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Educational inequality in Colombia: family background, school quality and student achievement in Cartagena

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This study examines the effects of family socio-economic disadvantage and differences in school resources on student achievement in the city of Cartagena, Colombia. Using data from the ICFES and C-600 national databases, we conduct a multilevel analysis to determine the unique contribution of school-level factors above and beyond family background. The results from the hierarchical linear models show that while family socio-economic background significantly affects student achievement, school composition and school resources explain as much as half of the effects of family background. More specifically, the achievement gap in public schools is explained in large part by differential resource allocation and concentration of poor students in public schools, which in turn lowers student achievement.

Keywords: Colombia; achievement; school poverty; hierarchical linear modelling; educational resources; school sector

Introduction

Despite a host of policies and increases in governmental funding aimed at improving primary and secondary schooling in Colombia, substantial educational inequality remains. The persistent achievement gaps between more affluent and impoverished students partly reflect the vast differences in educational resources and school quality experienced by students throughout Colombia. While student enrolment across Colombia has increased and the dropout rate has begun to decline these accomplishments have not been matched by increases in school quality, particularly for students from disadvantaged households (Sarmiento 2000). To date, few studies have examined what school factors might account for these differences in student achievement, particularly after controlling for family socio-economic background. Further, most studies of educational outcomes in Colombia have focused on

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the capital city of Bogotá. As a result little is known about which factors may be more or less important in predicting student achievement in major cities other than Bogotá. This study will contribute to a growing body of literature on the relationship between school resources and student success by examining how family background and school quality impact student achievement in the coastal city of Cartagena, Colombia.

Utilising national survey data from the Colombian Standardized Academic Test (ICFES) combined with data from the C-600 and C-100, which provides information on the physical infrastructure and educational resources provided by all schools in Cartagena, we examine two main questions. First, what is the unique and collective impact of family background, school type and school quality on student achievement? Second, to what extent do school-level factors, including poverty composition, explain the influence of family background and school sector (e.g. public versus private) on student achievement? Unique to this study is the utilisation of hierarchical linear modelling (HLM) techniques, rarely used in studies of educational inequality in Colombia. Hierarchical linear modelling allows us to take into account the nested structure of the data (students within schools) and to test whether there is a unique contribution of school factors to the variability in student achievement test scores across schools in Cartagena, above and beyond individual characteristics and family background.

Theoretical background

During the late-1960s, Blau and Duncan (1967) published their seminal work, *The American occupational structure*, which reframed the study of social mobility and inequality by focusing on the intergenerational processes of social stratification. While Blau and Duncan emphasised the importance of family socio-economic background in influencing educational and occupational attainment, they also recognised the quintessential role of schools in social reproduction. Their status attainment models posited that individual mental or cognitive abilities were initially influenced by parental resources and further converted into 'marketable' skills through the formal education system (Blau and Duncan 1967; Granovetter 1981). The path models estimated by Blau and Duncan (1967), and later by Featherman and Hauser (1978), showed father's educational and occupational status had a moderate association with sons' occupational status, but most of the association operated through completed years of schooling by the son. They concluded that an individual's educational attainment was actually more important than family socio-economic background in predicting occupational attainment. Although not the first to view education as reducing social inequality by providing equal educational opportunity (Davis and Moore 1945; Sewell, Haller, and Straus 1957; Parsons 1959; Dreeben, 1967), their work empirically demonstrated the importance of the educational system

as a principal mechanism by which individuals could overcome their social origins.

During the same time period, a different view of the educational system was also emerging based on social reproduction theory and work by sociologists like Bourdieu in France, Collins in the USA and others (Bourdieu 1973; Bourdieu and Passerson 1977; Willis, 1977; Collins, 1979). According to social reproductionists, rather than reduce the impact of social origins on adult success and promote equality of opportunity, schools functioned to reproduce the inequalities found in the social structure and cultural order of a particular society. In line with this perspective, Bowles and Gintis (1976) published *Schooling in capitalist America*, which described how families, schools and the capitalist economy interact to produce inequality. In their book, they argued schools actually reinforce the existing class structure and limit social mobility by reproducing the hierarchical division of labour found in capitalist society. According to Bowles and Gintis, schools replicate the structure of authority relations in the labour market and socialise students according to their socio-economic background to accept the legitimacy of the system and their role within the hierarchical order. Critical of Blau and Duncan (1967), they posited that the effects of class background had been grossly underestimated principally because students from different social class backgrounds have fundamentally different schooling experiences, which impact their chances for upward mobility and success in adulthood. Bowles and Gintis' ideas about the sources of inequality, the importance of family background in shaping educational opportunities and the limited ability of schools to act as agents of social reform was strengthened by findings from The Coleman report a decade earlier as well as research conducted later by Jencks and colleagues (Coleman et al. 1966; Jencks et al. 1972).

Early research on school effects

In the mid-1960s, James Coleman (1966) and his colleagues published the highly influential Coleman Report, which suggested that school facilities had little impact on student's educational achievement. Commissioned by the US Office of Education to assess whether children of different race, colour, religion and national origin experienced different educational opportunities, their empirical findings suggested family socio-economic background was a stronger predictor of academic achievement than differences in school resources and curriculum. However, consistent with Bowles and Gintis's theory of schooling as reproducing class-based inequalities in society, Coleman and his colleagues also found the most important school-level factor predicting student achievement was the socio-economic composition of the school's student body. Further, they found that low-income students had higher achievement and experienced larger achievement gains over time if they attended middle-class verses high-poverty schools. A re-analysis of the data

by Jencks and his colleagues (1972) in the early-1970s as well as the Plowden report from Great Britain (Peaker 1971) supported the earlier conclusions reached by Coleman (1967) and highlighted the influential role played by family background and school composition in the process of educational stratification.

While a great deal of research on social stratification and the role of education in social reproduction was taking place in the USA and other industrialised countries, researchers were also interested in trying to understand how schools affected social mobility processes in developing countries (Foster, 1963; Clignet and Foster 1966). In direct contrast to the findings regarding the relative unimportance of school resources published in the Coleman Report (1967), Heyneman (1976), using data from Uganda, was one of the first to suggest that family factors were actually less important compared to school resources in predicting educational achievement for students in developing countries. Years later, Heyneman and Loxley (1983) followed up on these findings by utilising data from 29 countries to examine whether economic development affected the magnitude of the relationship between family socio-economic background, school resources and student achievement. Their results showed that the smaller association between school resources and student achievement relative to family socio-economic background was found mostly in industrialised countries, like the USA. However, within developing countries, school and teacher quality explained much more of the variation in student achievement. This effect, known as the Heyneman-Loxley (HL) effect, along with the Coleman report fuelled new research on school effectiveness in both industrialised and developing countries and laid the groundwork for years of debate among researchers on the importance of schools in determining educational achievement and attainment.

School quality and student achievement

Over the last few decades, a flurry of research has examined the relationship between school quality and educational outcomes. Research in the USA tended to support the earlier findings by Coleman et al. (1966) and Jencks (1972) and showed student achievement was more closely tied to differences in family background rather than school resources (Hanushek 1986). However, there was some evidence suggesting that smaller class sizes and more specific school resources related to teacher training were related to improved student learning and achievement (Krueger 1999, 2001; Arum 2000).

In contrast, empirical studies in developing countries have generally found school expenditures, infrastructure, instructional quality, class size and teacher attributes to be strongly associated with student learning, particularly in countries where the distribution of educational resources is highly unequal (Fuller and Clarke 1994; Heneveld and Craig 1996; Gamoran and Long

2006; Behrman 2008). Indeed, numerous studies have shown that basic material inputs such as the availability of textbooks as well as the quality of school facilities can have an impact on student's opportunities to learn and ultimately educational achievement and attainment (Heyneman, Jamison, and Montenegro 1984 ; Lockheed, Vail, and Fuller 1986; Lockheed and Verspoor 1991; Duflo 2001). Studies of Latin American countries, specifically, have shown that textbooks and facilities such as libraries can have a significant effect on student achievement (Harbison and Hanushek 1992; Postlethwaite and Ross 1992; Schiefelbein and Schiefelbein 2000; Anderson 2005). One study in Nicaragua, for example, found that students who had access to textbooks scored one-third of a standard deviation higher in mathematics compared to students who did not have access to textbooks (Jamison et al. 1981).

There is also increasing evidence that providing access to information and communication technologies can have a significant effect on learning for students in developing countries (Linden, Banerjee, and Duflo 2003). A recent study conducted by the Organisation for Economic Co-operation and Development (OECD) (2006) found that 15-year-olds who had access to computers for at least five years scored much higher in mathematics compared to students with less or no access to computers. Finally, studies have examined whether class size and student-teacher ratios can have a significant impact on student achievement, although research in both developed and developing countries has yielded mixed results (Pritchett and Filmer 1997; Hanushek and Kimko 2000; Woessmann 2001; Hanushek 2003; Pritchett 2004).

School composition and peer effects

Following the work of Coleman et al. (1966), research over the past few decades has also examined the impact of school composition on student achievement and attainment. In general, studies in the USA and in developing countries have shown that once individual family background is controlled, students who attend schools with greater concentrations of students from higher socio-economic backgrounds have greater achievement (Gamoran 1996; Caldas and Bankston 1997; Lee, Smith, and Croninger 1997; Bryk and Driscoll 1988; OECD 2004; Somers, McEwan, and Willms 2004; Rumberger and Palardy 2005). An equally important strand of the school composition literature has examined the impact of school sector on student achievement. While early research by Coleman, Hoffer and Kilgore (1982) found that private schools significantly improved test scores, more recent evidence suggests that the effects of attending a private school may have smaller impacts on achievement (Altonji, Elder, and Taber 2005). In Latin American countries, studies have generally found support for the private school advantage, even after controlling for family socio-economic background (Psacharopoulos 1987; Lockheed and Bruns 1990; Cox and Jimenez 1991;

Mizala, Romaguera, and Reinaga 1999; McEwan and Carnoy 2000; McEwan 2001).

Researchers have hypothesised that the effects of student composition and school sector may operate through their effects on peer relationships. According to social capital theory, the quality of peer relationships may influence educational achievement and success by providing a system of norms and values that youth can draw upon to help them (or not) navigate the schooling experience (Bourdieu 1987; Coleman 1988; McQuillan 1998). For example, studies have shown that students in schools with a higher socio-economic status (SES) are more likely to make friends with students who are more goal-oriented, whose parents have greater educational expectations and who are more involved in the school (Fejgin 1995; Lou et al. 1996; Teachman, Paasch and Carver 1996), all of which are positively associated with achievement.

On the other hand, school composition and school sector may affect student achievement to a large extent because it is related to differences in school quality. Schools with a high proportion of students from low-income families may be less likely to have a clear academic mission and high expectations for students and may lack the resources to be effective places of learning (Bryk and Driscoll 1988; Gottfredson 2001). For example, high poverty schools or low-achieving public schools may experience difficulty in hiring and retaining skilled and experienced teachers necessary to create a positive learning and social environment compared to economically advantaged or private schools (Anderson 1988; Lippman, Burns, and McArthur 1996; Gottfredson 2001). Higher SES schools have also been associated with a more academic school climate, better teacher-student relations, higher teacher expectations and fewer disciplinary problems (Willms, 1999; OECD, 2005).

School effects in Colombia

The study of school quality in Colombia has largely focused on estimating the impact of attending public or private schools on educational achievement and attainment, with less attention paid to how schools influence achievement. Studies on the impact of school sector have largely examined students in the capital city of Bogotá and the results have been mixed. Piñeros and Rodríguez (1999) utilised data from students enrolled in their last year of public and private secondary schools in Bogotá and found that students enrolled in public schools actually had higher achievement once family socio-economic background was controlled. Their results also showed educational resources and school facilities such as science and language laboratories and sports facilities, were positively related to student scores on the national achievement test called the ICFES exam. On the other hand, recent work by Nuñez, Steiner, Cadena and Pardo (2002) shows a clear private school advantage. They analysed the differences in achievement test scores between students in private and public high schools for 36 cities in Colombia and found students in private

schools had appreciable higher achievement measured by the ICFES compared to similar students in public schools after controlling for parent education.

While evidence suggests school sector may play a role in explaining existing gaps in student achievement and attainment in Colombia, less is understood about what factors may account for the effects of school sector on student success. In one of the few studies to examine the impact of school resources and school sector, Gaviria and Barrientos (2001b) analysed data from Bogota and found school attributes such teacher education, student-to-teacher ratio and infrastructure had positive and significant effects on achievement, controlling for family SES. However, the positive effects were restricted to students enrolled in private schools.

A more recent study by Somers, McEwan and Willms (2004) estimated multilevel models to explore the effectiveness of public and private schools in 10 countries, which included Colombia. They found that socio-economic composition of the student body accounted for most of the achievement gaps between public and private schools. This finding coupled with those of Gaviria and Barrientos (2001b) suggests that differences in the allocation of school resources as well as differences in school composition may play an important role in explaining achievement gaps between public and private schools in Colombia.

The current study

While prior research suggests school sector may play a role in explaining existing gaps in student achievement in Colombia, few studies have examined what factors may account for the effects of school sector and school composition on student success. Indeed, if school sector and other school characteristics, such as poverty composition, affect student achievement because of their correlation with other school resources, then improving school quality will reduce educational inequality without altering the compositional make-up of students in schools. However, if school composition remains predictive of achievement even after differences in school quality are accounted for, incremental increases in school resources may have little impact on reducing inequality in achievement without also addressing socio-economic segregation among schools.

The current study extends prior research on educational inequality in Colombia in several ways. First, many of the empirical studies of the nature of educational inequality in Colombia have focused on Bogotá, the country's capital. Our study shifts the focus away from Bogotá to examine the impact of family and school factors on student achievement in another context, Cartagena. Moreover, studies on educational inequality in Bogotá often examined the effects of attending public or private schools but rarely examined whether school-level factors influence educational outcomes. Our study examines

whether school poverty composition and school resources explain the socio-economic gaps in student achievement and the differences in achievement between public and private schools in Cartagena. Further, we examine whether school poverty composition affects student achievement, in part, because it is correlated with school resources. Few studies in Colombia have utilised a multilevel approach to study student achievement. Rather, a high proportion of studies have employed a single-level methodology, which is inappropriate to account for the nested nature of students within schools. Our study takes into account the nested structure of the data and models the impact of school-level factors above and beyond family characteristics. Finally, most studies of stratification processes in developing countries rely on classic status attainment models (Blau and Duncan 1967) and fail to fully incorporate contextual and structural factors that may limit individual opportunities and success (Kerckhoff 1995).

Education in Cartagena, Colombia

Cartagena is one of four major cities in Colombia (see Figure 1). While there have been some positive economic changes in the city due to government investment in the tourism industry, on which the local economy depends heavily, poverty within the city has also increased (Streicker 1995). Poverty rates in Colombia are very high (50%), but the distribution of income in Cartagena is even more unequal. According to recent estimates, more than 80% of the households in Cartagena were categorised as poor or very poor by the SISBEN, an indicator used by the government to determine which households are eligible to receive government assistance. These inequalities mirror those found in the educational system.

Although the Constitution mandates yearly increases in educational spending, the allocation of educational resources across regions in Colombia has not been equal (World Bank 2002). In Cartagena, many schools still lack the most basic equipment and school supplies – textbooks, blackboards, desks – although wide variation exists within and between cities. At the same time,

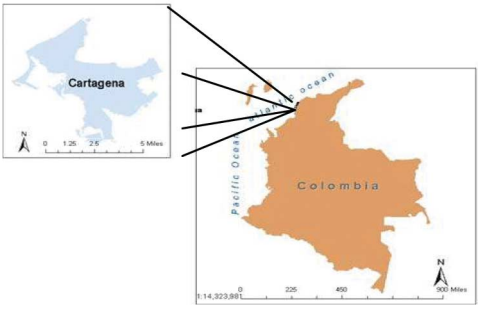

Figure 1. Map of Cartegena, Colombia.

changes in the Constitution made it possible for local governments to charge fees for students in public schools. Therefore, families are increasingly required to pay student fees and to purchase books for their children even if they attend public schools (World Bank 2002; Glewwe and Kremer 2006). It is reasonable to expect, therefore, that availability of school resources, such as libraries, may have a positive impact on student achievement (Heynenam, Jamison, and Montenegro 1984; Duflo 2001).

In Colombia, as in many developing countries, there has been an increase in students attending private schools. In the elementary grades (first to fifth), private schools comprise less than 19% of the entire student enrolment. However, enrolment in private schools for secondary education is approximately 35%. While there are some religious private schools in Colombia operated by the Catholic Church, most are for-profit schools. Admission to private schools is largely based on academic criteria and/or the family's ability to pay school fees, school supplies and transportation costs (Uribe et al. 2006). There is wide variation within private schools in terms of schooling costs. For instance, Uribe et al. (2006) pointed out that in 2002, yearly tuition fees for private schools in Bogota varied from $30 to $2400 and typically did not include transportation, books, classroom supplies and school uniforms. In addition, private schools might also require additional fees for school activities and expect parents to make 'voluntary' donations (bonos).

While the Colombian Constitution guarantees its citizens 10 years of free and mandatory education, the Ministry of Education does not have a system in place to coordinate public and private schools to ensure that the provision of mandatory education is achieved equitably. Indeed, public and private schools systems are essentially managed separately by different educational authorities with respect to financing, supervision and accountability. While the Ministry of Education requires public schools to meet certain standards with respect to the physical structure, teachers and management of resources, these standards have not been regularly enforced (World Bank 2003). As a result, large disparities exist between public and private school systems, in terms of both quality and access. Finally, while the government has begun a programme to provide some subsidies for religious private schools that enrol low income students, most private schools are comprised of middle- and upper-class students.

Although the majority of students who complete high school in Colombia often hold high educational aspirations, only 35% attend post-secondary education. This is due in part to the limited availability of colleges and the ability to pay for tuition as well as the role standardised test scores play in determining who goes onto college (Forst, Heaton and Haas 2004). In Colombia, all students in their last year of high school take the ICFES standardised achievement test. While the results do not determine whether the student will graduate from high school (i.e. upper secondary school), students must score

high on the ICFES test in order to be accepted to any public institution of higher education and most private universities. Thus, students who attend low performing schools are at a severe disadvantage when it comes to applying for college even if they manage to graduate high school. In addition, research has shown the scores on the ICFES standardised achievement tests are also significant predictors of educational attainment and labour market success in Colombia (Psacharopolous 1994).

In the Caribbean region, where Cartagena is located, the net school enrolment is 84% in elementary education and 52% in middle and high school – not significantly different from the national average. However, an examination of standardised achievement test scores across cities reveals important differences between the larger cities in the country and smaller cities, particularly those located on the periphery like Cartagena. For example, while 18% of the schools in Bogotá ranked in the two highest categories (out of six) of aggregated ICFES scores, only 10% of schools in the coastal city of Cartagena scored this highly. Perhaps more importantly, only 1% of the schools in Bogotá ranked in the two bottom categories, while an alarming 30% of schools in Cartagena were ranked in the lowest categories (Sarmiento 2000). The large number of schools in Cartagena whose students scored well below what is required on the ICFES exam for admission to higher education, coupled with the importance of student achievement for economic success, make it necessary to understand what role family background and school quality play in fostering differences in student achievement.

Methods

Data

The present study shifts the traditional focus of educational research in Colombia, on the capital city of Bogota, to examine how family and school factors influence student achievement in another context, Cartagena. The research questions addressed in this study require data at both the student-level and the school-level in Cartagena. We utilised information from several national data sets in order to compile a database sufficient to answer the proposed questions. To create the school-level database we merged two national datasets, the C-600 and C-100, collected in 1999 by the Colombian Ministry of Education and the Department of National Statistics (DANE). This merged file included school-level information on educational resources and infrastructure, as well as dropout and enrolment data for every school in Cartagena. Included in the school-level file is a school quality ranking for all high school institutions derived from the aggregated performance of the students for a given year, compiled by the Ministry of Education.

The school-level data file was then merged with the student-level database, the Colombian ICFES collected in 2003, compiled by the Colombian

Institute for the Advancement of Higher Education, which contains testing data for all students in their senior year of high school and information on their family background.[1] Within the USA and many other developed countries, the practice of merging different datasets is accomplished by linking common identifiers provided in the data files. However, compiling and merging different datasets in Colombia required a much more complicated procedure because there are different school identifiers contained in the C100/C600 and ICFES databases. To merge the data containing the school-level information (C-100/C-600) with the student-level information (ICFES), we manually matched the files using information on the school name and address provided in both datasets. For further information on this matching process see Appendix 1.

Sample

Since the information collected by the Ministry of Education in both the C-100/C-600 and the ICFES is mandatory for all schools and high school seniors, the sample is not random. Rather, the final sample of students and schools represents the approximate population of high school seniors in schools for the year 2003 in Cartagena. Students without math and reading scores and without valid school identifiers were excluded from the dataset. The final sample in the merged student-school file included 8708 seniors in 133 schools that contained school identifying information as well as achievement test score data.

Missing data

We examined the possibility of selection bias resulting from the exclusion of students without valid testing information or school identifiers. However, the final sample did not differ significantly from the sample of students who were dropped because of missing data. Other missing data in the final sample were dealt with using imputation procedures in STATA.

Dependent variable

Student achievement

Data from the ICFES, administered to Cartagena students in their last year of high school in 2003, was used to measure of student achievement. The ICFES exam serves two purposes. First, as was previously noted, the ICFES is the primary admissions tool used by all colleges and universities to determine the quality of its applicants (ICFES 1999). Second, since the exam was designed to measure what students learned during secondary school in each of the subject areas, it is also used as a tool for evaluating the quality of secondary schools. Data from the ICFES is collected and evaluated by the Ministry of

Education and used to inform policies directed toward improving school effectiveness and learning outcomes in secondary school. It is also important to note that studies of social stratification in Colombia have found student scores on the ICFES to be highly predictive of post-secondary educational attainment and earnings in the labour market (Psacharopolous 1994).

We utilise the Mathematics and Language components of the Common Core of Basic Competence (*Nucleo Comun Competencias Basicas*) to measure reading and mathematics achievement. Although there are a total of eight tests administered, including subject tests in social science and natural science, the analysis was restricted to mathematics and reading because these tests were administered to everyone. Further, research suggests that mathematics and reading achievement are important indicators of the quality of education and to be important predictors of labour market success in Colombia (Nuñez and Sanchez 1998). The ICFES Mathematics and Language (reading) components of the Common Core contain 35 multiple choice questions on content students should have learned during secondary school. The test scores range from 0 to 100.

Explanatory student-level variables

Family socio-economic background

A scale was constructed to create a composite measure of family socio-economic status, which utilised student-level information from the ICFES on mother and father's education, household income and mother and father's occupation. Mother and father's education is measured as the number of years of completed schooling. Family income is an ordinal variable with 8 categories, where 1 indicates a household income of less than 1 minimum monthly wage ($497.000 pesos/month U$228/month) and 8 indicates a household income of more than 15 times the minimum monthly wage. There were 9 occupational categories, which included entrepreneur, managerial, white collar, blue collar, worker, retiree, house, student and unemployed. The composite measure of family SES had very high reliability (Chronbach's alpha = .70).

Student characteristics

A dummy variable for student's sex (male = 1) and a continuous variable indicating age at the time of the test were also included as controls in the analysis. The control for sex is important as previous research in Colombia has found males are significantly more likely to have higher math achievement and lower reading achievement (Gaviria and Barrientos 2001a). Since the amount of family resources available to the student may depend upon the number of children in the family, a continuous variable indicating the number of siblings living in the household was also included in the analyses.

Explanatory school-level variables

School physical infrastructure and educational resources

Exploratory factor analysis was used to identify underlying dimensions of school quality among a set of correlated variables. The analysis showed that the school-level variables loaded onto two unique scales that captured different dimensions of school quality: physical infrastructure and educational resources. Both factors rely on school-level information provided in the C-600/C-100, which avoids potential problems due to aggregation biases introduced when using student or teacher reports and aggregating up to the school level.

The first scale represents physical infrastructure and includes five items: whether the school has a cafeteria, the ratio of toilets per student enrolment, the ratio of sinks per student enrolment, number of health personnel per student enrolment and the number of non-teaching staff per student enrolment. The second scale represents educational resources and includes eight items: amount of science equipment, number of audiovisual supplies, number of teachers with postgraduate degrees, number of school counsellors, whether the school has a computer laboratory, whether the school has a language laboratory, whether the school has a library and whether the school has sports facilities. Teacher-student ratio was also included (number of teachers per 100 students) as an additional measure of school quality.

Table 1 describes the variables used in the factor analysis that led to the construction of the two school quality scales, along with their associated Cronbach's alpha for internal reliability. While these measures do not capture specific teacher or classroom practices, they do provide a good measure of the quality of school inputs and the opportunities to learn experienced by different students. A high quality school has good physical facilities as well as adequate equipment, educational materials and well-trained teachers, all of which provide greater opportunities to learn and improve student achievement.

School composition

Two measures were included to capture the composition of the student body in the schools: poverty composition and school sector. A continuous variable of the percent of students enrolled in the school whose families were in the lowest of two income categories (less than $984.00 pesos/month) was used to measure poverty composition of the school. A dummy variable indicating whether the secondary school was public (= 1) or private (= 0) was also included in the analyses.

Analytic strategy

The purpose of this study is twofold. First, to estimate the unique contribution of school factors to the variation in student achievement in Cartagena, above

Table 1. School quality measures: means, standard deviations and reliability for physical infrastructure and educational resources scales.

Items	Mean	SD	Range
Physical infrastructure scale			
Number of toilets	32.90	46.38	0–195
Number of school staff	19.72	28.36	0–109
Number of sinks	25.80	52.81	0–218
Number of health personnel	.99	1592	0–5
School has cafeteria (1 = yes)	.56	.50	0–1
Cronbach's alpha	.80		
Educational resources scale			
Science equipment	1.78	1.54	0–5
Quantity audiovisual equipment	8.94	7.18	0–42
Number of teachers with postgraduate degree	3.17	6.77	0–31
Number of counsellors	1.45	1.32	0–6
System laboratory in school (1 = yes)	.68	.47	0–1
Library in school (1 = yes)	.14	35	0–1
Language laboratory in school (1 = yes)	.27	.45	0–1
Sport facilities in school (1 = yes)	.94	.25	0–1
Cronbach's alpha	.50		

and beyond family socio-economic background. Second, to determine whether school resources, including poverty composition, explain the achievement differences between students who attend private versus public schools. In order to answer these questions, we estimated a series of HLM or multi-level models, which take into account the nested structure of the data and allow us to model the unique impact of school characteristics on educational achievement (Raudenbush and Bryk 1986).

To determine the combined impact of student-level characteristics and school-level attributes on reading and mathematics achievement test scores, we estimated a multi-level model utilising the xtmixed commands available in STATA. The multi-level or HLM model combines a student-level model with a school-level model. The student-level model estimates the amount of variance in student's reading/mathematics achievement test scores that lies within schools. The school-level model estimates the amount of variance in student achievement that lies between schools. All independent variables were centred within schools around the mean for each school. Group mean centring at the student level was preferred because it maximises the remaining outcome variance explained by school level covariates and it allows for more ease in the interpretation of results (Raudenbush and Bryk 2002).

Separate analyses were conducted for reading and mathematics achievement. In Model 1, student achievement is regressed on independent variables

at the student level including family SES, number of siblings, age and gender. In Models 2–5, several school-level characteristics – public, school poverty, infrastructure, educational resources and teacher-student ratio – are added sequentially to the regression model predicting average student achievement in mathematics and reading.

Results

Descriptives

Table 2 presents the summary characteristics for the student and school-level variables included in the multilevel analysis. The sample is 46% male and on average 17 years old. The age range of the sample is considerably wider (13–24 years) compared to most samples of seniors in high school in industrialised countries like the USA. Most of the students in the sample have three siblings. A significant portion of students in the sample are from lower-SES families. The school-level characteristics indicate that a little over half of the 2003 senior cohort in Cartagena attended public schools. On average, impoverished students comprise 30% of the student body for all schools. Almost a quarter of all students in Cartagena attend schools with the fewest (lowest quartile of scale) educational resources and poorest physical infrastructure. The average teacher-student ratio is 4 teachers per 100 students.

Table 2. Descriptive statistics of variables.

Variables	Mean	SD	Range
Student-level variables			
Dependent variable			
Reading achievement test score	47.63	8.14	12–90
Mathematics achievement test score	41.35	5.16	1–73
Student characteristics			
Male	.46	.50	0–1
Age	16.83	1.48	13–24
Family background			
Family SES	.00	.88	−2.20–3.33
Number of siblings	3.01	1.90	0–9
School-level variables			
Public	.56	.50	0–1
Teacher-student ratio	3.97	1.57	1.28–14.25
School poverty composition	30.08	21.97	0–100
Physical infrastructure scale	.00	1.00	−.69–3.51
Educational resources scale	.00	0.91	−1.47–2.10

Predictors of mathematics achievement

One of the primary goals of this study is to examine the unique effect of school attributes above the contribution of family and student attributes to the variation in ICFES mathematics and reading scores for the year 2003 across high schools in Cartagena. In order to model the unique effects of family background and school characteristics, as well as take into account the nested structure of the data, all models are estimated using HLM. The results of a full random-intercept HLM model of mathematics achievement and reading achievement are presented in Tables 3 and 4, respectively. Model 1 presents the results for the baseline model that include the individual characteristics and family background. Models 2–5 add school-level factors to the models predicting student mathematics and reading achievement test scores.

Student characteristics and family background effects

In the results shown in Model 1 of Table 3, male students have significantly higher mathematics achievement. Older students and those with more siblings have lower mathematics achievement. Students from higher socio-economic background have significantly greater mathematics achievement compared to students from lower-SES families. The next series of models add school characteristics to determine how much of the impact of family socio-economic background on mathematics achievement is due to variation in school factors.

School sector and student composition effects

Model 2 introduces the effect of public schools. As expected, this coefficient is negative, statistically significant and quite large. Students who are in public schools have significantly lower mathematics achievement test scores compared to students in private schools, controlling for sex, age and family SES. Moreover, the effect of public schools alone decreases the effect of family SES on mathematics achievement by 10%. Interestingly, this negative public school effect is reduced by half when school poverty composition is added to the equation predicting math achievement in Model 3. That is, the negative effect of being in a public school on mathematics achievement is partly due to the fact that public schools have greater concentrations of impoverished students. The results in Model 3 support the hypothesis that the depressing effect of public schools on student achievement reflects the disadvantages arising from the segregation of students in poor schools, regardless of the type of school. In addition, school composition accounts for an additional reduction of 14% in the magnitude of family background on mathematics achievement. Again, this suggests that students from higher socio-economic backgrounds have higher mathematics achievement in part because they are more likely to attend private schools and low poverty schools.

Table 3. Hierarchical linear models of mathematics achievement.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	43.68[d] (.75)	43.98[d] (.75)	44.09[d] (.75)	44.05[d] (.75)	43.32[d] (.80)
Level 1 covariates					
Male	.38[c] (.12)	.36[c] (.12)	.38[c] (.12)	.38[c] (.12)	.38[c](0.12)
Age	−.13[c] (.04)	−.13[c] (.04)	−.11[c] (.04)	−.11[b] (.04)	−.11[c](0.04)
Number of siblings	−.08[b] (.03)	−.07[b] (.03)	−.06[a] (.03)	−.06[a] (.03)	−.06[a](0.03)
Family SES	.42[d] (.07)	.38[d] (.08)	.33[d] (.08)	.32[d] (.08)	.31[d](0.08)
Level-2 covariates					
Public school		−.86[d] (.24)	−.44 (.27)	−.48[a] (.28)	−.53[a](0.27)
School poverty composition			−.02[c] (.01)	−.01[b] (.01)	−.01 (0.01)
Infrastructure factor				.39[a] (.22)	.07 (.29)
Educational resources factor					.51[b] (.23)
Teacher-student ratio					.13[b] (.06)
Number of students	8708	8708	8708	8708	8708
Number of schools	129	129	129	129	129

Note: Standard errors in parentheses; [a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$, [d] $p < 0.001$.

Table 4. Hierarchical linear models of reading achievement.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	65.41[d] (1.09)	66.47[d] (1.11)	68.07[d] (1.09)	68.18[d] (1.08)	68.41[d] (1.27)
Level 1 covariates					
Male	−.37[b] (.17)	−.38[b] (.17)	−.36[b] (.17)	−.35[b] (.17)	−.35[b] (.17)
Age	−1.02[d] (.06)	−1.02[d] (.06)	−1.01[d] (.06)	−1.01[d] (.06)	−1.01[d] (.06)
Number of siblings	−.18[d] (.05)	−.17[d] (.05)	−.16[d] (.05)	−.15[d] (.05)	−.15[c] (.05)
Family SES	1.06[d] (.11)	1.03[d] (.11)	.95[d] (.11)	.95[d] (.11)	.94[d] (.11)
Level 2 covariates					
Public school		−2.45[d] (.59)	.09 (.58)	−.1 (.57)	−.35 (.58)
School poverty composition			−.10[d] (.01)	−.08[d] (.01)	−.07[d] (.01)
Infrastructure factor				1.58[c] (.49)	.67 (.67)
Educational resources factor					.98[a] (.51)
Teacher-student ratio					−.08 (.13)
Number of students	8708	8708	8708	8708	8708
Number of schools	129	129	129	129	129

Note: Standard errors in parentheses; [a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$, [d] $p < 0.001$.

Effects of school quality

Model 4 reveals educational resources in schools have a significant and positive effect on student mathematics achievement. Although school infrastructure appears significant and positive when entered alone in Model 4, it does not have an independent effect once educational resources are controlled. Students who are in schools with greater educational resources have significantly higher mathematics achievement compared to students in schools with fewer resources (Model 5). Educational resources completely explain the impact of school infrastructure on mathematics achievement. Adding educational resources and infrastructure to the final model reduces the effect of school poverty on achievement by almost half and reduces the family SES effect by an additional 7%. This suggests that the schools with greater percentages of impoverished students are also the schools with fewer resources, which in part explains why students have lower mathematics achievement in these schools. Interestingly, adding school resources to the model actually increases the negative effect of public school, which suggests that students have lower mathematics achievement in these schools than their level of resources would predict. Overall, school-level factors explain almost half of the effect of family SES effect on mathematics achievement.

The teacher-student ratio coefficient in Model 5 is significant and positive, which suggests that students in schools with more teachers per students have better mathematics achievement. Schools with lower teacher-student ratios may negatively affect student achievement in several ways. First, larger schools with fewer teachers may make it more difficult to monitor and regulate student behaviour. Second, a lower teacher-student ratio may mean more interpersonal relationships and opportunities for conflict between students or peer groups (Welsh et al. 2000). Finally, student-teacher relationships may be more intimate in schools with higher teacher-student ratios because teachers are more likely to know students and their parents outside of school (Gottfredson and Gottfredson 1985). As a result, teachers may have more interactions with students during and outside of class, which may foster student academic engagement and performance in school as well as create a climate that is safe and undisruptive.

Predictors of reading achievement

Student characteristics and family background effects

Table 4 presents the results for reading achievement. The baseline model (Model 1), indicates that older students have significantly lower reading achievement, remaining negative and significant throughout the analysis. This coefficient is likely capturing the effect of earlier grade repetition, previous dropout or late entrance to school, for which there is no available data in Colombia at the student level.

The baseline model also indicates that being a male is negatively associated with reading achievement, contrasting the positive and significant effect

observed on math scores. This is a sensitive result, since it indicates the still appreciable gender segregation into science and humanities among boys and girls in Cartagena. This gender segregation in high school achievement is later translated into college major preferences, where female students clearly show a tendency for social science majors, while male students show a strong preference for engineering and similar fields with an intensive mathematics component (Galvis and Rangel 2006). In addition, similar to the results for mathematics achievement, the number of siblings presents a negative and significant influence on reading and family SES is strongly associated with reading achievement, suggesting that reading achievement is influenced by family processes.

School sector and student composition effects

In Model 2, similar to what was observed for mathematics achievement, the effect of public schools on reading achievement is negative, highly significant and remarkably large. However, it only reduces the effect of family SES on reading achievement by 3%. This suggests that the impact of parents' background on student achievement is much stronger for reading compared to mathematics. In addition, unlike the results for mathematics achievement, the lower reading achievement among students in public schools is completely explained by the poverty composition of students in the school (Model 3). This finding supports Somers, McEwan and Willms's (2004) finding that school SES mediated the relationship between school sector and student achievement across 10 cities in Colombia. The poverty composition of the school also reduces the effect of family SES on reading achievement by 7%.

Effects of school quality

In Model 5, the introduction of educational resources and infrastructure into the analysis decreases the school composition effect by 30%. That is, students in schools with a high concentration of impoverished students have lower reading test scores, in part because these schools also have fewer educational resources such as language laboratories or libraries and poorer infrastructure in the school. As was the case for mathematics achievement, the results for reading achievement indicate that the reading achievement gap between students in private and public schools is due to the disproportionate percentage of poor students in public schools. Finally, the results in Model 5 suggest that there is not a unique contribution of either teacher-student ratio or school infrastructure once school sector, poverty composition and educational resources are taken into account.

Conclusion

The primary goal of our study was to estimate the effect of school characteristics on math and reading achievement of senior high school students in the

city of Cartagena, for the year 2003. We were also interested in determining whether school resources explained the lower achievement experienced by students who are in public schools and high-poverty schools. Overall, the results indicate that school resources are an important factor in explaining differences in student achievement in one major city in Colombia, Cartagena. Like other studies of developing and Latin American countries, our findings suggest that students who attend schools with better adequate equipment, more access to educational materials, laboratories and counsellors as well as well-trained teachers have greater opportunities to learn and higher achievement (Harbison and Hanushek 1992; Fuller and Clark 1994; Anderson 2005). Further, the results highlight the potentially important role played by socio-economic segregation in schools in shaping educational opportunities and outcomes.

Results from our multilevel model of student achievement using data for all senior high school students in Cartagena determined the unique contribution of school-level attributes in explaining the variability in student achievement. The results indicate that there are positive and unique effects of educational resources on mathematics and reading achievement, above and beyond family characteristics. These findings support those found by Piñeros and Rodríguez (1999) in Bogotá. Our findings also indicate that family SES is mediated at least in part by school sector, school composition and school resources. While students in private schools have higher mathematics and reading achievement test scores, this is almost entirely due to the presence of more middle-class and affluent students and the differential allocation of resources between high- and low-poverty schools. This finding extends the results of Somers, McEwan and Willms (2004), who found that the SES composition of the student body fully explained the school sector achievement gaps in Colombia by demonstrating that school resources account for most of the poverty composition effect.

The results show that school resources play an important role in explaining the effects of school poverty composition on student achievement. However, even after controlling for school quality, poverty composition remains significantly and negatively associated with lower reading achievement. This may be indicative of unmeasured teacher and classroom practices, curriculum or peer effects related to student achievement (Coleman 1988; Gottfredson, 2001).

Altogether, these findings suggest that poor students in Cartagena experience a double disadvantage, that of social segregation exacerbated by school segregation, when it comes to educational opportunities and school quality. Poor students are much more likely to attend high-poverty schools with fewer educational resources, a process that significantly depresses their mathematics and reading achievement, even after controlling for family SES. Given that Colombia exhibits a high level of inequality relative to other countries in Latin American, policies targeting the reduction of inequalities among disadvantaged socio-economic groups should become a national

priority. Particularly, redistributive policies ought to consider children that are both socio-economically segregated in poor households and spatially segregated in poor schools and neighbourhoods. Moreover, given the evidence for within-country inequalities, educational policies should not only be informed by national aggregated analysis, they must also include and motivate research at smaller levels like that of cities. Decisions made without the consideration of the context are an unwarranted risk that could lead to inefficient educational programs and investment.

Limitations

While this study adds to the growing body of literature examining the impact of school quality on student achievement in developing countries, and Colombia specifically, there are limitations. First, while the data from Cartagena provides specific details on physical and educational resources of the school as well as individual student achievement and family background data, it was cross-sectional. As a result, we could not include a control for the student's ability upon entry into secondary school, which may overestimate the impact of school effects in the study. For example, if students in our sample score lower on the achievement tests not because they attended schools with poorer resources and more impoverished students but because they have certain unmeasured characteristics that make them end up in these kinds of schools as well as score lower on achievement tests, then the impact of school quality and resources would be overestimated. Second, students are not assigned to schools randomly. While we include a comprehensive measure of family socio-economic status, there may be unobserved variables such as parent motivation and student effort and engagement that influence what kinds of schools students attend as well as their achievement. Third, we do not have specific measures of teacher practices, curriculum or peer group processes, all of which have been shown to have important impacts on student achievement. Since it is likely that these unmeasured processes are related to both the poverty composition and educational resources of the school, as well as student achievement, we can only speculate as to why these factors matter for student achievement. Finally, our data come from students who are in their last year of secondary schooling, a highly selective group of students. Since many low-income students in Cartagena and Colombia as a whole, drop out before finishing secondary school, our analysis also likely underestimates the impact of family socio-economic background as well.

Notes

1. We would have liked to use more recent testing and school-level data. However, access to national data is restricted in Colombia and there is a significant delay between when the data is collected and when it is available for researchers to

analyse. It took almost two years for our petition to be granted for both the ICFES dataset and the C-600. Due to confidentiality policies and practices of exclusive use, the most recent datasets we could gain access to were the 2003 ICFES data and the C-600 data from 1999.

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Appendix 1

The creation of the dataset involved three major steps. First a student dataset was created from the ICFES files, containing information on 9000 high school seniors in 157 Cartagena schools. This dataset included information on family background including family income, parents' educational level, parents' occupation and number of siblings. Next, a school dataset was created based on DANE files for over 800 schools in the city for all levels – preschool to high school – and from this file a dataset for a total of 157 secondary in the city was extracted. Finally, these two data files were merged to create a file with 8708 seniors that contained valid testing information in 2003 in 129 schools.