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Parental Lower-Income and Monetary Investment: Direct and Indirect Relation with Math Achievement during Third Grade in Bangladesh

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Abstract

Drawing from the family investment model we examined parental monetary investments in essential math materials and math tutoring as mediators of the association between lower-income and math achievement during third grade. Data were collected from Bangladeshi third-graders (N = 1150, M_{age} = 8.01 at baseline, 52.00% boys) and their mothers during the course of 12 months. Results from SEM suggested that there were significantly positive and direct relations between lower-income, fewer monetary investments, and poor math outcomes in grade 3, after accounting for child and maternal characteristics. Although all significantly estimated mediating pathways from lower-income to poor math outcomes were decreased by 30%, fewer parental monetary investments in number word-book, paper-book, pen-pencil box, and math tutoring than in calculator and geometry box explained a greater amount of variance in the associations of lower-income with poor math achievement, after accounting for control variables. Future directions for research and policy implications are discussed.

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Introduction

Developmental theory and research suggest that family poverty or lower family income during childhood has the

most detrimental effects on children's mathematics development and achievement (Duncan et al., 2007; Duncan, Ziol-Guest, & Kalil, 2010; Rittle-Johnson, Fyfe, Hofer, & Farran, 2017). Decades of research in the US have found that children growing up in lower-income families have poorer math scores (e.g., standardized test or GPA) than their higher-income peers throughout elementary schooling (Duncan & Brooks-Gunn, 1997; Jordan, Huttenlocher, & Levine, 1992, 1994; 1994; Jordan, Levine, & Huttenlocher, 1994; Sirin, 2005). In Bangladesh, we know that children growing up in the lower income families with poor conceptual, spatial, and counting skills in primary mathematics perform significantly worse than their middle-income peers in primary school examinations (Aboud, 2006; Aboud & Hossain, 2011; Haider, Islam, Mia & Sorcar, 2005; Uddin, 2017, 2022). Much less is known about how parental lower-income influences monetary investments and children's primary math achievement (Uddin, 2022).

Developmental psychologists and economists long observe that parental investments (e.g., money, time, expectation, and involvement) in different domains of math education and practice enhance children's conceptual and spatial knowledge and operational skills in primary mathematics (Foster, 2002; Kalil & DeLeire, 2004; McLoyd, 1998; National Research Council, 2001). Despite public efforts (e.g., textbooks) and some cash benefit (100 TK.) to each needy child in the US and in Bangladesh, growing research reveals that children from poor or lower-income families are deprived of parental monetary investments in math educational materials and tutoring services for their primary math learning (Hossain & Zeitlyn, 2010; Kaufhold, Alverez, & Arnold, 2006; Mayer, 1997; Nath, 2007; Uddin, 2022; Lombardi & Dearing, 2020; Wolf & McCoy, 2019). While the indirect effects of parental math expectation, math anxiety, and parental support or parental involvement in math learning activities on the income-math achievement link are well-evident in the US and in Bangladesh, less is known about how fewer parental monetary investments in several domains of math essential materials (e.g., number word-book, paper-book, pen-pencil and geometry box, calculator) and tutoring service by which parental lower-income might negatively influence math achievement during early primary grades (Hossain et al., 2010; Lombardi et al., 2020; Nath, 2007; Uddin, 2022; Wolf et al., 2019). In this study, we use a structural equation modeling to examine the extent to which fewer parental monetary investments in the different domains of math educational materials and math tutoring mediate the association between parental lower-income and poor math achievement among Bangladeshi third graders, informing early policy implication to improve economically disadvantaged children's math achievement.

Parental Monetary Investments by Which Family Income Links to Math Achievement

Parental monetary investment founded in economics is the most fundamental aspect of the family investment model (FIM) to understand pathways by which family income influences children's academic achievement (Becker, 1993; Becker & Tomes, 1979; Conger & Donnelan, 2007; Haveman & Wolfe, 1994; Kalil et al., 2004). The FIM from the social causation view asserts that fewer parental monetary investments in education lead to poorer academic achievement of children (Conger et al., 2007; Foster, 2002; Hamilton, Cheng, & Powell, 2007; Hamilton, 2012). Researchers argue that parents with lower-income, compared to their higher-income peers, cannot afford to buy and provide basic necessities (e.g., food, dress, housing, toy, medicine, care) and home-enriching materials (e.g., books, toys) to their children that might foster

their educational development and school achievement. Particularly, children whose parents cannot afford to provide school supplies and educational materials (e.g., school dress, number word-book, paper-book, note-book, pen-pencil box, geometry box, calculator, and mini-computer) and special math services (e.g., math coaching, math tutoring) are at greater risks in their math development and school achievement (Hamilton et al., 2007; Kaufhold et al., 2006). Theoretically, lower-income constraints parents' financial abilities to invest in home educational materials and special services that might negatively influence children's primary math achievement.

In the US and in some low- and middle-income countries (LMICs), the line of theory and research from the field of a home environment has found that fewer parental monetary investments in the provisions of home-enriching materials (e.g., books, toys) and special trips (e.g. visit to a library, museum and book fair) outside the home by which lower-income explains 30-50% differences in children's early cognitive skills and math school readiness (Guo & Harris, 2000; Linver, Brooks-Gunn, & Kohen, 2002; Lombardi et al., 2020; Wolf et al., 2019; Yeung, Linver, & Brooks-Gunn, 2002). A great deal of extant research also demonstrates that fewer parental provisions in electronic devices (e.g., tape or record player, computer) and game items (board game, card game) by which lower-income negatively influences children's early cognitive and mathematical skills (Coley, Sims, & Votruba-Drzal, 2016; Coley, Kruzik, & Votruba-Drzal, 2020; Ramani & Siegler, 2008; Scalise, Daubert, & Ramani, 2020; Schneider, Hastings, & LaBriola, 2018; Galindo & Sonnenschein, 2015; Wolf et al., 2019). Experimental research and meta-analysis have found significant positive effects of the different types of calculator use on math achievement during high school to college education (Close, Oldham, Shiel, Doodley, & O'Leary, 2012; Ellington, 2003). Likely, a large body of research has found significant positive relations between SES (e.g., education and income) and private tutoring and academic achievement (e.g., mathematics, English) throughout schooling (Atalmis, Yilmaz, & Saatcioglu, 2016; Berberoğlu & Tansel, 2014; Dawson, 2010; Lee, 2013; Park, Byun, & Kim, 2011; Stevenson & Baker, 1992; Sohn, Lee, Jang, & Kim, 2010). Particularly, Atalmis et al. (2016) examined the association between SES, private tutoring, and math achievement among seventh graders in Turkey. Applying Baron and Kenny's (1986) approach, they found significantly positive and direct relations ($_{SES}$= .202, SE_{SES}= .029, p<0.001) between family income and private tutoring (measured as the number of private tutoring, private tutoring centers, & one-to-one tutoring) and math achievement among seven graders ($_{SES}$= .927, *SE*= .301, p<0.01). In addition, they also found private tutoring partially mediated the relationship between family income and math achievement among seventh graders in the country.

Taken together, fewer monetary investments in home-enriching materials (e.g., books, toys, calculators, tape or record players, computers, board games, card games etc. and special services) in the US and internationally are important mediators by which lower-income negatively influences children's early cognitive and math achievement during kindergarten through second grade (Atalmis et al., 2016; Elliott & Bachman, 2018; Galindo et al., 2015; Linver et al., 2002; Lombardi et al., 2020; Siegler & Ramani, 2008; Wolf et al., 2019; Yeung et al., 2002). To date, very little research has examined fewer parental monetary investments in children's essential math materials (e.g., number word-book, paper-book, pen/pencil box, geometry box, calculator) and math services (e.g., math tutoring) by which parental lower-income influences children's math achievement in early primary grades (Uddin, 2022). The present study based upon the FIM and previous research contributes to family investment literature by testing fewer parental monetary investments in the essential math materials and math tutoring through which parental lower-income might link to poor math achievement

among Bangladeshi third graders.

Bangladesh Context

Bangladesh is a low-middle-income country with 165 million people. Despite the promising history of poverty reduction in the past decades, about 1 in 4 Bangladeshi were living in poor families in 2016 (Bangladesh Bureau of Statistics, BBS, 2016). According to Household Income and Expenditure Survey (HIES) 2010, 24.5% of the population was relatively poor and 13% were chronically poor. Bangladeshi children from poor families usually start their compulsory primary schooling (equivalent to grade 1) at the age of five to six (e.g., the first of January of the calendar year). The aim of compulsory primary education is to ensure the optimal development of all children and to prepare them in mathematics and Language (Khan, Motin, Begum, & Uddin, 2012; Rahman & Islam, 2009). Following the math curriculum, primary instructors teach children to recognize the number and number signs and to count numbers with simple calculations, such as addition and subtraction during first grade through second grade (Khan, Motin, Begum, & Uddin, 2013). In grade 3, children learn to solve simple math story-problems and early geometry, using basic rules such as addition, subtraction, multiplication and division (Khan, Motin, Begum, & Uddin, 2014). Although children in grade 3 are encouraged and motivated by several school tasks to learn primary mathematics, lower quality of primary education, poor class instruction, high teacher-student ratio, and teacher's absence or limited efforts in the primary schools located in the slum areas affect their math education at primary school (Mollah, Ullah, Halder, & Dhali, 2019). Consequently, children who enroll in lower-quality primary schools tend to achieve a poor GPA in mathematics (Aboud, 2006; Aboud et al., 2011; Rahman et al., 2009; Uddin, 2017). The Ministry of Primary and Mass Education (2019) indicated that about 50% of the poor students enrolled in the lower quality primary schools achieved a poor GPA (C or F grade) in mathematics and English and dropped out early from primary school.

Actually, mathematics is a hierarchically developmental subject in which children learn from simple mathematics (e.g., number sense, counting skills, and geometry) in grade 1 to grade 2 to relatively complex ones in grade 3 (Uddin, 2022). To develop children's mathematics skills and achievement in the above-mentioned lower-quality primary school context, parental monetary investment and special math services in children's math education in grade 3 are necessary. But extant research has shown that parents with lower-income have limited monetary abilities to purchase and provide number word-book (e.g., Arabic, English, Roman) to develop children's symbolic or non-symbolic math knowledge, paper-book (white paper-book), pen/pencil and geometry box and calculator to enhance their math practice, and special math services (e.g., home-based- and center-based math tutoring) to overcome mathematics limitations in grade 3 (Aboud, 2006; Aboud et al., 2011; Hossain et al., 2010; Haider et al., 2005; HIES, 2010; Uddin, 2022). For example, Hossain et al. (2010) found that most of the children (n= 6768) growing up in lower-income families had no school bag (62.5%), geometry box (55%), extra number word books (65%), and pen and pencil box (23%) to go to primary school. Consequently, they had poor class attendance and a poor GPA in mathematics and English. In tutoring services, some research demonstrates that parents with lower-income or unemployment cannot provide special math services such as private math tutoring or center-based tutoring for their children's extra-math care within and outside the home, as are

children in middle-income families (Hossain et al., 2010; Mahmud, 2021; Nath, 2007). In turn, fewer monetary provisions in the essential math materials and math services might affect children's math knowledge development and math skills (Hossain et al., 2010; Hossain, 2016; Kabeer & Mahmud, 2009). Particularly, Uddin (2022) found that fewer monetary investments in math-book, magazines, quizzes, and tutoring from fourth grade to fifth grade partially mediated the associations between lower family income and poor math achievement in fifth grade. Although parental lower-income, fewer monetary investments in essential materials and special services, and children's poor math achievement in grade 3 are widely reported in previous research, we do not know about how lower-income via fewer monetary investment in children's math education influences third graders' math achievement in Bangladesh context (Mahmud, 2021; Uddin, 2017, 2022).

The Present Study

Therefore, the goal of the present study was to explore the extent to which fewer parental monetary investments in the six domains of essential materials and math service (e.g., number-word-book, paper-book, pen-pencil box, geometry box, calculator and math tutoring) explain the relation between parental lower-income and poorer math achievement in third grade final exam. Specifically, we tested the following hypotheses in Bangladesh context: 1) parental lower-income during third-grade entry (January of the calendar year) is directly and significantly associated with the poorer math achievement in third-grade final exam (e.g., 12 months later, December) with control variables; 2) parental lower-income during third-grade entry is directly and significantly associated with fewer monetary investments in essential materials and math tutoring during the course of 12 months (e.g., January to December) with control variables; 3) Based upon the FIM and previous research we expected that parents with lower-income would have fewer monetary abilities (after expenses for family living) to invest in essential materials and special math services for children, so fewer monetary investments would partially mediate the associations between parental lower-income and children's poorer math achievement in third grade final exam (Atalmis et al., 2016; Conger et al., 2007; Coley et al., 2020; Guo et al., 2000; Linver et al., 2002; Yeung et al., 2002). As number word-book, paper-book, math-tutoring and pen/pencil box than calculator and geometry box are more effective for math learning and practice in grade 3, we expected that fewer monetary investments in number word-book, paper-book, math-tutoring and pen/pencil box than calculator and geometry box would have more mediating effects of parental lower-income on children's poor math achievement in third grade exam.

Based on the FIM and research testing the six mechanisms of the parental monetary investment in Bangladesh context may better explain the association between lower-income and poor math achievement in third grade (Uddin, 2022). The present study on our hypothesized model shown in Figure 1, therefore, contributes to the family investment literature, focusing on parental lower-income, fewer parental monetary investments in essential materials and math services for children, and their math achievement in third grade. In order to provide empirical evidence on the six latent constructs, the present study examines how much money the parents spend on the six domains such as number word-book, number paper-book, pen-pencil box, geometry box, calculator, and math tutoring underlying the relation between lower-income and poorer math achievement in third grade. We simultaneously tested the multiple hypotheses regarding

the six mechanisms that could account for the strong association between lower-income and poorer math scores in third grade. Instead of taking the more common piecemeal approach that considers each mediator individually, our analysis estimated the relative contribution of each of the six mediators, controlling for others- a strategy that should reduce potential bias in the estimated role of each mediator. We expected that these six mediators would account for a substantial portion of the association between lower-income and poorer math achievement in third grade.

Finally, we control several background characteristics, including the mother's education, mother's math knowledge, mother's math support, family size, child's age and sex. In Bangladesh, past research has shown that a low-level of parental education is significantly associated with fewer monetary investments and poor math knowledge and math support for a child's math education (Uddin, 2022). In turn, these fewer monetary investments and poor math support negatively influence children's math education and achievement. In this patriarchal country, researchers observe that parents invest more money and time in male children than female children because they are dependent on the male child in their old age, while a daughter marries off and becomes a member of her husband's family (Lee, 2010; Shafiq, 2011; Uddin, 2015a, 2021). In the resource-scarce households, female children, compared to male children, are deprived more of parental monetary and time investment in their education (Uddin, 2021, 2022). Parental monetary investment, therefore, also influences gender differences in math education and achievement. The inclusion of these relevant control variables should reduce bias in the estimation of the unique contributions that each proposed six mediator makes to the relation between parental lower-income and poorer math achievement in third grade.

Method

Participants and Procedure

The sample to test our research hypotheses was selected from the Underprivileged Children's Educational Program (UCEP), Rajshahi city, Bangladesh. Since 1972, UCEP has been working with disadvantaged children in the urban slum areas of Dhaka, Gazipur, Chittagong, Barisal, Khulna, Rangpur, and Rajshahi city to provide quality primary education from first grade to eighth grade (Rahman, Yasmin, Begum, Ara, & Nath, 2010). The UCEP expanded its programs in Rajshahi city in 1994 and established five primary schools located in Tikapara, Chhotabongram, Darikharbona, Bolonpur, & Mahisbathan where skillful teachers were providing primary education to disadvantaged children. To examine primary school achievement of disadvantaged children, a first comprehensive longitudinal survey study covering a wide variety of family characteristics and children's educational achievement in English, Math, Bengali, science and other courses during third to fifth grade was conducted in 2014-2016 approved by our university (Hossain, 2016). The researcher using simple random sampling (e.g., lottery method) selected 1150 third graders (Mage= 8.01, *SD* = .78) out of 2298 students from the five schools and their mothers (Mage = 30.02, *SD* = 5.24) in 2014 and continued fourth grade to fifth grade. As the study had a rich sampling frame and good research outcomes to study disadvantaged families and their children's primary school education in the city, so all third graders and their mothers (age range 25-40 years) were selected for this study purpose. The subjects selected for this study were fully matched with our research goal.

The Wave 1 (W1) data that mainly covered family income and socio-demographic characteristics were collected from the selected subjects (N = 1150) in January 2014 when the subjects enrolled in third grade in the primary schools. To analyze mediating effects, we further collected data on parental monetary investments in essential materials and special services for children at the end of third grade (December 2014). In so doing, 14 items for the six mediators of parental monetary investments in children's math education were derived from previous research (Atalmis et al., 2016; Caldwell & Bradley, 1984; Uddin, 2022; Zadeh et al., 2010). Data on third grade math scores were collected from the subjects in primary school settings. In doing so, we used Chen, Chang, Liu, & He's (2008) approach for data collection from the school record. Although a total of 1150 participants and also their mothers actively participated in the research at W1, 5 subjects were absent at W2 data collection, because their parents were reluctant to participate in the study process. As the results of the *t-test* (not found) suggested that the absent families did not significantly affect the predictor variable and other focal variables, so we finally used 1145 subjects to analyze the hypothesized model proposed in Figure 1.

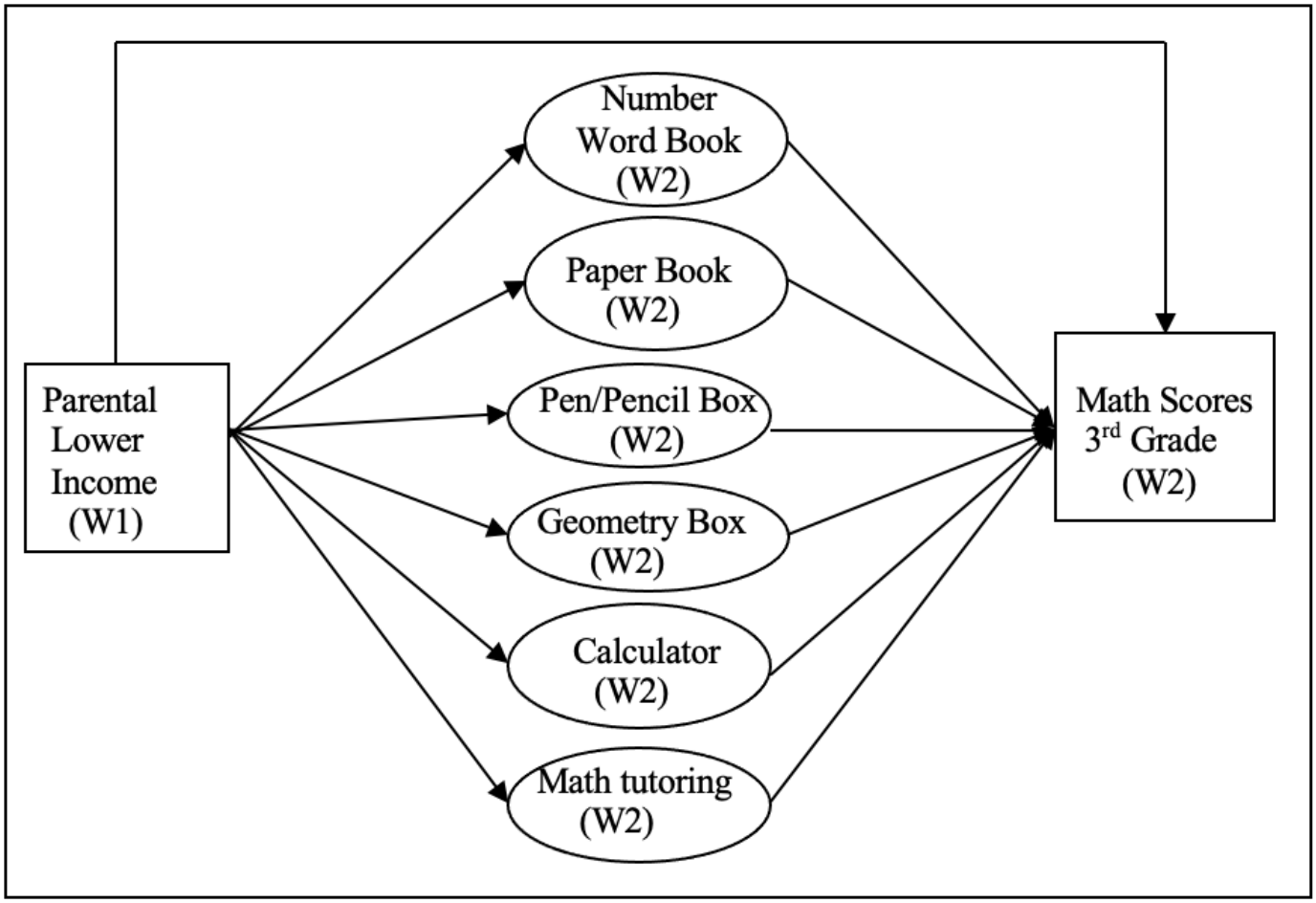

Figure 1. Hypothesized Model

We appointed two trained interviewers (e.g., one male, one female) for data collection. Before data collection, a two-day workshop was arranged for the research orientation and data collection with proper instruments. All instruments were

pretested in the sample, consulted with the head teacher and necessary adjustments were made to the instruments in Bangladesh context. Interviewers built up a rapport with the mothers and focal children and each head teacher of the primary schools. Interviewers also maintained some ethical considerations, including confidentiality, privacy, mutual benefit, and reciprocity. Particularly, data collectors in the primary school setting worked with the head teacher to designate a quiet classroom where an assessment of math proficiency during third grade was conducted in the school setting. Data collectors spent several minutes informally chatting or singing a song and gossiped a cricket game with children prior to beginning the assessment. Then, data collectors administered an assessment in the Bengali language. Interrater reliability between pair data collectors was calculated with Cohen's kappa and ranged from 0.57 to 0.81, with an average kappa value of 0.79 (Wolf et al., 2019). In the entire process of data collection, the interviewers conversed in the Bengali language with the participants in both family and school settings and then the responses were converted into English by the present researcher (Uddin, 2015a). The present researcher supervised the entire research process.

Measures

Parental Lower -Income

In the present study, we measured lower parental income at one point in time, prior to assessing their monetary investments and children's math achievement in grade 3. We asked parents (e.g., mother and father) separately to report their annual income (12 months) from jobs, small business, capital investment, pensions, public assistance, social assistance, food subsidies, child's stipends from school, and other sources if any (Uddin, 2022). Then we calculated parental income by summing maternal income (M = 65.00, SD = 18.80) and paternal income (M = 98.00, SD = 15.85) from all sources during the course of 12 months (Duncan, Magnuson, & Votruba-Drzal, 2015). We also asked the parents about the total members (M = 4.51, SD = 1.87) who lived with them in the home, starting at the first assessment. For the lower parental-income assessment, we divided total annual parental income by the total number of household members living in the family (Hoyt, Sabol, Chaku, & Kessler, 2019; Lugo-Gil & Tamis-LeMonda, 2008). Then the averaged values of parental income were presented in thousand Taka (M = 38.00, SD = 12.83; Yeung et al., 2002). In Bangladesh, the family's annual income was below the fifth thousand taka or income-to-need ratio 1.0 and received social support from different programs (e.g., food subsidies, public assistance, and child's stipends from school) was called a lower-income family. In this study, the raw data on annual lower parental-income was used as a predictor variable.

Parental Monetary Investment

Parents' monetary investments in children's developmentally age-appropriate essential materials and special services that foster children's cognitive development and math skills throughout schooling were measured covering number word book, paper-book, pen-pencil box, geometry box, and calculator adapted version from HOME and other studies (Atalmis et al., 2016; Caldwell & Bradley, 1984; United Nations Children's Fund, 2006; Uddin, 2022; Zadeh et al., 2010). First of all, the *number word-books* that enhance conceptual and symbolic math knowledge were measured with 3

items: English, Bengali, and Arabic version of number word-books, following National Research Council (2001). This measure differs from the past research and the Multiple Indicators of Cluster Survey that used whether or not caregivers provided number word-books or picture-word books in a low-resourced context (UNICEF, 2015; Wolf et al., 2019). *Paper-books* on which children practice math at home and at school or they submit homework at school were measured with 3 items, including a white paper book, dotted paper-book, and note-book (Nath, 2007). *Pen-pencil-box* covers different types of pens and pencils with shapes, sizes and colors that enhance children's mathematical information processing, thinking, and reasoning through longhand writing and drawing (Mueller & Oppenheimer, 2014). In the current study, a pen-pencil box differs from earlier research in conceptual content: Pen is mightier than the laptop note taking was measured with 2 items such as a pen-box and a pencil box (Mueller et al., 2014). Like pen-pencil box, *geometry box* includes mathematical instruments (e.g., compass, divider, ruler, protractor, set square, & sharpener) that also enhance spatial knowledge and mathematical learning (e.g., space and shape, size, angles & distances of different objects) through drawing. In the current study, the geometry box was measured with 2 items simple geometry box and a complex geometry box. A *calculator* is a machine that helps the students to do math operations (e.g., add, subtract, multiply, divide, square roots, calculus and graph, depending on the types of calculators used: pocket calculator or scientific calculator (Close et al., 2012; Ellington, 2003). In this study, we included 2 items such as a pocket calculator and a scientific calculator. At last, *math tutoring* was measured with 2 items: private tutoring at home and center-based tutoring outside the home adapted from Atalmis et al. (2016) instrument. We asked each mother whether or not you purchased and provided number word-books (3 items), paper-books (3 items), pen-pencil boxes (2 items), calculators (2 items) and math tutorings (2 items) for your focal child in the last twelve months. If yes, let us know about how much money (e.g., Taka) did you spend on the focal child's number word-book, paper-book, pen-pencil box, geometry box, calculator, and math tutoring, using Likert type of scaling from 0 = none, 1 = 100-500, 2 = 600-1000, 3 = 1100-1500 to 4 = 1600 and above. The mean score was 2.14 (SD = .47) for the number word-book, 2.13 (SD = .48) for the paper-book, 2.25 (SD = .57) for pen-pencil box, 2.00 (SD = .54) for the geometry box, 2.19 (SD = .36) for calculator and 2.4 (SD = .78) for math tutoring. These six components of the parental monetary investment showed positive bivariate correlations with each other (*rs* = .15-.61) and the internal consistency of Cronbach alpha was .55 - .65 (e.g., .65 for number word-book, .64 for paper-book, .60 for pen-pencil box, .58 for geometry box, .55 for the calculator and .64 for math tutoring). The average values of the six components were separately used as mediators in the final analysis (see, detail in Table 1).

Variables	Mean or %	SD	Range
1. W1 Annual parental lower-income in Taka*	38.00	12.83	30-50
2. W2 Number word-book in Taka	2.14	.47	0-4
3. W2 Number paper-book in Taka	2.13	.48	0-4
4. W2 Pen/pencil box in Taka	2.25	.57	0-4
5. W2 Geometry box in Taka	2.00	.54	0-4
6. W2 Calculator in Taka	2.19	.36	0-4
7. W2 Math tutoring in Taka	2.40	.78	0-4
8. W2 Third grade math score	55.79	7.22	0-100
9. W1 2nd grade math score (good %)	60.22	6.89	0-100
10. W1 Mother's age	30.02	5.24	25-40
11. W1 Mother's education in year	10.26	2.03	0-12
12. W1 Mother's math knowledge (Yes %)	40.52	-	-
13. W1 Mother's math support	4.00	2.03	0-10
14. W1Child's age in year	8.01	.78	8.00-9.00
15. W1 Child gender (male %)	52.00	-	-

Table 1. Sample Descriptive Characteristics (N = 1145)

Note: The figures are presented in thousand.

Third Grade Math Achievement

Primary math achievement (PMA) refers to how students (e.g., male, female) do well in math examinations in the domains of basic rules of operation and their related story-problems, fraction & decimal, average & percentage and primary geometry, as well as their behavior at school over time (Uddin, 2017, 2022). The data on math achievement during third grade were obtained from primary schools. The scores (also marks) of mathematics during third grade were based on objective examinations conducted and evaluated by school teachers over the years (Chen, Chang, Liu, & He, 2008). The total marks for the math course were 100; a test score of 60 is usually considered the cutoff point between a pass and a failure in the course. We also collected data on second-grade math scores (M = 60.22.79, SD = 10.23) from the school record. In the present study, math achievement scores (M = 55.79, SD = 13.26) in the third grade final exam were used as an observed outcome variable.

Covariates

We included child and mother characteristics as control variables. Mothers reported their age (in years; M_{age} = 30.02, SD = 5.24), family size (number of members living together; M = 4.51, SD = 1.87), mother's education in years (M = 10.26, SD =3.89) and mother's math knowledge on the content of third-grade mathematics (Yes = 0, 40.52%, No = 1, 59.48%) and number of mother's math involvement at each month (M = 4.00, SD = 2.03). Regarding child characteristics, mothers also reported their focal child's date of birth from age (M = 8.21, SD =.78) at baseline, and child

gender (0 = female 48%, 1 = male 52%). These data on the covariates were collected at W1.

Analytic Plan

We began our analysis with descriptive and bivariate correlation among predictor, mediator, and outcome variables and then we tested mediating pathways from W1 average parental lower-income through W2 parental monetary investments to W2 math achievement in third grade. Researchers argue that if there is no simultaneous relation between predictor and mediator and then between mediator and outcome variables with control extraneous factors, there is no possibility to test mediating effects (Cole & Maxwell, 2003). In so doing, we used structural equation modeling (SEM) with Amos (Analysis of Moment Structure, version 20.0) to conduct pathway analysis (Byrne, 2016; Kline, 1998). Parental lower-income and third grade math scores represent a single observed indicator, while parental monetary investments had six latent constructs such as number word-book, paper-book, pen-pencil box, geometry box, calculator, and math tutoring. Using latent variable modeling relations, the path analysis can decompose the extent to which lower-income and parental monetary investments have direct effects on third grade math scores (e.g., because of interaction between lower-income and parental monetary investments). In addition, the latent variable analysis also has indirect effects of lower-income via parental monetary investments on later poor math scores (Linver et al., 2002).

The present SEM analysis has two components: 1) measurement model and 2) structural model (Byrne, 2016). While our measurement model describes model identification and the factor loadings of the six latent constructs, our structural model describes the coefficients of latent relations between lower-income and six mediators and then between mediators and third-grade math scores. In the structural model shown in Figure 1, we outlined both direct and indirect pathways through which W1 lower-income relates to W2 poorer math scores in third grade exams. In the model, all mediators of the parental monetary investments are dependent variables of W1 lower-income, but independent variables of W2 poorer math score. Before testing the mediation model, we conducted confirmatory factor analysis (CFA) to identify the measurement model and to evaluate the factor loadings of the six mediators (see, Table 3). At last, we tested the full mediation model to identify simultaneous mediating effects of the six latent variables on the strong association between lower-income and third graders' math scores (see, Figure 2). In the model, control variables (e.g., mothers' and children's age, mothers' education, math knowledge and math educational involvement, family size, and previous math score) were included to know the effects of control variables on the focal model (Linver et al., 2002). Finally, we evaluated model fit, using chi-square, goodness-of-fit index (GFI), comparative fit index (CFI), and the root mean square error of approximation (RMSEA; Hu & Bentler, 1999).

Model	χ^2	*df*	GFI	TLI	RMSEA	CFI	Standardized Factors loadings	*SE*
Number Word Book	211.01**	21	.901	.922	.012***	.967		
English word book							.803	.021
Bengali word book							.782	.024
Arabic word book							.790	.022
Number Paper Book	196.15*	27	.956	.961	.023***	.983		
White paper book							.691	.031
Dotted paper book							.680	.042
Note-book/pad							.671	.051
Pen-Pencil Box	122.08*	13	.951	.968	.022***	.991		
Pen box							.781	.040
Pencil box							.821	.021
Geometry Box	105.23**	18	.973	.982	.041***	.952		
Simple box							.740	.033
Complex box							.762	.012
Calculator	110.04*	20	.913	.944	.034***	.911		
Pocket calculator							.670	.023
Scientific calculator							.690	.034
Math Tutoring Service	125.17*	28	.987	.996	.012***	.988		
Home-based tutoring							.811	.012
Center-based tutoring							.832	.023

Table 3. Factor Loadings of Parental Monetary Investments

Note: *GFI = Goodness of fit index; TLI = Trucker Luice Index; RMSEA = the root mean squared error of approximation; CFI = Comparative fit Index.*

* p <.05, ** p <.01, *** p <.001

Results

Bivariate Correlation

The results of descriptive analyses can be found in Table 1. The results revealed that there were substantial differences in parental lower-income (range 30-50 thousand taka) within the present sample, with an average income of 38.00 (SD = 12.83). Six latent constructs of parental monetary investments in children's math education also were different in the sample, with the lowest cost in pen-pencil box (M = 137.50, SD = 14.57) to the highest cost in math tutoring (M = 750.00, SD = 94.28). The results of the bivariate correlation are presented in Table 2. The results suggested that lower-income was significantly and positively associated with the six latent constructs such as number word-books, paper-books, pen-pencil boxes, geometry boxes, calculators and math tutoring (rs = 0.22 - 0.48, p < 0.05). These latent variables, in turn, were significantly and positively associated with children's poorer math scores in third-grade final exams (rs = 0.19 – 0.61, p< 0.05). The covariates such as previous math score, mother's lower education, mother's poor math

knowledge and mother's involvement in children's math education were also positively associated with third grade math score (rs = 0.03 – 0.18, p< 0.01). As the pattern and directions of associations among predictor, mediators, and the outcome variable (r = 0.34 - 0.65) of the bivariate correlation analysis were consistent with our hypothesized model in Figure 1, we used structural equation modeling for the measurement model and the structural model. The results of the measurement and structural model are given below.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. W1 Lower-income	1.00												
2. W2 Word-book	0.48*	1.00											
3. W2 Paper-book	0.22*	0.34*	1.00										
4. W2 Pen-pencil	0.24*	0.43*	0.42*	1.00									
5. W2 Geometry	0.24*	0.30*	0.51*	0.45*	1.00								
6. W2 Calculator	0.23*	0.51*	0.41*	0.66*	0.65*	1.00							
7. W2 MT+	0.23*	0.33*	0.23*	0.52*	0.26*	0.35*	1.00						
8. W2 3rd grade math	0.19*	0.61*	0.24*	0.31*	0.41*	0.31*	0.32*	1.00					
9. W1 2nd grade math	0.10*	0.31*	0.17*	0.14*	0.23*	0.34*	0.35*	0.18*	1.00				
10. W1 ME+	0.14*	0.22*	0.26*	0.44*	0.33**	0.21*	0.29*	0.15*	0.23*	1.00			
11. W1 MMK+	0.09*	0.11*	0.20*	0.15*	0.31*	0.07**	0.10*	0.03**	0.25*	0.21*	1.00		
12. W1 MMEI+	0.05*	0.15*	0.13*	0.17*	0.25**	0.05**	0.12*	0.09**	0.28*	0.19*	0.02*	1.00	
13. W1 Child's sex	0.12*	0.34*	0.36*	0.14*	0.23*	0.22*	0.19*	0.16*	0.29*	0.28*	0.23*	*-0.02*	1.00
14. W1 Child's age	0.21*	0.11*	0.20*	0.35*	0.20*	0.17**	0.37*	0.18*	0.09*	0.18*	0.17*	*-0.03*	*0.01*

Table 2. Bivariate Correlation Coefficients for Major Variables

+ Note: MT = Math tutoring; ME = Mother's education; MMK = Mother's math knowledge; MMS = mother's math support

**p<.05, **p<.01; The figures italicized are not significant.*

The Measurement Model

The standardized factor loadings from the CFA conducted for the six latent constructs of parental monetary investment in children's math education are shown in Table 3. The results indicated that the measurement model was fully identified for the six latent constructs. The results suggested that the convergent validity for all fourteen indicators onto their respective factors (the standardized factor loadings of the six latent constructs) was relatively high from .803 to .782 for number word-book, from .691 to .671 for paper-book, from .821 to .781 for pen-pencil box, from .762 to .740 for geometry box, from .690 to .670 for calculators and .832 to .811 for math tutoring (see, Figure 2). The global fit statistics indicated that the measurement models fit with the data and were adequate for all latent constructs (see, Table 3).

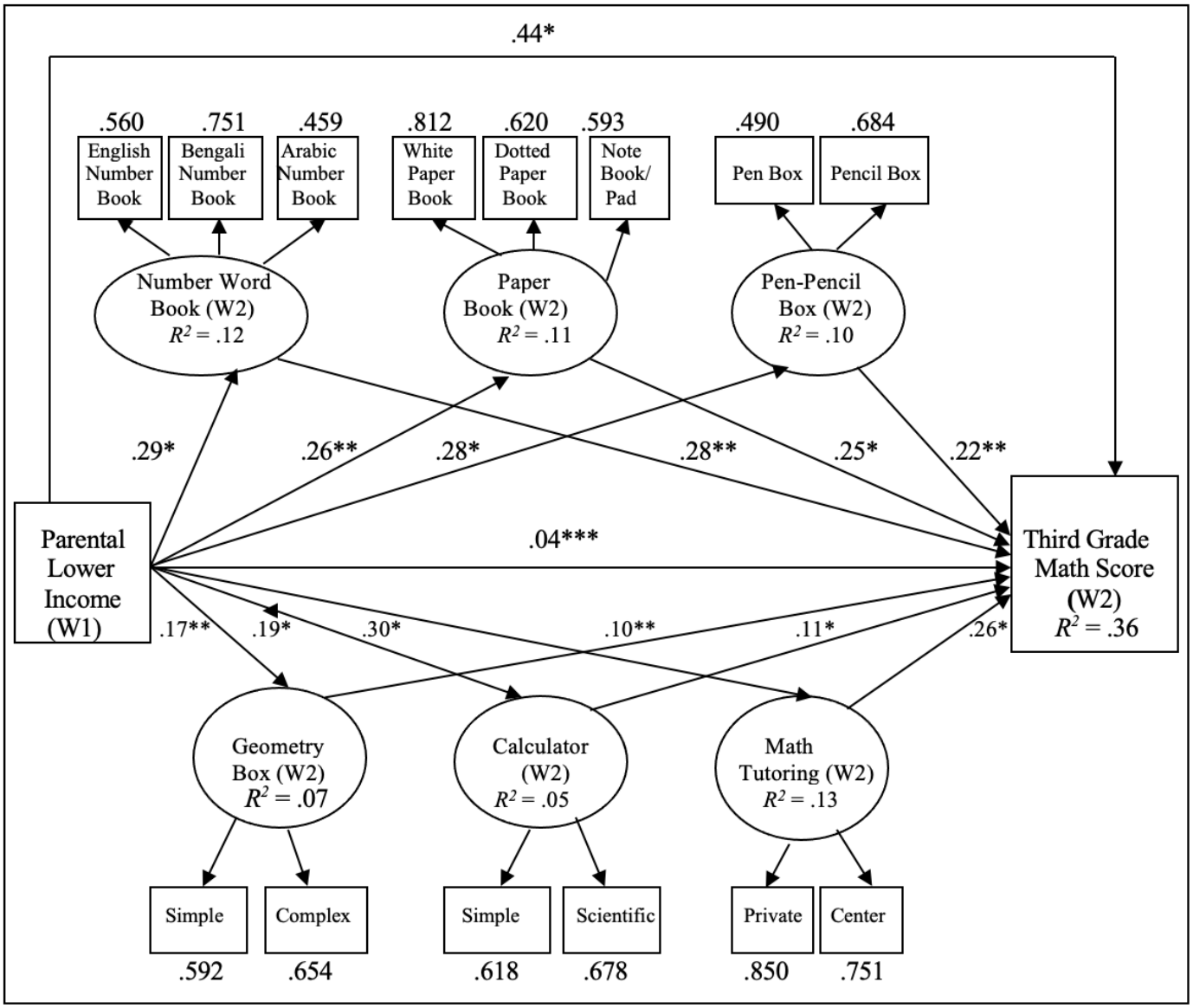

Figure 2. Full mediating model for parental lower-income predicting math scores during third-grade. Standardized path coefficients are shown. Standardized path coefficients presented in the upper line represent parameter estimates for the direct relation of parental lower-income with math scores without the mediators, but those in the middle line represent for the pathways with the mediators.

*p< .05, **p< .01, ***p< .001.

The Structural Model

The structural model examined the direct, indirect, and total pathways of the associations between parental lower-income, parental monetary investment, and children's third grade math scores, after accounting for the mother's education, mother's math knowledge and educational involvement. The direct association between lower-income and math score was positive and significant, after accounting for control variables (= .44, *SE* = .03, *p*< .05), as was expected in hypothesis 1. The structural model showed adequate fit to the data at ^{2} (159), N = 1145, *df* = 23) = 218.11, *p*< .05; GFI = .974; TLI = .963; CFI = .961; RMSEA = .044. The model explained a 28% variance in the children's math outcomes.

Figure 2 presents standardized coefficients ( ) with standard errors (SE) for the path coefficients that are depicted with a solid line. Table 4 presents unstandardized and standardized coefficients ( ) with standard errors (SE) for each direct, indirect, and total paths between predictor, mediators, and children's math outcomes that were computed, using the product of coefficients.

Variable	**Direct effects**			
	Unstandardized Coefficients	***SE***	Standardized Coefficients	***SE***
Lower-income	0.98	0.89	0.26*	0.04
Number word-book	1.10	0.71	0.27*	0.02
Number paper-book	1.02	0.90	0.41*	0.03
Pen-pencil box	0.98	0.91	0.34*	0.02
Geometry box	1.32	0.99	0.30*	0.01
Calculator	0.96	0.89	0.14*	0.03
Math tutoring	1.22	0.88	0.39*	0.03
	Indirect effects			
	Unstandardized Coefficients	***SE***	Standardized Coefficients	***SE***
Lower-income ->word-book->math score	0.79*	0.41	0.11***	0.02
Lower-income->paper-book -> math score	0.18*	0.21	0.08***	0.03
Lower-income->pen-pencil box->math score	0.21**	0.15	0.01***	0.02
Lower-income->geometry box->math score	0.19*	0.11	0.08***	0.03
Lower-income->calculator->math score	0.16*	0.20	0.08***	0.03
Lower-income->math tutoring->math score	0.27*	0.18	0.08***	0.03
Lower-income->word-book->paper-book->pen-pencil box->geometry box->calculator->math tutoring->math score	0.19*	0.21	0.08***	0.03
	Total effects			
	Unstandardized Coefficients	***SE***	Standardized Coefficients	***SE***
Lower-income	1.81*	0.91	0.21*	0.03

Table 4. Direct, Indirect and Total Effects of Parental Lower-Income and Parental Monetary Investments on Children's Third Grade Math Scores

* p <.05, ** p <.01, *** p <.001,

Direct Effects

The results from the SEM indicated that there were significantly positive and direct associations between lower-income, all parental monetary investments, and children's math outcomes, after accounting for control variables. Particularly, lower-income was significantly and positively associated with the number word-book = .29, *SE* = .02, p< .05, paper-book = .26, *SE* = .01, p< .01, pen/pencil box = .28, *SE* = .02, p< .05, geometry box = .17, *SE* = .03, p< .01, calculator = .19, *SE* = .04, p< .05 and math tutoring = .30, *SE* = .03, p< .05. We also found significant positive and direct relations between all parental monetary investments and children's third-grade math outcomes. Specifically,

children's third grade math scores were positively and significantly associated with number word-book, = .28, *SE* = .01, *p*< .01, paper-book, = .25, SE = .03, *p*< .05, pen/pencil box = .22, *SE* = .03, *p*< .01, geometry box = .10, *SE* = .03, *p*< .01, calculator = .11, *SE* = .05, *p*< .05 and math tutoring = .26, *SE* = .03, *p*< .05.

Indirect and Total Effects

Like direct effects, we also found indirect effects of the six latent variables of the parental monetary investments in essential math materials and math tutoring for children that partially explained the 09-24% variance in the relations between lower-income and children's third grade math outcomes. Specifically, when we included all mediators in the baseline model, direct and positive relations between lower-income and children's third grade math outcomes were reduced by 30%, = .04, *SE* = .03, *p*< .001. In particular, fewer parental monetary investments in number word-book, paper-book, math tutoring, and pen/pencil box than calculator and geometry boxes had more mediating effects of parental lower-income on children's poorer math outcomes in third grade exams. Overall, the findings of the study suggested that our mediators partially explained the relationship between lower-income and children's poor math outcomes in the third grade final exam with control variables in Bangladesh. Particularly, the total effects of lower-income had a marginal total effect on third grade math scores (= .48, *SE* = .02, *p* < 0.001).

Discussion

In the present study, we followed Bangladeshi children over 12 months (e.g., January to December) to examine parental monetary investments in number word-books, paper-books, pen/pencil boxes, geometry boxes, calculators and math tutoring as potential mediators of the associations between parental lower-income and math achievement in third grade. In so doing, we used standard questionnaire instruments to measure parental monetary investments explained to underlie the relationship between lower-income and children's poor math achievement (Uddin, 2022). The results from structural equation modeling confirmed that fewer monetary investments in children's math education over the course of 12 months partially and significantly mediated the associations between lower-income and lower math achievement, after accounting for background characteristics in Bangladesh. The findings of the study point to the potential parental monetary investment pathways by which the detrimental effects are transmitted from parental lower-income to children's poorer math achievement during third grade entry through third grade final exam. Below, we contextualize the findings in detail.

Although the direct associations between parental lower-income and children's lower math scores in third grade were positive and statistically significant, some of the associations were accounted for by six potential mediators: Fewer monetary investments in the number word-book, paper-book, pen/pencil box, geometry box, calculator and math tutoring in children's math education and practice during the course of 12 months. The FIM and previous research suggest that fewer parental monetary investments in math educational materials (e.g., number word-book, number of toys, electronic device, and number of game items) and special math services are important mechanisms by which lower-income negatively influences children's math achievement during kindergarten through second grade (Coley et al., 2016; Mistry,

Biesanz, Chien, Howes, & Benner, 2008; Mistry, Benner, Biesanz, & Clark, 2010; Ramani et al., 2008; Scalise et al., 2020; Schneider et al., 2018; Votruba-Drzal, 2003; Galindo et al., 2015; Uddin, 2022; Wolf et al., 2019). In the present study, we found that lower-income parents had limited financial abilities (after expenses for family maintenance) to purchase and provide these necessary educational materials and extra math services to children during the course of 12 months that, in turn, influenced children's lower math scores on third grade final exam in Bangladesh. The present findings confirm and extend prior research, showing that parental lower-income via fewer monetary investments in math educational materials and extra math services at home is indirectly and significantly associated with lower math scores during childhood through early adolescence in high- and low-income countries (Atalmis et al., 2016; Coley et al., 2016; Casey et al., 2018; Gershoff et al., 2007; Galindo et al., 2015; McCoy et al., 2015; Nath, 2015; Uddin, 2022; Wolf et al., 2019).

In high-income countries, although parental financial spending on children has increased during the past decade, several studies have documented the negative effects of persistent family poverty or lower family income on children's mathematics achievement during early primary grades, because children growing up in lower-income families have limited access in math educational materials (e.g., number word-book, paper-book, pen/pencil box, geometry box, calculator) and extra math services to enhance math achievement at elementary school (Atalmis et al., 2016; Coley et al., 2016; Kaufhold et al., 2006; Casey et al., 2018). In the US, Kaufhold et al. (2006) found that about 15 million children growing up in lower-income families had no school supplies or backpacks to go to school for learning. Consequently, the lack of school supplies, materials and resources influenced their frustration and burnout and poor mathematics achievement in elementary school. National Research Council (2001) and other studies (Casey et al., 2018; Lombardi et al., 2020) found that parents with a limited income had fewer monetary abilities to purchase and provide number-word books in different languages (e.g., Arabic, English, Spanish etc.) to their children. In turn, these fewer monetary investments negatively influenced children's early conceptual and symbolic knowledge of number system and story-problem-solving skills and math achievement during early primary grades (Casey et al., 2018; National Research Council, 2001). Buchman et al. (2010) in the U. S. and Atalmis et al. (2016) in Turkey found that low-income children had limited opportunities to access math tutoring services (e.g., one-to-one or center-based tutoring) that, in turn, affected their math scores during fifth grade to seventh grade.

In low- and middle-income countries, although parental financial spending has increased on child care and child health care, several studies have reported the negative effects of fewer monetary investments on children's math achievement (Bornstein & Putnick, 2012; Bornstein, Putnick, Bradley, Lansford, & Deater-Deckard, 2015). In Bangladesh, Nath (2015) and his colleagues (Hossain, 2016; Shafiq, 2011; Uddin, 2017, 2022) found that poverty status at the household level was significantly associated with fewer monetary investments in learning resources such as guidebooks, notebooks, calculators, and private tutoring in fifth grade preparation that, in turn, negatively influenced math scores on the fifth grade final exam. Shafiq (2011) found that lower-income parents, compared to lower-middle-income parents, spent less amount of money on children's math and English education that in turn negatively influenced primary school achievement, after accounting for family size and gender status. In a recent study, Uddin (2022) found that fewer monetary investments in children's math books, magazines, quizzes and math tutoring during fourth grade to fifth grade

partially mediated the associations between lower-family income and children's poor math achievement in fifth grade. In this study, the researcher also found that fewer monetary investments in math books and math tutoring than in math magazines and math quizzes had more mediating effects of lower-family income on children's poor math achievement in fifth grade.

Limitations and Direction for Future Research

The present study advanced prior work by using a rigorous SEM statistical approach that differs from previous studies in the given field (Linver et al., 2002; Nath, 2015; Shafiq, 2011; Uddin, 2022). Using this statistical approach, we found strong effects of parental lower-income via fewer monetary investments on children's poor math outcomes in third grade. The findings of the study contribute to research that finds direct associations between family poverty or lower-income and preschoolers and preadolescents' mathematics and cognitive achievement in high- and low-income countries (Linver et al., 2002; Uddin, 2022). Despite this strength, the current study has some limitations. First, the findings of the study from the local-level sample were lower-income- and culture-specific, because 90% of the respondents were ethnically Muslims with lower-income. We, therefore, cannot generalize the findings across other social classes, gender, ethnic groups and regions. Second, although we proposed a causal mediation model and then we followed and collected data on parental lower-income at W1, six latent variables of the monetary investments and children's math outcomes at W2 (e.g., 12 months), the lack of pure longitudinal data (e.g., three or more waves of data on each variable) and use of sophisticated statistical approach of data analysis may make difficult to establish the causal direction of mediating pathways from parental lower-income to children's poorer math outcomes (Cole & Maxwell, 2003). Future studies should be conducted to establish the causal direction of mediating pathways from persistent lower-income via fewer parental monetary investments in math educational materials and extra math services to children's math achievement over time (Cole et al., 2003; Watts et al., 2015). Third, although the family investment model has multi-dimensional pathways by which parental lower-income negatively influences children's math achievement over time, due to budget constraints we only measured six dimensions of parental monetary investment and did not include other components of the family investment model such as time investment, emotional investment, motivational investment, sociocultural investment, parenting, and parental stress (Sohr-Preston, et al., 2013; Schofield et al., 2011; Uddin, 2022). Future studies should analyze these important parental investment pathways to better understand how persistent lower-income negatively influences children's math achievement over time (Kornrich & Furstenberg, 2013; Lombardi et al., 2020).

Conclusion and Implications

In the present study, we followed Bangladeshi children during the course of 12 months to examine parental monetary investment pathways by which parental lower-income influences math achievement in third grade. The results from structural equation modeling suggested that fewer monetary investments in children's math educational materials and math services significantly and partially mediated the association between lower-income and poorer math achievement, after accounting for some background characteristics in Bangladesh. The present findings are consistent with previous

research conducted in high- and low-income countries (Uddin, 2022). The findings, therefore, may have social policy implications (e.g., economic support, income generating activity, job training and job support,) to improve children's early primary math achievement associated with changes in lower-income and likely in fewer monetary investments in math educational materials and services in the home environment. Several intervention studies have found that changes in lower-income families enhance parents' financial abilities to provide more cognitively stimulating and educational materials to their children in the home that, in turn, improve children's elementary math and reading achievement in the high-income country (Dahl & Lochner, 2008; Dearing, McCartney, Taylor, 2001; Duncan, Morris, & Rodrigues, 2011; Duncan, Magnuson, & Votruba-Drzal, 2014; Votruba-Drzal, 2003). In Bangladesh, descriptive studies reveal that job training and support and income-generating activity programs for lower-income families increase parents' income daily or monthly. In turn, the boosting income may enhance parents' monetary abilities to invest in their children's development and math achievement (Shafiq, 2011; Uddin, 2022).

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