

Parity, Age at First Birth, and Cognitive Function in Middle-aged and Older Chinese Women: A Cross-sectional Study from the China Health and Retirement Longitudinal Study

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Abstract

Background

Reproductive factors have been increasingly recognized as potential determinants of cognitive aging in women. However, evidence from low- and middle-income countries remains scarce. This study examined the cross-sectional associations of parity and age at first birth with cognitive function among middle-aged and older Chinese women.

Methods

We used cross-sectional data from Wave 4 (2018) of the China Health and Retirement Longitudinal Study (CHARLS). A total of 5,762 women aged 45 years and older were included. Parity was derived from life history data. Cognitive function was assessed using a composite score (range 0–28). Multivariable linear regression was used to estimate the associations. Sensitivity analyses excluded participants with elevated depressive symptoms, multiple chronic conditions, and stratified by urban versus rural residence.

Results

Each additional birth was associated with a 0.58-point lower cognitive score (beta=-0.58, 95% CI: -0.70 to -0.47, $p < 0.001$). Compared with women who had 2 births, those with 4 or more births had significantly lower cognitive scores (beta=-1.58, 95% CI: -2.03 to -1.13, $p < 0.001$). Higher age at first birth was associated with better cognitive function (beta = 0.14 per year, 95% CI: 0.09 to 0.18, $p < 0.001$). A significant interaction was observed between parity and age at first birth ($p = 0.014$). All associations remained consistent across sensitivity analyses.

Conclusions

Higher parity and younger age at first birth were independently associated with lower cognitive function in Chinese women. These cross-sectional findings support the maternal depletion hypothesis and highlight reproductive history as a potential risk indicator for cognitive aging.

1. INTRODUCTION

Cognitive decline and dementia represent one of the greatest public health challenges of the 21st century, particularly in rapidly aging societies such as China [1, 2]. Women are disproportionately affected by Alzheimer's disease and related dementias, accounting for approximately two-thirds of all cases globally [3]. This sex disparity has prompted growing interest in reproductive factors as potential determinants of cognitive aging.

The maternal depletion hypothesis posits that repeated pregnancies and childbirths may deplete maternal physiological reserves, including nutrients, hormones, and energy stores, potentially increasing vulnerability to cognitive decline in later life [4, 5]. Pregnancy involves substantial metabolic and immunological demands, including the preferential transfer of docosahexaenoic acid (DHA) from mother to fetus [6]. Each pregnancy may also expose women to elevated estrogen and cortisol levels, which could have lasting effects on hippocampal and prefrontal cortical structures [7].

Age at first birth may also influence cognitive trajectories. Women who give birth at younger ages may experience interrupted educational and occupational opportunities and socioeconomic disadvantage, all established risk factors for cognitive decline [8, 9]. Conversely, later childbearing may be associated with greater educational attainment and accumulated cognitive reserve [10].

Epidemiological evidence from high-income countries has produced inconsistent findings [11–14]. Most existing evidence comes from Western populations, and data from low- and middle-income countries (LMICs), where the burden of dementia is growing fastest, remain scarce.

China presents a particularly important and unique setting for this research. Chinese women of the current older generation experienced high fertility rates before the implementation of the one-child policy in 1979, with many women having four or more births [15]. The coexistence of a high-fertility historical cohort and a one-child policy cohort within the same national dataset allows for comparative analyses that are not feasible in most other populations. Moreover, China's rapid demographic transition, combined with limited healthcare and nutritional resources during the reproductive years of the current older generation, may amplify the effects of maternal depletion.

Therefore, the present study aimed to examine the cross-sectional associations of parity and age at first birth with cognitive function among middle-aged and older Chinese women.

2. METHODS

2.1 Study Design and Data Source

This cross-sectional study used data from Wave 4 (2018) of the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative longitudinal survey of Chinese adults aged 45 years and older [15]. The study was approved by the Ethical Review Committee of Peking University, and all participants provided written informed consent.

2.2 Study Population

Female participants from Wave 4 (2018) were included if they: (1) were aged 45 years or older; (2) had complete cognitive assessment data; (3) had valid parity information; and (4) had at least one birth (parity ≥ 1). The analytical sample comprised 5,762 women.

2.3 Variables

Parity and age at first birth. Parity was derived from the CHARLS Life History module as the maximum number of children ever reported across ages 15–80. Age at first birth was the age at which the participant first had a child. Parity was examined as a continuous variable and categorically (1, 2, 3, or 4 + births, with 2 as reference). Age at first birth was analyzed as continuous and categorized (≤ 20 , 21–25, 26–30, > 30 years).

Cognitive function. Cognitive function was assessed using four tests: (1) immediate word recall (0–10); (2) delayed word recall (0–10); (3) serial 7 subtractions (0–5); and (4) orientation (0–4). A composite score was calculated (range 0–29) [16].

Covariates. Age (continuous), education (illiterate, primary, middle+), marital status, CESD-10 depression score (continuous), and self-reported physician-diagnosed hypertension, diabetes, heart disease, and stroke (each yes/no). Smoking (ever vs. never) and alcohol consumption (ever vs. never) were also adjusted.

2.4 Statistical Analysis

Descriptive statistics were calculated. Multivariable linear regression models examined the associations of parity (continuous and categorical) and age at first birth (continuous) with cognitive function. Model 1 adjusted for age; Model 2 additionally for education and marital status; Model 3 (fully adjusted) included all covariates. Stratified analyses by age group (< 60 vs. ≥ 60 years) and education level were conducted. The parity-by-age-at-first-birth interaction was tested. Robust standard errors (Huber-White) were used. Statistical significance was set at $p < 0.05$.

2.5 Sensitivity Analyses

Three sensitivity analyses assessed robustness: (1) excluding participants with CESD-10 ≥ 10 ; (2) excluding those with two or more chronic conditions; (3) stratifying by urban versus rural residence. All used the same covariate adjustment as the main model.

3. RESULTS

3.1 Participant Characteristics

A total of 5,762 women were included. The mean age was 64.1 years (SD = 8.3), mean parity was 3.0 (SD = 1.6), and median age at first birth was 24.0 years (IQR: 21–27). The majority (93.0%) were illiterate. The mean cognitive score was 10.2 (SD = 6.9). Women with 1 birth had a higher median age at first birth (27.0 years) and greater proportion with formal education (13.4%). Detailed characteristics are in Table 1, and the participant screening and inclusion flow is presented in Fig. 1.

Table 1
Baseline characteristics by parity group, CHARLS 2018 (n = 5,762)

Characteristic	Overall (n = 5762)	Parity 1 (n = 655)	Parity 2 (n = 1915)	Parity 3 (n = 1445)	Parity 4+ (n = 1747)
Age, years, mean (SD)	64.1 (8.3)	61.9 (8.8)	63.8 (8.2)	64.7 (8.1)	65.4 (8.0)
Education, n (%)					
Illiterate	5355 (93.0)	567 (86.6)	1766 (92.2)	1352 (93.6)	1670 (95.6)
Primary	363 (6.3)	75 (11.5)	137 (7.2)	87 (6.0)	64 (3.7)
Middle or higher	44 (0.8)	13 (2.0)	12 (0.6)	6 (0.4)	13 (0.7)
Married/partnered, %	74.8	84.6	79.3	73.5	67.4
Age at first birth, median (IQR)	24 (21–27)	27 (24–30)	24 (22–26)	23 (21–25)	22 (20–24)
Cognitive score, mean (SD)	10.2 (6.9)	11.8 (7.2)	10.4 (7.0)	9.8 (6.7)	9.4 (6.7)

3.2 Parity and Cognitive Function

In the fully adjusted model, each additional birth was associated with a 0.58-point lower cognitive score (beta=-0.58, 95% CI: -0.70 to -0.47, $p < 0.001$). When analyzed categorically (Table 2), women with 1 birth had higher scores than those with 2 births (beta = 1.54, 95% CI: 1.01 to 2.08, $p < 0.001$), while those with 3 births (beta=-0.85, 95% CI: -1.28 to -0.42, $p < 0.001$) and those with 4 or more births (beta=-1.58, 95% CI: -2.03 to -1.13, $p < 0.001$) had significantly lower scores(Fig. 2).

Table 2
Associations of parity and age at first birth with cognitive function

Variable	Model 1 beta (95% CI)	p	Model 2 beta (95% CI)	p	Model 3 beta (95% CI)
Parity (per birth)	-0.62 (-0.74, -0.50)	< 0.001	-0.58 (-0.70, -0.47)	< 0.001	-0.58 (-0.70, -0.47)
Parity 1 vs 2	1.57 (1.04, 2.10)	< 0.001	1.54 (1.01, 2.07)	< 0.001	1.54 (1.01, 2.08)
Parity 3 vs 2	-0.89 (-1.32, -0.46)	< 0.001	-0.85 (-1.28, -0.42)	< 0.001	-0.85 (-1.28, -0.42)
Parity 4 + vs 2	-1.65 (-2.10, -1.20)	< 0.001	-1.58 (-2.03, -1.13)	< 0.001	-1.58 (-2.03, -1.13)
Age at first birth (per year)	0.14 (0.09, 0.19)	< 0.001	0.14 (0.09, 0.18)	< 0.001	0.14 (0.09, 0.18)

3.3 Age at First Birth and Interaction with Parity

Higher age at first birth was associated with better cognitive function (beta = 0.14 per year, 95% CI: 0.09 to 0.18, $p < 0.001$). A statistically significant interaction was observed (beta for interaction=-0.04, $p = 0.014$), indicating that the cognitive cost of high parity was greater among women who first gave birth at older ages(Fig. 3). Crude mean scores by parity and age at first birth groups are presented in Figure S3. Full regression coefficients for the parity $\times$ age at first birth interaction model are provided in Table S2.

3.4 Stratified and Sensitivity Analyses

The parity-cognition association was consistent across strata (Table 3). Among women aged ≥ 60 , each additional birth was associated with a 0.68-point lower score (95% CI: -0.82 to -0.55), compared with - 0.48 (95% CI: -0.74 to -0.22) among those < 60 . Three sensitivity analyses confirmed robustness (Table S1). After excluding participants with elevated depressive symptoms ($n = 3,148$), the association remained significant (beta=-0.69, 95% CI: -0.86 to -0.52, $p < 0.001$). After excluding those with multiple chronic diseases ($n = 4,302$), the association was attenuated but significant (beta=-0.52, 95% CI: -0.66 to -0.38, $p < 0.001$). In the urban-rural analysis, the association was significant in both rural (beta=-0.32, $p < 0.001$) and urban (beta=-0.63, $p < 0.001$) residents, with a stronger effect in urban settings (p for interaction < 0.001).

Table 3
Stratified analysis: parity (per birth) and cognitive function

Stratum	n	beta (95% CI)	p-value	p for interaction
Overall	5762	-0.58 (-0.70, -0.47)	< 0.001	-
Age < 60 years	2106	-0.48 (-0.74, -0.22)	< 0.001	0.18
Age ≥ 60 years	3655	-0.68 (-0.82, -0.55)	< 0.001	
Any education	407	-0.61 (-1.06, -0.16)	0.008	0.42
Illiterate	5355	-0.57 (-0.69, -0.45)	< 0.001	

4. DISCUSSION

This study is, to our knowledge, the first large nationally representative investigation of the associations between parity, age at first birth, and cognitive function in Chinese women. We found that higher parity and younger age at first birth were independently associated with lower cognitive performance. It is essential to emphasize that this study is observational and cross-sectional in design; therefore, our findings demonstrate statistical associations, but they cannot establish causal relationships or temporal sequences [17].

The observed dose-response relationship between parity and cognitive function is consistent with the maternal depletion hypothesis. Several biological mechanisms may explain this association. First, docosahexaenoic acid (DHA) depletion represents a particularly relevant pathway in the Chinese context. DHA is an essential omega-3 fatty acid critical for neuronal membrane structure, synaptic plasticity, and cognitive function [6]. During pregnancy, DHA is preferentially transferred from mother to fetus across the placenta, with studies documenting substantial reductions in maternal blood DHA concentrations during gestation [18]. Al and colleagues demonstrated that maternal DHA status progressively declines across pregnancy, with each successive pregnancy further depleting stores when dietary intake is inadequate [19]. In our study population of predominantly rural Chinese women born in the 1940s-1960s, dietary intake of DHA-rich foods was likely very limited. With four or more pregnancies being common in this cohort, cumulative DHA depletion could have reached levels sufficient to compromise long-term brain structure and function. This nutritional depletion mechanism may be more pronounced in our Chinese sample than in Western populations with historically better dietary omega-3 intake [20].

Second, repeated pregnancy-related hormonal fluctuations may contribute to cognitive vulnerability. Pregnancy is characterized by dramatic increases in estrogen, progesterone, and cortisol. Hoekzema and colleagues demonstrated that pregnancy is associated with substantial and long-lasting reductions in brain gray matter volume, particularly in regions subserving memory and social cognition [7]. Galea and colleagues further showed that reproductive experience, including repeated pregnancies, is associated with lasting alterations in hippocampal neurogenesis and synaptic plasticity [21]. In our study, women with 4 or more births would have experienced these hormonal fluctuations repeatedly over an extended reproductive span, potentially resulting in cumulative structural changes to hippocampal and prefrontal regions critical for cognitive function [22].

Third, high parity may accelerate biological aging through increased allostatic load. Women with high parity experience repeated episodes of pregnancy-related physiological stress, which may elevate oxidative stress, accelerate telomere shortening, and promote systemic inflammation. Pollack and colleagues found that parous women had leukocyte telomeres equivalent to 11 years shorter than nulliparous women, an effect larger than that of smoking or obesity [23]. Kresovich and colleagues further demonstrated a dose-response relationship, with women having four or more births showing the greatest telomere shortening compared with those having zero or one birth [24]. In our Chinese sample, women with high parity often faced additional physical labor demands during and between pregnancies in agricultural settings, potentially compounding the allostatic load and accelerating cellular aging [25].

Fourth, the protective association between older age at first birth likely operates through the cognitive reserve pathway [10]. Women who delayed childbearing were more likely to complete education, establish careers, and maintain intellectual engagement. Karim and colleagues found that each additional year of delay in first birth was associated with better cognitive performance in later life, independent of total parity [26]. Seblova and colleagues further demonstrated that older maternal age at first birth was associated with larger hippocampal volumes and better executive function [27]. In our

sample, women with 1 birth had a median age at first birth of 27 years and 13.4% had formal education, compared with 22 years and 4.1% among women with 4 or more births. Given that 93% of our sample was illiterate, even modest differences in educational attainment may translate into meaningful cognitive advantages through the reserve mechanism.

The significant interaction between parity and age at first birth ($p = 0.014$) adds an important nuance: the cognitive cost of high parity was greater among women who first gave birth at older ages [9]. This suggests that the combination of late first birth followed by multiple subsequent births, which compresses the reproductive window, may be particularly detrimental. Alternatively, this interaction may reflect socioeconomic selection: women who started childbearing later but still had many children may represent a distinct subgroup with particular characteristics warranting further investigation.

The superior cognitive performance among women with only 1 birth is noteworthy. These women had a substantially higher median age at first birth (27.0 years) and greater proportion with formal education (13.4%). The one-child policy implemented in 1979 selectively affected urban, educated women who were more likely to comply, introducing a socioeconomic selection effect [28]. These women may have had greater educational and occupational opportunities due to reduced childcare responsibilities, enabling them to accumulate more cognitive reserve. This finding highlights the complex interplay between population policy, reproductive behavior, and cognitive outcomes unique to the Chinese context.

The finding that the parity-cognition association was stronger in urban than in rural residents can be explained through several mechanisms. First, urban women typically had greater access to education and professional occupations, making cognitive reserve more sensitive to reproductive interruptions [29]. Second, urban families faced more intensive child-rearing expectations, including educational investment and extracurricular supervision, which may have disproportionately reduced mothers' cognitive engagement. Third, urban women with high parity represent a more selected group, as urban residency was historically associated with stronger family planning enforcement. Fourth, rural women may have had more physically demanding lifestyles that provided some compensatory protection against cognitive decline, whereas urban women experienced both reproductive depletion and reduced physical activity [30].

Our findings extend prior research from high-income countries to the Chinese context, where nutritional resources during pregnancy were historically limited and where a unique fertility policy natural experiment occurred [12, 14]. The consistency of our results with Western studies suggests that the parity-cognition association may be generalizable across diverse socioeconomic contexts, although the magnitude may vary with nutritional, healthcare, and educational resources [13].

4.1 Limitations

Several limitations should be considered. First, the cross-sectional design precludes causal inference. Unmeasured confounding, including genetic factors and early-life socioeconomic conditions, may

explain part of the observed associations [17]. Longitudinal studies with repeated cognitive assessments are needed.

Second, our study lacked several important reproductive variables. CHARLS 2018 did not collect data on breastfeeding duration, pregnancy complications, miscarriage or stillbirth history, or age at menopause [5, 18]. These variables are relevant because breastfeeding has been associated with both maternal nutrient depletion and cognitive protection; pregnancy complications may independently affect cardiovascular risk; and early menopause is associated with both lower parity and worse cognitive outcomes.

Third, regarding measurement precision, parity (number of live births) was derived from retrospective self-report across the life course. Prior research suggests that the number of live births is recalled with high accuracy, as it represents a highly salient life event [31]. However, age at first birth may be subject to greater recall bias, with a tendency toward heaping at certain ages. We consider the parity measure more reliable than the age at first birth measure. Fourth, the cognitive assessment in CHARLS is relatively brief. Fifth, our sample was predominantly illiterate (93%), which may limit variance in cognitive scores. Sixth, we could not distinguish biological from adopted children, though the vast majority in this cohort are biological.

5. CONCLUSIONS

In this large nationally representative study of Chinese women, higher parity and younger age at first birth were independently and dose-dependently associated with lower cognitive function in middle and older age. Women with 4 or more births scored approximately 1.6 points lower on a 29-point cognitive assessment compared with women who had 2 births, while each additional year of age at first birth was associated with a 0.14-point higher score. A significant interaction between parity and age at first birth suggests that late first birth followed by multiple subsequent births may be particularly detrimental.

These cross-sectional findings are consistent with the maternal depletion hypothesis and highlight reproductive history as an important risk indicator for cognitive aging in women. From a public health perspective, our results suggest that reproductive history should be considered in cognitive risk assessment, particularly in settings where high parity was historically common. Future longitudinal studies should examine biological mechanisms linking reproductive history to cognitive aging and investigate whether nutritional interventions during pregnancy can mitigate adverse cognitive outcomes in high-parity women [20, 24].

Declarations

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author Contribution

Lu Jiaping performed data cleaning, descriptive statistics, primary regression analysis, and drafted the original manuscript. Xu Qiulian assisted in participant screening according to inclusion and exclusion criteria, sorted baseline characteristic data, and revised the results section. Xu Heng proposed the research hypothesis, designed the overall analytical framework, supervised all statistical procedures, repeatedly revised the full manuscript, and served as the corresponding author. All authors have read and approved the final version to be submitted.

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Data Availability

The CHARLS datasets analysed in the current study are publicly available upon registration and application through the official CHARLS website (<http://charls.pku.edu.cn/>). The statistical code used for data analysis is available from the corresponding author on reasonable request.

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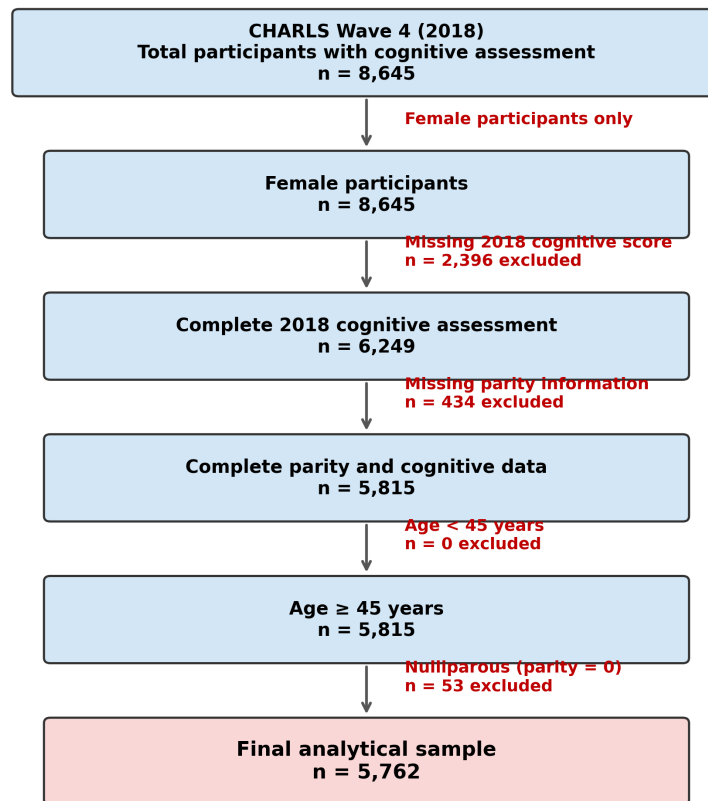
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Figures

Figure 1. Study Participant Flow Chart



Final Sample Characteristics

Age, mean (SD)	64.1 (8.3) years
Parity, mean (SD)	3.0 (1.6)
Illiterate	93.0% (n=5,355)
Age at first birth, median	24.0 years
Cognitive score, mean (SD)	10.2 (6.9)

Figure 1

Study participant flow chart.

Figure 2. Association of Parity and Age at First Birth with Cognitive Function in Middle-aged and Older Chinese Women

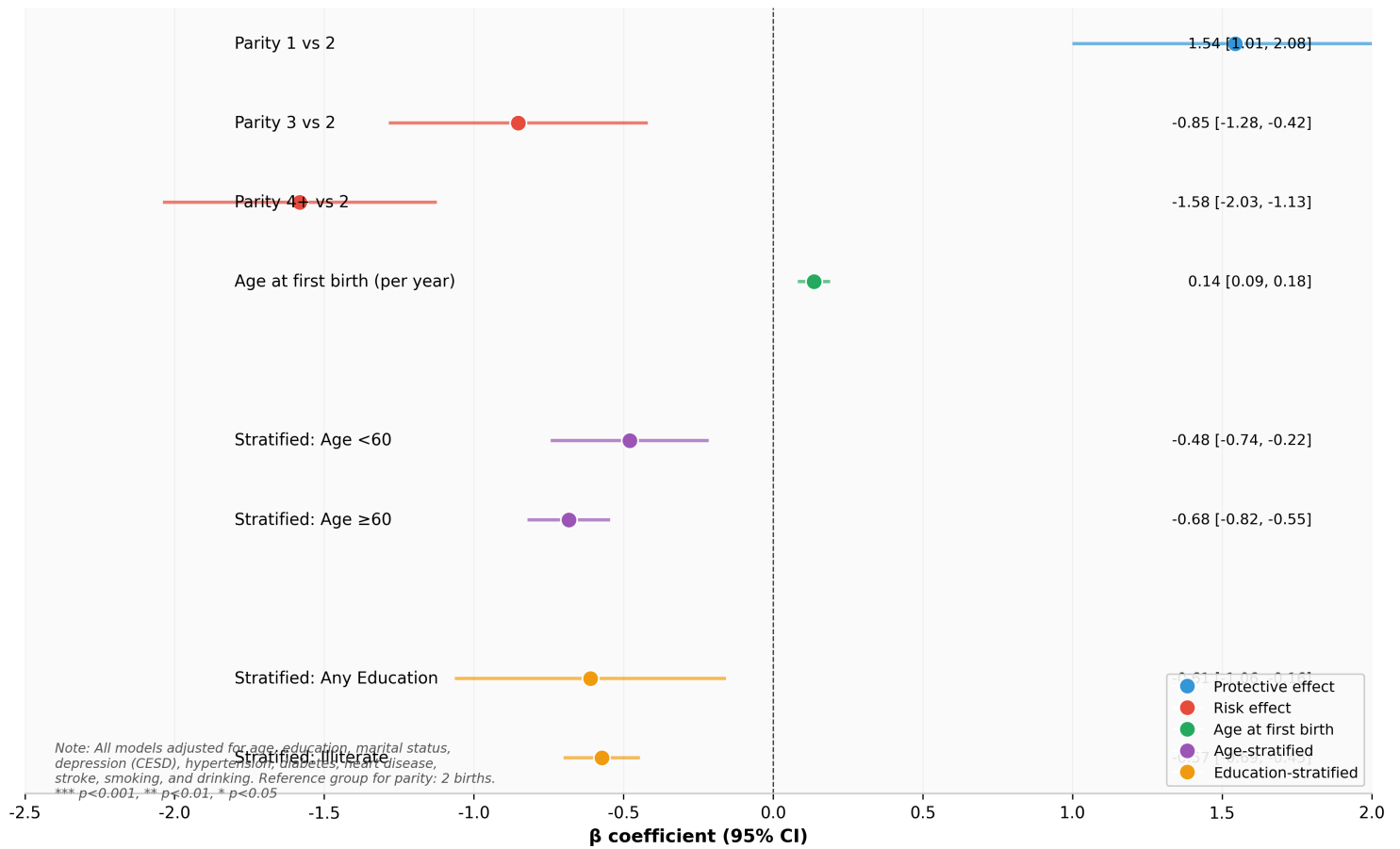


Figure 2

Association of parity and age at first birth with cognitive function. Reference group for parity: 2 births. Error bars represent 95% confidence intervals.

Figure 3. Parity, Age at First Birth and Cognitive Function in Chinese Women Aged 45+ (CHARLS 2018)

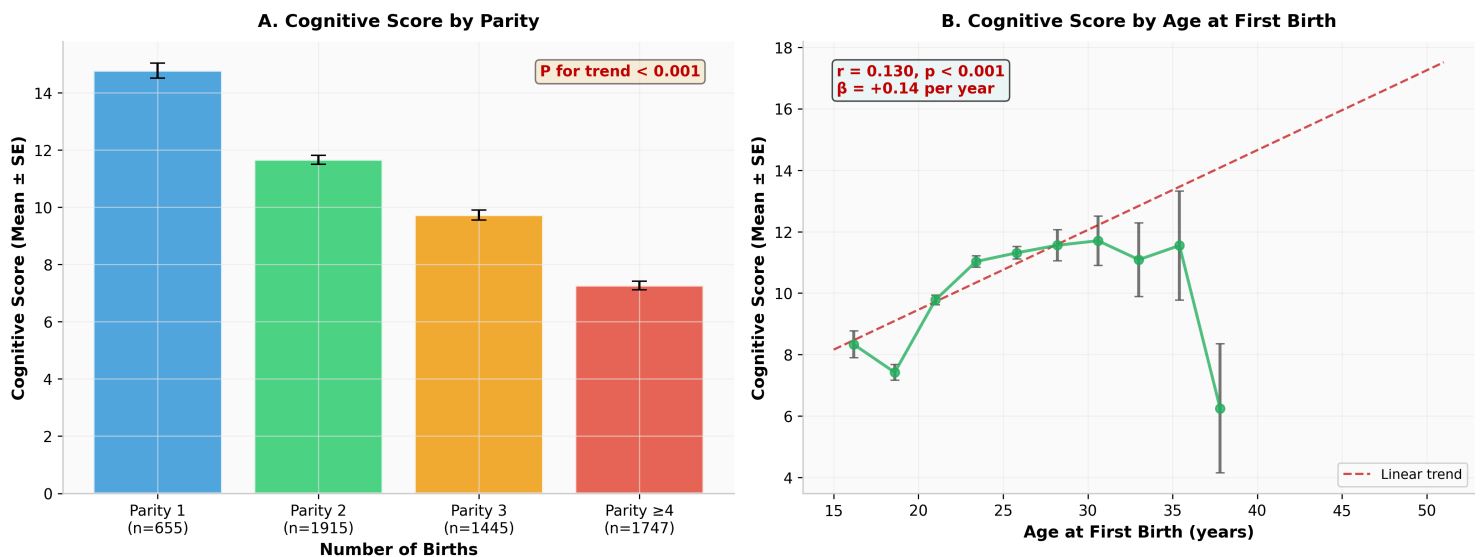


Figure 3

Parity, age at first birth and cognitive function. Panel A: mean cognitive scores by parity. Panel B: relationship between age at first birth and cognitive score with linear trend.

Supplementary Files

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