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School effects on non-verbal intelligence and nutritional status in rural Zambia☆

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ABSTRACT

This study uses hierarchical linear modeling (HLM) to examine the school factors (i.e., related to school organization and teacher and student body) associated with non-verbal intelligence (NI) and nutritional status (i.e., body mass index; BMI) of 4204 3rd to 7th graders in rural areas of Southern Province, Zambia. Results showed that 23.5% and 7.7% of the NI and BMI variance, respectively, were conditioned by differences between schools. The set of 14 school factors accounted for 58.8% and 75.9% of the between-school differences in NI and BMI, respectively. Grade-specific HLM yielded higher between-school variation of NI (41%) and BMI (14.6%) for students in grade 3 compared to grades 4 to 7. School factors showed a differential pattern of associations with NI and BMI across grades. The distance to a health post and teacher's teaching experience were the strongest predictors of NI (particularly in grades 4, 6 and 7); the presence of a preschool was linked to lower BMI in grades 4 to 6. Implications for improving access and quality of education in rural Zambia are discussed.

Physical health indicators (e.g., body mass index; BMI) have been linked to individual differences in cognitive development (Ivanovic et al., 2004; Ivanovic, Forno, Castro, & Ivanovic, 2000; Jensen & Sinha, 1993) and are important foundations for learning and childhood achievement (Grantham-McGregor et al., 2007). In many high-income countries (HIC), BMI and obesity increases are the most pervasive trends (Finucane et al., 2011; Li, Dibley, & Yan, 2011), and both have been associated with lower performance IQ (Parisi et al., 2010) and lower non-verbal reasoning (Lawlor et al., 2006). Despite research on developmental indices from HIC, many parts of the world, especially African low- and middle-income countries (LMIC), decreases in BMI or low BMI have been observed, suggesting that many people are underweight (Finucane et al., 2011). In a previous investigation in rural Zambia (Hein, Reich, Thuma, & Grigorenko, 2014), we found (a) that BMI of 3rd to 7th grade students was approximately one standard deviation below international norms; (b) that BMI was positively related to non-verbal intelligence; and (c) that grade was positively related to both BMI and non-verbal intelligence after controlling for age and gender. As accomplished years of schooling have an apparent impact on cognitive skills, the present study sought to examine school effects on BMI and non-verbal intelligence.

Since the inception of school effectiveness research in the United States by economically-driven input–output studies (Coleman et al., 1966), there has been an ongoing debate over whether schools are capable of improving student outcomes over and above students' family background and peer effects. While there is no doubt that cognitive development is susceptible to broad environmental influences (Bronfenbrenner & Morris, 2006), the literature on the effects of increased inputs and resources on student achievement is rather inconclusive (Hanushek & Luque, 2003; Heyneman & Loxley, 1983). For instance, it has been noted that smaller classes (Hanushek, 1999; Hoxby, 2000) and schools (Leithwood & Jantzi, 2009) do not necessarily yield better students outcomes. Instead, class-size and school-size effects on student achievement may be non-linear (Borland & Howsen, 2003; Borland, Howsen, & Trawick, 2005). There is also considerable disagreement regarding the effect of school expenditure on outcomes such as reading achievement (Archibald, 2006; Holmlund, McNally, & Viarengo, 2010). Furthermore, there is mounting evidence of the effect of teachers on student achievement (often cumulative and persistent) in studies that measured the "teacher effect" as variation in achievement between

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classrooms adjusted by student background (Konstantopoulos & Chung, 2010; Nye, Konstantopoulos, & Hedges, 2004; Rivkin, Hanushek, & Kain, 2005). However, less is known about which measurable and observable teacher characteristic impacts students' achievement (Hanushek, 1992). Most studies attribute positive effects mainly to teacher experience, education and credentials (e.g., Clotfelter, Ladd, & Vidgor, 2007; Darling-Hammond & Youngs, 2002). School principals have also been related to student achievement, mostly through indirect pathways such as allocation of teachers to classrooms, hiring practices and decisions related to the curriculum (Coelli & Green, 2012). However, these effects are comparatively small and difficult to measure (Witziers, Bosker, & Krüger, 2003).

Two considerations may moderate these factors differently in different countries, cultures, and societies. First and foremost, there has been little systematic empirical research on correlates of cognitive skills for children in LMIC (Engle et al., 2007; Grantham-McGregor et al., 2007). Consequently, the quality of education and the impact of various aspects of formal learning environments on children's development in LMIC are not well understood and are often debated. This debate is frequently bound to a human capital perspective on cross-country comparisons linking international test score data to economically-driven measures such as the increase in educational achievement obtained from an additional year of schooling (Hanushek, 2013; Kaarsen, 2014). However, this approach exhibits shortcomings when it comes to identifying educational factors that are related to students' outcomes for populations that have either not participated in international standardized benchmark tests or, if they did, are prone to producing floor effects either due to the tests' high levels of difficulty or lack of local relevance of the test content (van der Gaag & Adams, 2010). Moreover, non-verbal reasoning and adequate nutrition are important foundations for learning in the classroom but are habitually understudied. Hence, research on the environmental correlates of these factors in understudied populations is needed.

Second, the variability in emphasis on formal learning and how well the implemented system of education fits the needs and conditions of the community or society that it is meant to serve should be considered. The variety of demands—both cognitive and physical—to which children in different parts of the world must successfully adapt may not overlap with what is considered important in Western societies. Many societies have reacted to globalization by crafting educational policies that deliberately aim to foster a skillset necessary for competition within the global labor market. Yet the tremendous cultural diversity of societies worldwide (Kagitcibasi, 2012) and their efforts to re-focus on demands for new skills have led to varying emphases on the organization of formal learning environments in local communities (Hein, Reich, & Grigorenko, 2015), rendering it unlikely that school factors have an universal impact on children's development. For these reasons, we believe it important to extend our perspective by collecting micro-level data from an understudied population: school students in rural Zambia. Here, we aim to build on the available data on school effects in LMIC to examine the differential impact of school contextual factors on non-verbal cognitive skills and physical health.

1. School effects in LMIC and sub-Saharan Africa

Research investigating effects of school quality on cognitive development and how different factors shape cognitive skills has originated mainly from the United States and Western Europe (Evans, 2006; Ferguson, Cassells, MacAllister, & Evans, 2013). Over the past three decades, most of these studies of school effects on student achievement in LMIC (Glewwe, Hanushek, Humpage, & Ravina, 2011; Riddell, 2008; Scheerens, 2001) have examined the impact of school structure and organization, physical and human resources (e.g., class size, teacher training and teacher salaries, availability of textbooks, general facilities and equipment; Fuller, 1987; Fuller & Clarke, 1994; Lee & Zuze, 2011) and instructional processes (e.g., teacher's use of instructional time, the amount and type of curriculum covered; Fuller & Heyneman, 1989). However, the international literature is equivocal regarding the effects of school quality and school inputs on cognitive performance and academic achievement in LMIC (Hanushek, 1995; Kremer, 1995).

For instance, some studies conclude that the findings across HIC and LMIC are quite similar, including the relatively insignificant role of smaller classes or higher teacher–student ratio in explaining variation in school performance (Hanushek, 1995; Khoo & Khoo, 2005; Scheerens, 2001) and the positive effect of teachers' qualifications on student achievement (Fuller, 1987; Fuller & Clarke, 1994). In contrast, some investigations doubt the importance of factors identified in HIC (Baker, Goesling, & Letendre, 2002; Hanushek & Luque, 2003), concluding that the relationships between facilities and school resources and student achievement (Hanushek, 2006) are as ambiguous as the effect of school expenditure, higher teacher salaries, and teacher training (Glewwe, Grosh, Jacoby, & Lockheed, 1995). For Southern and Eastern Africa, Lee, Zuze, and Ross (2005) identified school composition, human and fiscal resources, and organizational characteristics to be consistently linked to student achievement. The authors also found that schools in urban areas had higher average achievement compared to schools in rural areas—a finding that was particularly pronounced for Zambia. However, it remains unclear which school factors impact students' cognitive skills in rural Zambia.

Recent studies have examined the occurrence of malnutrition in urban versus rural environments (Fotso, 2007), several focusing on the new “double burden” of obesity, generally in urban centers, and undernutrition, most often in rural areas (Bulbul & Hoque, 2014; Nguyen et al., 2013; Pawloski, Curtin, Gewa, & Attaway, 2012). These differences have been attributed to SES, lifestyle (more sedentary) and food type (higher fat content) availability factors that are more prevalent in urban areas. More refined studies of child malnutrition have examined the role of locale in BMI. A study in Kenya found that high BMI mothers and children are spatially clustered, while low BMI mother–child pairs are much more dispersed (Pawloski et al., 2012). A study of BMI distributions on the neighborhood level in LMIC found similar dispersions, with local conditions appearing to exert more influence on BMI for low-SES women in middle income countries, and high-SES women in low-income countries. However, the contextual determinants of BMI in LMIC are still to be fully investigated (Corsi, Finlay, & Subramanian, 2012; Fotso, 2007). While local environmental factors such as social cohesion, community disorder (Carter, Dubois, Tremblay, Taljaard, & Jones, 2012), walking to school (Faulkner, Stone, Buliung, Wong, & Mitra, 2013), and school racial composition (Bernell, Mijanovich, & Weitzman, 2009) have been investigated in HIC (Faulkner et al., 2013), the influence of such factors on BMI have not been considered in LMIC, and no study in these countries has considered school effects on BMI.

Notably, the associations between school factors and non-verbal intelligence and BMI are bidirectional rather than causal. Specifically, given the family, home environment, and socio-geographic factors associated with both outcomes, more affluent parents and families may be concentrated in certain environments and areas, which could affect the availability of resources at a particular neighborhood school, as well as the average abilities and BMI of the student body at a school. Given the correlational nature of the present study, one has to keep in mind that more “capable” students may seek to attend schools with more resources in order to experience better educational opportunities. School location (i.e., proximity to relevant players, such as the students it serves, or a charitable resource) may also be an important factor that may ultimately affect student BMI. This is because we aimed at understanding the community and its resources and how they are associated with the outcomes of students living in these communities. Some of the schools' characteristics (e.g., the distance to a health post) are less about