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Maternal Education is a Major Factor in Growth Regulation in Twins and Singletons

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Abstract

Background: The social, economic, political, and emotional (SEPE) environment plays a crucial role in shaping human development both pre- and post-birth, with direct and independent effects on growth, as research shows.

Objectives: This study examines the growth of twins and singletons and their association with maternal education as one of the social-economic (SE) variables.

Methods: This cross-sectional study utilized Nutritional Status Monitoring for Children under 5 Years Old in Bandung District in September 2019. A total of 158 healthy children aged < 5 years, involving 35 twins (70 children) and 88 singletons, were included. Data on weight and length at birth and weight and length/height taken at age 8.6 to 60 months were plotted according to WHOCGS 2006. Statistical analyses and visualizations, including SE variables analysis, were conducted using density plots, correlation plots, St. Nicolas House Analysis (SNHA), and ANOVA.

Results: At birth, z-scores of the body length, weight, and body mass index (BMI) of twins were lower than those of singletons ($P < 0.05$). After birth, z-scores of twins' length/height, weight, and BMI adjusted to those of singletons, with maternal education being the strongest among SE variables of early childhood growth adjustment.

Conclusions: Twins were shorter, lighter, and had a lower average BMI at birth than singletons. There was no apparent association between birth measurements and SE variables. However, after birth, maternal education starts to gain a central position in regulating child growth.

Keywords: Child, Growth, Educational Status, Maternal, St. Nicolas House Analysis, Twins

1. Background

At birth, twins are smaller and lighter than singletons. However, the differences in length and weight often disappear as early as one year of life (1). Some studies have observed differences in head circumference, weight, and length up to 2.5 years of age (2). Another study showed growth differences up to four years of age, except for twins born small-for-gestational-age (3). Twins attain normal adult height but are slightly shorter than their singleton siblings (2, 4). Growth differences at birth are attributed to the average short length of twin pregnancies and the intrauterine environment. After birth, twins catch up in body size (2).

The social-economic-political-emotional (SEPE) environment provides important material and moral conditioning for human growth before and after birth. This concept is broader than the traditional view, as it embraces political and emotional environments (5). Social-economic-political-emotional factors directly and independently influence human growth (6, 7). Education, earnings, occupation, and the social status of parents and grandparents are well-known SEPE determinants of children's growth and health (8, 9). Mainly, maternal education as one of the SEPE factors is important for children's growth and health (10-12). However, studies on the association between maternal education and the growth of twins are rare.

Conducting research on the growth of twins in Indonesia while considering socio-economic, political, and emotional factors is paramount for understanding the complex interplay of influences shaping their development. By examining how variables such as parental education, family income, access to healthcare, number of siblings, and others impact the growth trajectories of twins compared to singletons, this research can uncover disparities and inform targeted interventions to mitigate them. Such research not only enriches our understanding of twin development but also underscores the importance of holistic support systems to ensure the optimal growth and flourishing of twin children in Indonesia. We hypothesized that:

(1) After birth, twins' growth catches up, and singletons' growth remains constant.

(2) Mothers' educational level is associated with anthropometric indices at birth of twins (birth weight and birth length).

(3) Mothers' educational level is associated with the early postnatal growth of twins.

2. Objectives

This study examines the growth of twins and singletons and their association with maternal education as one of the socio-economic (SE) variables.

3. Methods

The study was conducted among children from 31 Sub-Districts of Bandung District, Indonesia, including urban and rural areas, who are required to participate in the Nutritional Status Monitoring for Children under 5 Years Old program at the Bandung District Health Office. This monitoring aims to collect information and monitor follow-up actions for the growth and development of healthy children in Bandung District. Screening/monitoring of infant growth and development is recommended to be conducted monthly. For children aged 12 to 24 months, it is recommended every 3 months, and for children aged 24 months to 72 months, it is recommended every 6 months. Demographic data of parents and place of residence are also collected. Bandung District has an area of 1 762.40 km^2 and comprises 31 sub-districts with a population of 3 575 982. The sex ratio of the total population is 102.4 males to 100 females. Most women were employed as laborers/employees (42.5%) or family workers (18.9%) (13).

The inclusion criteria for this study stipulated the utilization of all secondary data sources, provided that they were complete. Only datasets with comprehensive information were considered eligible for analysis. The exclusion criteria for this study involved excluding incomplete datasets and outlier data points. Any secondary data that lacked comprehensive information or contained outliers were omitted from the analysis.

Initially, 178 twins and siblings of twins were included. In the final analysis, the number was reduced to 158 children after excluding outliers and incomplete data and consisted of 35 twin pairs and 88 singletons (Figure 1). Their ages ranged from 8.6 months to 60 months. From the singletons group, 33 were female, and 55 were male. From the twins' group, 33 were females, and 37 were males.

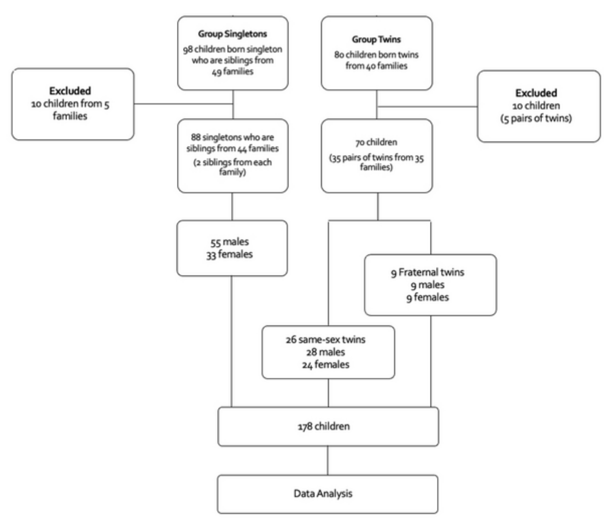

Figure 1. Flow Chart of Study Subjects

Social-economic (SE) variables were selected based on data availability, including anthropometric measurements such as length/height and weight during the newborn period and later ages up to 60 months.

These variables are contained within the Nutritional Status Monitoring for Children under 5 Years Old at the Bandung District Health Office. Measurements were performed by healthcare providers using standardized tools during routine visits to primary healthcare in Bandung District. The measurement technique and nutritional status evaluation were performed according to Child Anthropometric Standards in Indonesia (14).

Weight measurements were conducted with the Indonesian Dacin scale, a widely used tool in primary maternal and child health care for children, providing accuracy to the nearest 100 grams. For children aged two years or younger, length was measured using an infantometer in a supine position. Height measurements were taken with a microtome stadiometer in children older than two years, ensuring precision to the nearest 1.0 millimeter. Sanes Sumber Makmur manufactured the Dacin scale, and GEA Medical produced both the infantometer and microtome.

The z-scores of length at birth (LAZbirth), weight at birth (WAZbirth), height-for-age (HAZ), weight-for-age (WAZ), and BMI-for-age (BAZ) at ages between 8 and 60 months were calculated using the WHO Anthro plus software (15).

Statistical analyses were performed using R Gui (https://cran.r-project.org). Pearson's correlation was employed to examine associations between variables, St. Nicolas' House Analysis (SNHA) with a threshold value of r > 0.3, and one-way analysis of variance (ANOVA). The SNHA technique is a novel non-parametric statistical method that helps translate correlation matrices into network graphs by tracing "association chains." A series of coefficients of determinants characterized by the symmetry of ranks of R^2 both in the forward and backward direction is named "association chains." Thus, the association chains formed are ranked according to the magnitude of the correlation coefficients (R^2), for example, c[A*B], c[B*C], c[C*D], with the property c[A*B]>c[A*C]> c[A*D], and c[D*C]> c[D*B]> c[D*A]. Performance metrics, including balanced classification rate and F1-score, indicated that SNHA outperformed approaches employing intricate correlation value thresholds and those relying on partial correlations when analyzing bands and hubs (16). This method is well-suited for managing the correlations commonly encountered in anthropometric, SE, and sociodemographic variables (16).

This innovative method converts the correlation matrix into a network graph, serving as a valuable visual tool and aiding in data exploration. Researchers currently utilize SNHA to document associations among diverse growth, SE, and sociodemographic variables, representing them as a chain (17, 18). Principally, St. Nicolas's house forms a network comprising "nodes" and "edges" (16). Corrplot is usually presented along with SNHA graphs since they complement each other for better visualization. In addition, density plots and ANOVA were used to assess and visualize the associations and distribution of growth parameters.

The investigated variables are as follows: (1) Mother's age at birth (MaB) refers to the age of the mother at the time when she gave birth to the subject of this research; (2) father's occupation (FaOccu) refers to the profession of the father at the time when the subject of this research was born; Father's education (FaEdu) refers to the level of education attained by the father at the time when the subject of this research was born; (3) mother's occupation (MOccu) refers to the profession of the mother at the time when the subject of this research was born;(4) mother's education (MEdu) refers to the level of education attained by the mother at the time when the subject of this research was born. Family income refers to the total earnings or financial resources acquired by a household within a given month.

4. Results

Social-economic variables investigated in this research are included in Table 1. The education levels of fathers and mothers were significantly different among SE variables in twins and singletons (P < 0.05).

Table 1. Classifications of Socio-economic (SE) Variables of Twins and Singletons [a]

Variables and Category	No. (%)		P-Value [a]
	Singletons	Twin	
Father age, mean (SD)	36.13 (6.5)	35.43 (7.5)	0.482
Father's education (FaEdu)			0.006
Elementary (1 - 6 y)	21 (23.9)	34(37)	
Junior high (7 - 9 y)	24 (27.3)	8 (8.7)	
Senior high (10 - 12 y)	30 (34.1)	20 (21.7)	
College (13 - 16 y)	13 (14.8)	8 (8.7)	
Father's occupation (FaOccu)			0.87
Entrepreneurs	34 (38.6)	27 (38.6)	
Labors	54 (61.4)	43 (61.4)	
Mother age (MoAge), mean (SD)	32.4 (6.0)	33.06 (7.5)	0.497
Mother's education (MoEdu)			0.006
Elementary (1 - 6 y)	18 (20.5)	31 (44.3	
Junior high (7 - 9 y)	29 (33.0)	16 (22.9)	
Senior high (10-12 yrs.)	27 (30.7)	19 (20.7)	
College (13 - 16 y)	14 (15.2)	4 (5.7)	
Mother's occupation (MoOccu)			0.31
Entrepreneurs	12 (13.6)	9 (12.9)	
Labors	7 (8.0)	11 (15.7)	

Not working	69 (78.4)	50 (71.4)	
Family's monthly income (Income) [b]			0.151
Low	23 (26.1)	22 (31.4)	
Middle	53 (60.2)	32 (45.7)	
High	12 (13.6)	16 (22.9)	
Type of health insurance (HIn) [c]			0.32
Premium	24 (27.3)	11 (15.7)	
Non-premium	56 (63.6)	50 (73.4)	
None	8 (9.1)	9 (12.9)	
Number of siblings (Sibs)			0.359
1	9 (9.9)	12 (17.1)	
2	74 (81.3)	50 (71.4)	
3	8 (8.8)	8 (11.4)	

[a] Chi-square test, the value of < 0.05 is set as the level of significance.

[b] Low if below Rp. 1.000.000, intermediate if it is between Rp.1.000.000-Rp. 3.000.000, High if more than Rp. 3.000.000. (classification is slightly adjusted based on the Indonesian Central Bureau of Statistics) (19).

[c] Premium if BPJS (Indonesia Social Security Agency of Health), non-premium if JKN-KIS, and SKTM (complimentary Indonesian National Health Insurance provided explicitly for individuals with low income) (20).

At birth, twins were shorter, lighter, and had a lower BMI than singletons (Table 2). After birth, twins' height, weight, and BMI z-scores adjusted to those of singletons, with maternal education being the strongest predictor of early childhood growth adjustment. In this process, the height and weight z-scores of singletons can be observed to decline, while twins' Z-scores remain relatively stable. The z-scores of length at birth, WAZbirth, HAZ, WAZ, and BAZ at ages between 8 and 60 months are presented in Figure 2. These differences became smaller at later ages. This was also supported by ANOVA results (Table 2).

Table 2. Age and Gender of Twins and Singletons, Age of Mother at Birth, and Anthropometric Measurements [a]

Variables	Singleton; N = 88	Twin 1; N = 35	Twin 2; N = 35	P-Value [b]
Children age (mo)	37.22 ± 14.48	31.94 ± 13.64	31.94 ± 13.64	0.07
Gender				
Boy	55 (62.5)	14 (40)	23 (65.7)	0.22
Girl	33 (37.5)	21 (60)	12 (34.3)	
MaB (y)	29.27 ± 6.05	29.91 ± 7.04	29.91 ± 7.04	0.83
WAZbirth	-0.85 ± 1.06	-2.21 ± 1.30	-2.52 ± 1.23	< 0.001
BAZbirth	-0.87 ± 1.44	-1.83 ± 1.74	-2.43 ± 1.68	< 0.001
LAZbirth	-0.6 ± 1.16	-2.12 ± 1.75	-2.08 ± 1.49	< 0.001
WAZ	-1.59 ± 1.10	-1.67 ± 1.0	-1.68 ± 1.12	0.9
BAZ	-0.45 ± 1.15	-0.44 ± 1.21	-0.47 ± 1.47	0.99
HAZ	-1.94 ± 1.35	-2.17 ± 1.23	-2.12 ± 1.27	0.62

Abbreviations: MaB, mother age at birth; LAZbirth, length-for-age z-scores at birth; BAZbirth, BMI-for-age z-scores at birth; WAZbirth, weight-for-age z-scores at birth; HAZ, Growth after birth is represented by height-for-age z-scores; WAZ, weight-for-age z-scores; BAZ; BMI-for-age z-scores.

[a] Values are expressed as mean ± SD or No. (%).

[b] ANOVA test, the value of 0.05 is set as level of significance.

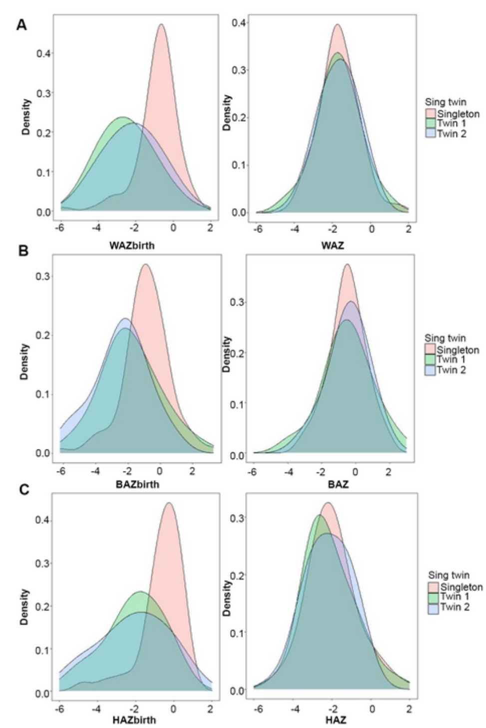

Figure 2. Density distributions. A, Weight-for-age z-scores of twins and singletons at birth (WAZbirth) and age 8.6 - 60 months (WAZ); B, BMI-for-age z-scores of twins and singletons at birth (BAZbirth) and age 8.6 - 60 months (BAZ); C, Length-for-age z-scores of twins and singletons at birth (LAZbirth) and age 8.6 - 60 months (HAZ).

Spearman correlations are presented as complots, and associations of variables are further elucidated using SNHA, a network graph. Figure 3A presents associations of SE variables such as the mother's age at birth (MaB), father's occupation (FaOccu), father's education (FaEdu), mother's education (MEdu), mother's occupation (MOccu), family's monthly income (Income), type of health insurance (Ins), number of siblings (SibS), and twin birth (STT) with birth measurements LAZbirth and WAZbirth using complot and SNHA. There were no reliable associations ($r > 0.3$) except for twin birth (STT). The association chain, SNHA, indicates that twin birth is the only variable linked with birth measurements. The other nodes either formed separate networks or remained disconnected. Among the factors investigated, only twin birth was related to birth measurements. Statistically significant associations between STT and LAZbirth ($F = 22.898$, df:

2.0, P < 0.05) and BAZbirth (F = 13.858, df: 2.0, P < 0.05) were confirmed by ANOVA.

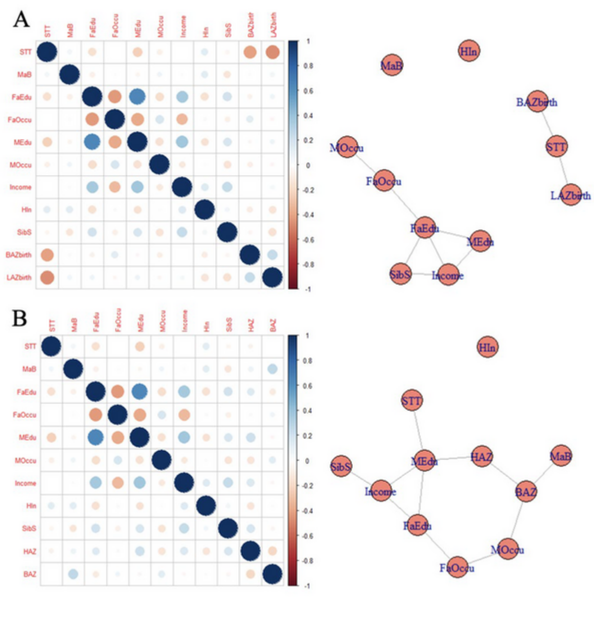

Figure 3. Correlation plot on the left and the St. Nicolas House Analysis (SNHA) graph on the right show the association of socio-economic (SE) variables with body measurements at birth (A) and age 8.6 - 60 months (B).

Association analysis of SE variables with growth at age 8.6 to 60 months showed that maternal education (Medu) was the only variable prominently correlated with the linear growth of the children (Figure 3B). Another reliable correlation was observed between BAZ and maternal age at birth (MaB). Compared to MaB, Medu was reliably associated with many other SE variables. The associations are depicted in SNHA. Association chains are formed between several variables, with maternal education being centrally located and directly connected to children's linear growth (HAZ). The plot highlights the pivotal position of the mother's education. A statistically significant association between the mother's education and HAZ (F = 3.15, df = 3.0, P < 0.05) was confirmed by ANOVA.

5. Discussion

The present study revealed that twins were shorter, lighter, and had a lower BMI at birth than singletons. These differences disappear later in infancy and childhood. Many studies have reported such observations from different countries (1-3) and were supported by this present study from Bandung District, Indonesia. Twins usually reach an average final height and BMI as adults (4). In contrast to the general perception that twins tend to catch up in height, weight, and BMI during early infancy, Bandung District's data showed that this catch-up was only relative. The findings of this study reject the first hypothesis. Similar to what has been observed in many low- and middle-income countries, Z-scores for height and weight tend to decline during the first two years of life (21). In this study, singleton babies showed a decline in height and weight Z-scores. However, twins do not participate in this decline and maintain their birth Z-scores in height, weight, and BMI. This timing of growth faltering, which is high in South Asian countries and often referred to as a critical window for nutritional intervention, may not be due to nutrition, as twin growth remains relatively stable (22).

Our findings also reject the 2nd hypothesis and accept the 3rd hypothesis about the association between maternal education and birth measurements and growth after that. In this study, twin pregnancy had a direct effect on fetal growth. After birth, maternal education was directly associated with children's growth. Studies have reported that maternal education is an important predictor of children's linear growth (16, 23-25). Postnatal growth rates up to 2 years vary with maternal educational status (26). Offspring of educated mothers exhibited increased birth length and experienced accelerated growth from birth to three months and up to 12 - 34 months (27).

Moreover, an earlier study reported similar observations regarding the physical growth of children in Indonesia (16). Mothers' education in Indonesia is linked to their children's health through the role of social capital. Mothers who have completed primary education or lower have less social capital than those with a higher level of education. The mechanisms are explained in terms of social networking and transfer of knowledge. Mothers' social capital is positively and significantly associated with children's health via improvement in mothers' knowledge, which affects their parenting behavior (28).

In India, a woman's decision-making authority within the family is considered a significant predictor of early childhood growth (29). Maternal autonomy related to visiting the market and financial access is associated with the linear growth of children (30). Other studies emphasize that literate mothers have better access to healthcare infrastructure than illiterate mothers. The decision-making power in the family, maternal autonomy, and access to health infrastructure could be reasons for the better growth of children of educated mothers. Maternal education is also known to impact prenatal care and ultimately reduce the incidence of low birth weight (31). Other social advantages conferred by better education are less counter to prejudices, discrimination, and violence during the early formative years of offspring. Studies indicate that emotional adversities faced by mothers during pregnancy and the neonatal period can impact the health and growth of children and may last until adulthood (32).

Regarding social status, findings indicate that within a traditional horticultural community, mothers with education and proficiency in two additional languages, including English alongside their local language, tend to have children exhibiting improved linear growth (33). Educated women are more likely to find partners with high status based on earnings, occupation, or any other traditional marker of social status, such as caste or ethnic group. Highly educated women are more likely to characterize a high-status society or a group within a country based on traditional social status markers. Thus, social status in different forms is self-perpetuating. This reflects the idea of strategic growth adjustment, which occurs when social dominance stimulates growth among peers. In humans, this phenomenon was studied among German boarding school boys educated in the Grand Ducal Carlsschule in Stuttgart. The schoolboys were aware of their social position, which resulted in their final height variation (34, 35).

5.1. Limitations

The present study indicates that maternal education plays a central role in the regulation of child growth among various SE variables, such as the mother's age at birth, father's education, father's occupation, mother's education, mother's occupation, family monthly income, type of health insurance, and the number of siblings. However, these were not a complete set of SEPE factors. This study used secondary data from Nutritional Status Monitoring for Children under 5 Years Old in Bandung District. There was no information on the political and emotional environments of the population under study, nor information regarding the IVF status of the twins, parental anthropometrics, or mothers' weight gain during pregnancy.

5.2. Conclusions

Twins displayed lesser height, weight, and a lower mean BMI at birth compared to singletons. Initially, there seemed to be no clear link between anthropometric measures and SE factors in twins, including parental education and occupation, family income, health insurance type, and the number of siblings. However, this changed postnatally, as maternal education emerged as a significant SE factor influencing children's growth.

These findings suggest potential implications for healthcare providers and policymakers, highlighting the importance of considering maternal education in interventions aimed at improving early childhood growth among twins. Furthermore, future research could delve deeper into understanding the mechanisms through which maternal education influences growth outcomes in twins and explore additional socioeconomic factors that may impact their development. Additionally, investigating the long-term effects of early growth disparities between twins and singletons on health and well-being outcomes could provide valuable insights for public health initiatives and clinical practice.

Footnotes

Authors' Contribution: Study concept and design: NN, ABP, YDI, BS; acquisition of data: NN, ABP, YDI, BS; analysis and interpretation of data: NN, BD; drafting of the manuscript: NN, BD, MH, CS, BB, ABP, MJ, YDI, BS; critical revision of the manuscript for important intellectual content: NN, BD, MH, CS, BB, ABP, MJ, YDI, BS; statistical analysis: NN, BD, MH, CS, ABP, YDI, BS; administrative, technical, and material support: NN, YDI, BS; Study supervision: ABP, YDI, BS; all authors read and approved the final manuscript.

Conflict of Interests: The authors affirm the absence of any conflicting interests. The funding sources did not play a role in the study's design, data collection, analysis, interpretation, manuscript writing, or the decision to publish the findings.

Data Availability: The data supporting the conclusions in the study are included in the article, and further inquiries can be directed to the corresponding author.

Ethical Approval: This study was approved by the Ethics Committee of the Faculty of Medicine, Universitas Padjadjaran (Ethical Approval number 1170/UN6.KEP/EC/2019) for studies involving humans and conformed to the ethical guidelines of the Declaration of Helsinki.

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Unpad (RDDU), https://drpm.unpad.ac.id/research-support/bantuan-article-processing-charge-apc/ .

Informed Consent: Written consent for participating in the Nutritional Status Monitoring was obtained from the parents according to the Bandung District Health Office policy.

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