social status, paternal education may represent the father's ability to contribute time, energy, and resources to support the mother's health before, during, and after pregnancy.

Mothers with a primary level of education were found to be twice as likely to have children with CP compared to mothers with tertiary education. Consistent with this, a study indicated that a low level of education might be linked to CP, with half of the cases reporting that their mothers were illiterate [43]. In our study, 12.6% of the mothers had only completed primary education, while 73.1% had attained a secondary school education. The low educational level of mothers stands out as a preventable risk factor for CP, similar to many other diseases, and can be addressed through appropriate legislative policies. Elevating the educational attainment of girls holds the potential to foster the emergence of educated mothers and the birth of healthier children. Moreover, an increase in education levels is associated with enhanced health literacy, enabling parents to acquire more knowledge about maintaining a healthy pregnancy and proper pregnancy follow-up [11, 51, 52].

#### Limitations, bias, and generalizability

The study relied on clinically collected data from the EMR which limited the risk factors we could evaluate. For example, reliable information on antenatal risk factors was not available: maternal eclampsia, maternal hypertension, maternal diabetes, physical problem (e.g., fall down), maternal viral diseases, and low birth weight (< 2500 g). Also, drugs used in pregnancy, maternal nutritional status during pregnancy, and maternal alcohol consumption during pregnancy could not be considered in our analysis.

#### Conclusion

Our case-control study revealed that both maternal and paternal age are significant risk factors for the occurrence of CP in children. Being a primiparous mother, along with the father's income level, mother's income level, and the educational status of both parents, also predicts the likelihood of having children with CP. The establishment of a nationwide CP register system in Nigeria is essential for gaining a comprehensive understanding of the condition, and it is imperative for enhancing healthcare services for children with CP.

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#### Authors' contributions

AOF, AOD, OPS, and OMT made substantial contributions to the conception and design of the study. MOO, AE, BEU, and OT participated in the data collection on EMR. AOF analyzed and interpreted the data. AOF and OMT revised the article critically for important intellectual content. The authors read and approved the final manuscript.

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#### Declarations

#### Ethics approval and consent to participate

The Health Research Ethics Committee of the Federal Medical Centre Abeokuta (FMCA) (FMCA/470/HREC) granted approval for the study. Official permission was also obtained from the Head of Physiotherapy Department FMCA.

#### **Competing interests**

The authors declare that they have no competing interests.

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