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Socio-Economic Determinants and Preschool Environment as Predictors of Intelligence in Early Childhood: A Twin-based Study

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors were equally involved in all stages of the research. They jointly conceptualized and designed the study, collected and analyzed the data, provided analytical tools, and collaborated in writing the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

This study aimed to examine the relative influence of socio-economic factors and preschool environment on the intelligence of young children using a twin research design. Twin study design allows researchers to estimate the proportion of variance in intelligence due to genetics, shared

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environment, and non-shared environment. This study conducted in the Bhiwani and Hisar districts of Haryana, the study involved 150 pairs of monozygotic (MZ) and dizygotic (DZ) twins aged 3 to 6 years. Participants were selected through snowball sampling. Data were collected using a self-structured socio-economic questionnaire and the Early Childhood Environment Rating Scale. Statistical analysis was carried out using SPSS, with chi-square tests applied to examine associations between intelligence and various socio-economic variables. Findings indicated a significant association between children's intelligence and mothers' occupation in Bhiwani (χ^2=7.94*) but not in Hisar. Father's occupation showed a significant correlation with intelligence in both districts (Bhiwani: χ^2=28.37*; Hisar: χ^2=13.02*). Family income was also significantly related to intelligence in both Bhiwani (χ^2=24.27*) and Hisar (χ^2=9.49*). However, the number of siblings did not show any significant relationship with intelligence in either district. Additionally, the preschool environment was significantly associated with intelligence levels in both Bhiwani (χ^2=15.95*) and Hisar (χ^2=10.69*). These findings highlight the critical roles that economic background, parental occupation, and early childhood learning environments play in shaping cognitive development during early childhood.

Keywords: Intelligence; socio-economic status; monozygotic twins; dizygotic twins; preschool environment.

1. INTRODUCTION

Understanding the intricate relationship between socio-economic status (SES) and intelligence has long intrigued psychologists, educators, and policymakers. This interest becomes particularly salient when examining twins, who offer a unique opportunity to disentangle genetic and environmental contributions to intellectual development. The study of twins allows researchers to explore how environmental differences, especially those tied to SES, can influence intellectual outcomes even among individuals with identical or similar genetic backgrounds.

Intelligence is generally defined as the ability to acquire and apply knowledge and skills. More technically, it encompasses a range of cognitive functions including reasoning, problem-solving, abstract thinking, and learning from experience (Nisbett et al., 2012). Socio-economic status (SES) is a complex construct typically defined by a combination of variables such as income, educational attainment, and occupational status (Bradley & Corwyn, 2002). SES affects nearly all aspects of a child's development, including health, access to resources, educational opportunities, and exposure to stimulating environments all of which have been shown to influence intellectual development.

The early environment, particularly in the formative years of childhood, plays a critical role in shaping intelligence. The concept of environmental plasticity suggests that cognitive abilities can be enhanced or hindered based on the quality of one's environment. For twins, especially those reared together, SES can moderate the extent to which their genetic potential for intelligence is realized. For instance, Turkheimer et al. (2003) found that in impoverished environments, the heritability of IQ is reduced, and shared environment plays a more prominent role. Conversely, in higher SES families, genetic factors play a larger role in cognitive outcomes, indicating that enriched environments allow genetic potentials to manifest more fully.

Twin studies have shown that both genetic and environmental factors contribute to intelligence, but the relative influence of these factors can change based on SES. Identical (monozygotic) twins share 100% of their genetic material, while fraternal (dizygotic) twins share about 50%, yet studies show that cognitive similarities can be significantly influenced by environmental differences when SES is considered (Plomin & Deary, 2015). For example, in low-SES contexts, identical twins may show greater disparities in IQ due to environmental constraints, while in high-SES contexts, their scores may be more similar, reflecting their shared genetics.

Moreover, the cumulative effects of SES-related factors, such as nutrition, parental involvement, access to quality education, and exposure to language, directly influence the development of intelligence in early life (Hackman & Farah, 2009). A child in a higher SES family is more likely to be exposed to a rich linguistic environment, cognitively stimulating materials, and nurturing caregiving all of which foster the

development of executive functions and problem-solving skills. This is particularly critical in early childhood, a period of rapid brain development, when environmental inputs have the greatest impact.

The association of SES with intelligence in twins has significant implications for educational and social policy. By highlighting the extent to which intelligence can be shaped by early environmental factors, particularly those tied to SES, such studies emphasize the importance of early intervention programs. These findings support the implementation of policies aimed at reducing SES-related disparities to promote cognitive development, especially in vulnerable populations.

In summary, the relationship between socio-economic status and intelligence is multifaceted and particularly informative when studied in twins. While genetic predispositions undoubtedly influence cognitive abilities, the environment shaped heavily by SES plays a critical and sometimes compensatory role. Especially in the early years, SES related factors can amplify or suppress genetic potentials for intelligence, making early environmental conditions a key focus for research and policy.

2. MATERIALS AND METHODS

2.1 Study Design

The twin research design used to investigate the relative influence of socio-economic factors and preschool environment on intelligence during early childhood. The research was conducted in the Bhiwani and Hisar districts of Haryana, targeting a sample of 150 twin pairs aged between 3 and 6 years.

2.2 Participants and Sampling

The study sample consisted of both monozygotic (MZ) and dizygotic (DZ) twin pairs within the specified age range. Participants were identified and recruited using the snowball sampling technique to ensure adequate and diverse representation across the population.

2.3 Data Collection

Socio-economic data were collected through a self-structured questionnaire completed by the parents or guardians. To assess the quality of the preschool environment, the Early Childhood Environment Rating Scale (Thelma et al., 2005) was employed.

2.4 Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were calculated, and chi-square tests were used to examine associations between variables.

3. RESEARCH FINDINGS

3.1 Association of Intelligence of Twins with Mother's Occupation

The data in Table 1 indicated that there was significant association of intelligence of twins with mother's occupation ($\chi 2=7.94^*$) in Bhiwani district. Further the data in this table also revealed that mother's occupation ($\chi 2=1.95$) was not associated with intelligence of twins in Hisar district.

3.2 Association of Intelligence of Twins with Father's Occupation

The data in Table 2 indicated that there was significant association of intelligence of twins with father's occupation ($\chi 2=28.37^*$) in Bhiwani district. Further the data in this table also revealed that father's occupation ($\chi 2=13.02^*$) was also significantly associated with intelligence of twins in Hisar district.

3.3 Association of Intelligence of Twins with Number of Siblings

As data in Table 3 indicated that there was no association of intelligence with number of siblings ($\chi 2=1.12$) in Bhiwani district. Further the data in this table also revealed that number of sibling ($\chi 2=0.01$) was not associated with intelligence of twins Hisar district.

3.4 Association of Intelligence of Twins with Family Income

As data presented in Table 4 indicated that there was association of intelligence of tins with family income ($\chi 2=24.27^*$) in Bhiwani district. In Hisar district, there was also association of intelligence of twins with family income ($\chi 2=9.49^*$).

Table 1. Association of intelligence of twins with mother's occupation

Mother's occupation	Intelligence				
	Bhiwani				
	Low	Moderate	High	Total	χ2
Homemaker	50(28.74)	67(38.51)	31(17.82)	148(85.06)	7.94*
Service	10(5.75)	5(2.87)	11(6.32)	26(14.94)	
Total	60(34.48)	72(41.38)	42(24.14)	174(100.00)	
	Hisar				
Homemaker	46(36.51)	45(35.71)	20(15.87)	111(88.10)	1.95
Service	5(3.97)	5(3.97)	5(3.97)	15(11.90)	
Total	51(40.48)	50(39.68)	25(19.84)	126(100.00)	

**Significant at 5% level of significance; Figures in parentheses denote percentages*

Table 2. Association of intelligence of twins with father's occupation

Father's occupation	Intelligence				
	Bhiwani				
	Low	Moderate	High	Total	χ2
Farmer	17(9.77)	22(12.64)	7(4.02)	46(26.44)	28.37*
Service	5(2.87)	14(8.05)	21(12.07)	40(22.99)	
Business	19(10.92)	24(13.79)	9(5.17)	52(29.89)	
Labourer	19(10.92)	12(6.90)	5(2.87)	36(20.68)	
Total	60(34.48)	72(41.38)	42(24.14)	174(100.00)	
	Hisar				
Farmer	25(19.84)	11(8.73)	5(3.97)	41(32.54)	13.02*
Service	11(8.73)	20(15.87)	7(5.56)	38(30.16)	
Business	10(7.94)	14(11.11)	8(6.35)	32(25.40)	
Labourer	5(3.97)	5(3.97)	5(3.97)	15(11.90)	
Total	51(40.48)	50(39.68)	25(19.84)	126(100.00)	

**Significant at 5% level of significance; Figures in parentheses denote percentages*

Table 3. Association of intelligence of twins with number of siblings

Number of siblings	Intelligence				
	Bhiwani				
	Low	Moderate	High	Total	χ2
One	32(18.39)	33(18.97)	23(13.22)	88(50.57)	1.12
Two or more	28(16.09)	39(22.41)	19(10.92)	86(49.43)	
Total	60(34.48)	72(41.38)	42(24.14)	174(100.00)	
	Hisar				
One	31(24.60)	30(23.81)	15(11.90)	76(60.32)	0.01
Two or more	20(15.87)	20(15.87)	10(7.94)	50(39.68)	
Total	51(40.48)	50(39.68)	25(19.84)	126(100.00)	

**Significant at 5% level of significance; Figures in parentheses denote percentages*

3.5 Association of Intelligence of Twins with Preschool Environment

As data presented in Table 5 revealed that there was significant association of intelligence of twins with preschool environment ($\chi2=15.95^*$) in Bhiwani district. Further the data in this table also indicated that preschool environment ($\chi2=10.69^*$) was significantly associated with intelligence of twins in Hisar district.

4. DISCUSSION

The findings of twin study indicated that the occupation of mother was associated with intelligence of twins in Bhiwani district but occupation of mother was not associated with intelligence of twins in Hisar district. The similar results of another study supported the present study that intelligence score of twins associated with role of mother and work status

Table 4. Association of intelligence of twins with family income

Family income	Intelligence				
	Bhiwani				
	Low	Moderate	High	Total	χ^2
Up to Rs 40,000	43(24.71)	39(22.41)	10(5.75)	92(52.87)	24.27*
Rs 40,000-Rs 90,000	12(6.90)	28(16.09)	24(13.79)	64(36.79)	
Rs 91,000 and above	5(2.87)	5(2.87)	8(4.60)	18(10.34)	
Total	60(34.48)	72(41.38)	42(24.14)	174(100.00)	
	Hisar				
Up to Rs 40,000	33(26.19)	22(17.46)	8(6.35)	63(50.00)	9.49*
Rs 40,000-Rs 90,000	13(10.32)	23(18.25)	12(9.52)	48(38.10)	
Rs 91,000 and above	5(3.97)	5(3.97)	5(3.97)	15(11.90)	
Total	51(40.48)	50(39.68)	25(19.84)	126(100.00)	

**Significant at 5% level of significance; Figures in parentheses denote percentages*

Table 5. Association of intelligence of twins with preschool environment

Preschool environment	Intelligence				
	Bhiwani				
	Low	Moderate	High	Total	χ^2
Low	29(16.67)	24(13.79)	13(7.47)	66(37.93)	15.95*
Moderate	26(14.94)	35(20.11)	13(7.47)	74(42.53)	
High	5(2.87)	13(7.47)	16(9.20)	34(19.54)	
Total	60(34.48)	72(41.38)	42(24.14)	174(100.00)	
	Hisar				
Low	8(6.35)	7(5.56)	5(3.97)	20(15.87)	10.69*
Moderate	38(30.16)	27(21.43)	11(8.73)	76(60.32)	
High	5(3.97)	16(12.70)	9(7.14)	30(23.81)	
Total	51(40.48)	50(39.68)	25(19.84)	126(100.00)	

**Significant at 5% level of significance; Figures in parentheses denote percentages*

of mother (Bratko et al. 2020). Ortner et al. (2011) reported the higher estimation of intelligence of twins was associated with full-time employment of their parents. The occupational status of mother improved the intellectual outcomes of children through increase in household income (Felfea and Hsinc, 2012). Shin (2019) supported the results of present study through providing the evidence that intelligence of children related to mother who had large social networks. Mother who knew by many people in neighbourhood positively affects the intelligence of their children. There may be the possibility that mothers who socialized locally provided children with more opportunities for playmates with other children or stimulation through more social activities.

The occupation of father was associated with intelligence of twins in both Bhiwani district and Hisar district. The results of present study line with Makharia et al. (2016) suggested that some environmental factors included parental occupation and education, family income are important factors to improve the intellectual outcomes of children. Moreover, they reported that children must be provided optimal environment in order to develop full genetic potential. Another study provided similar results as the results of the present study and revealed that parental occupation, education and income indices of the socioeconomic status of family and have been found to moderate the heritability of their intellectual outcomes of their children (Turkheimer et al. 2003). The key measures of socio-economic status of family included parental educational and occupational status and family income successfully capture the financial, human and social capital and affect the intellectual functioning of children and their overall developmental outcomes as well (Bradley and Corwyn, 2002). Another study suggested that Fatherhood is a very special time in a person's life and has many effects on a child's health and wellbeing and his/her life (Heinonen, 2022).

The number of siblings was not associated with intelligence of twins in both Bhiwani district and Hisar district. The results of present study supported by Lu and Treiman (2008) revealed

that the negative effect from the number of siblings is neither universal nor inevitable and that it is contingent on demographic, socioeconomic factors external to the family that influence both the availability of resources and their internal allocation within a family. Marteleto and De Souza (2012) another study that tried to identify a causal effect of number of sibling using twin births or gender composition of the firstborn children found that a considerable portion of the observed association between number of siblings and intelligence, educational attainment is attributable to unobserved factors. Choi et al. (2020) estimated that children with many siblings have lower average educational attainment compared with children raised in smaller families, and this disadvantage by number of siblings has been observed across many countries. Gibbs et al. (2016) suggested that parental resources are increasingly divided within the nuclear family as the number of children grows and where the relationship between number of siblings and intelligence is often weak. Calero et al. (2013) supported that intelligence of twins was not significantly associated with number of siblings but both younger and elder siblings boost the intelligence level through discussion and reflection. Shahaeian (2015) reported that the number of adult members living in home with each other or interact with children are more significant than the children had number of sibling for predicting development of intelligence. Moreover, they also suggested that frequency of interaction of children with their family members was strong judgement for intellectual abilities as compared to number of siblings.

The family income was associated with intelligence of twins in both Bhiwani district and Hisar district. The present study line with Maurin (2002) supported that family income was one of the major determinants of intelligence of children as higher family income entails the level of good schooling and intellectual stimulation to the children. Through all these facilities provided chance to children to reach their full genetic potential in terms of intelligence. Hanscombe et al. (2012) stated that the effect of genetic on intelligence is similar in low and high socio-economic status of families but children's shared experiences appear to explain the greater variation in intelligence in lower socio-economic status. The twin study in this area reported that significant moderation of the genetic component of intelligence of children by their parents' socio-economic status. The interactions between genetics and environment increase the heritability of intelligence with socio-economic status of family (Tucker-Drob et al. 2010). Purcell (2002) reported that increasing heritability with increasing SES at each of eight ages from early childhood to adolescence in a large.

The preschool environment was associated with intelligence of twins at over Bhiwani district and Hisar district. The present study related with another study Byrne et al. (2002) supported that intellectual skills of twins influenced by preschool environment of twins. They also suggested that relative influence of genetic, shared family environment, and non-shared environment on individual differences at and across different stages of development. Ritchie et al. (2015) revealed that substantial environmental influences on intelligence across the development. Larsen et al. (2019) reported monozygotic twins control for genes, gender, age, and aspects of the home and school environment shared by twins and observed that any difference between identical twins in academic outcomes can be attributed to the unique environment. Ritchie and Bates (2013) suggested that environmental gains were puffed up across time and across traits when support models in which reading is offered to act upon intelligence. Männistö and Pirttimaa (2018) found that interventions supporting school performance was sufficient to strengthen children's educational and socio-emotional development. According to Pokropek and Sikora (2015) the random experiences, most probably related to educational processes between children, their classmates and teachers have a much greater influence on educational gains than general learning situations.

5. CONCLUSION

The study provides compelling evidence that socio-economic factors particularly parental occupation and family income along with the quality of the preschool environment significantly influence the intelligence of young children. While maternal occupation was a key factor in Bhiwani, it did not show the same impact in Hisar, indicating regional variation. In contrast, father's occupation and family income emerged as consistent predictors of intelligence in both districts. The preschool environment also demonstrated a strong association with intellectual outcomes, underlining the importance of investing in early education settings. However, the number of siblings showed no significant

relationship, suggesting that family size may not directly affect intelligence during early childhood. These insights underscore the need for targeted interventions and policies that enhance early childhood education and support socio-economically disadvantaged families to foster optimal intellectual development in children.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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ETHICAL APPROVAL

Ethical approval was obtained prior to the commencement of the study.

CONSENT

Informed consent was secured from the parents or legal guardians of all participating children.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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