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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.

Keywords

non-verbal intelligence; Body Mass Index—BMI; multilevel analysis; school context; sub-Saharan Africa; Zambia

Physical health indicators (e.g., body mass index; BMI) have been linked to individual differences in cognitive development (D. M. Ivanovic et al., 2004; R. Ivanovic, Forno, Castro, & Ivanovic, 2000; Jensen & Sinha, 1993) and are important foundations for learning

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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, under revision), 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 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 has led to varying emphases on the organization of formal learning environments in local communities (Hein, Reich, & Grigorenko, Forthcoming), 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.

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

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(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 and colleagues (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 LMICs 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 LMICs 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 HICs (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 the school location, but more about the proximity between community and school.

School-related factors in Zambia

Primary education for all using a curriculum based on globally oriented, international blueprints is one of Zambia's goals. Its adoption of free access to basic education, in accordance with the World Education Forum re-commitment to education for all in 2000 was a notable change for Zambia (World Education Forum, 2000). The effects of this policy of free primary education are reflected in the drastic rise in student enrollment, from 1,806,754 in 2000 to 3,166,310 in 2007—an increase of 75 percent. An acute area of concern, as a result, is that the quality of education may be at risk with more children attending primary schools without an equivalent increase in resources.

In fact, there has been a general downward trend in the quality of educational supports in some areas of Zambia, according to the results of the third data collection in 2007 of the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ III; Musonde & Kaba, 2010) versus SACMEQ II (collected in 2000). That is, while some indicators of school quality reflect improvement, more portray a system struggling to balance quality with resources1. Our study took place in Southern Province where, as of 2007, over 85% of schools were located in rural, isolated areas (rising from 45% in 2000); the average proportion of schools in rural areas across Zambia was 64.7%.

SACMEQ III data (Musonde & Kaba, 2010) on Grade 6 teacher characteristics show a general decrease in their academic qualifications from 2000 to 2007. Specifically, the percentage of teachers being educated to G12 (through secondary school) fell from 71.7% to 50.7%, and the years of teaching experience fell from an average of 11.5 to 6.1 years of experience. With increased attendance and school enrollment, multiple sessions are scheduled to allow for more students to attend, but this leaves little time for teachers to prepare lessons, and high numbers of students leave little time for individual attention or skill practice.

SACMEQ also considered teachers' access to teaching aids such as maps, dictionaries, geometrical tools and English and mathematics teaching guides, which generally decreased across Zambia (except for the availability of English dictionaries). The prevalence of chalkboards, chalk, and wall charts, and the availability of other materials for teachers decreased generally across Zambia, and in Southern Province in particular. SACMEQ concluded that education delivery in Zambia was generally inadequate, in which limitations in teaching and learning materials, including furniture, could result in ineffective teaching and learning in the classroom. Based on these statistics we would not expect many differences between schools due to the often restricted availability of resources and lack of appropriate teacher training and experience, especially in the rural areas of Southern Province.

Note 1SACMEQ collects information on Grade 6 students, their home environment and school factors that may relate to their academic development in 16 countries, including Zambia. In their SACMEQ III report for Zambia, the consortium presents results for the country as a whole, and also for Zambia's nine provinces.

The Present Study

To date little is known about the associations between specific school contextual factors and student outcomes, especially in sub-Saharan Africa and rural Zambia. The present study sought to examine the effects of different school factors on non-verbal intelligence and nutritional status (i.e., BMI) of 3rd to 7th graders in rural Zambia, using hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002). Our interest was threefold: (1) to quantify the between-school variation in non-verbal intelligence and BMI; (2) to quantify the proportion of between-school variance attributable to the entire set of school contextual factors; and (3) to identify the school factors that are significantly associated with school-level non-verbal intelligence and BMI. In a previous investigation we found that both BMI and non-verbal cognitive skills increased significantly across these grades (Hein et al., under revision). Therefore, we applied separate HLM for grades 3 to 7 to explore whether between-school variation in non-verbal cognitive skills and BMI differs by grade.

Method

Participants

A total of 4609 students were approached for participation in the Bala Bbala Project (*Bala BBala* means 'read the word' in Chitonga), a large-scale study of the manifestation, prevalence, and etiology of specific reading disabilities (SRD) in rural Zambia (Hein, Reich, Thuma, & Grigorenko, 2014; Reich, Tan, Hart, Thuma, & Grigorenko, 2013; Tan, Reich, Hart, Thuma, & Grigorenko, 2014). Students were screened for malnutrition and visual and hearing impairments as these criteria could affect performance on measures utilized in this study. As part the screening and selection process, a stadiometer and a scale were used to measure height and weight of barefoot uniformed children. BMI was calculated as weight divided by height squared. For the vision screening children stood 6 meters from a chart and had to indicate the orientation of the letter E in different positions. Hearing was tested using an audiometer. Children were excluded (a) if they were malnourished (i.e., BMI-for-age value more than 3 *SD* below the international WHO norms) ($n = 296$), (b) based on the hearing and vision screening ($n = 39$), or (c) if they were missing at least two out of the three screening assessments ($n = 70$). Children were excluded if they had missing hearing or vision screening data, had vision poorer than 20/30 in both eyes or hearing loss over 40db for one or more of the assessed frequencies (i.e., 1000, 2000, and 4000 hertz) in both ears. A total of 405 children (8.8%) were excluded based on these criteria from the final sample.

The final sample comprised 4204 students (2116 male, 50.3%), grades 3 to 7, with a mean age of 12.73 years ($SD = 2.07$, range = 7.40 to 23.21). The students were from 36 schools, all of which were located within 50km of a district-level hospital. There was no difference in the percentage of boys and girls across grades ($\chi^2(4) = 2.23$, $p = .69$) and across schools ($\chi^2(35) = 18.10$, $p = .99$). However, there was a significant difference in the percentage of students from each grade across schools ($\chi^2(140) = 216.06$, $p < .001$). Although students were distributed about equally across grades (~20% from each grade) for most of the schools, the observed difference is mainly attributable to four schools with a low percentage of students from grade 7 (9.5%, 0%, 7.3%, and 8.3%, respectively), one school with few students from grade 6 (3.7%) and 7 (7.3%), and two schools with higher percentages of students from grades 3 (31.2%) and 4 (40.2%), respectively. The final sample did not differ from the excluded sample in the number of students from each grade ($\chi^2(4) = 4.92$, $p = .30$) and age ($M_{final} = 12.73$, $SD_{final} = 2.07$, $M_{excluded} = 12.92$, $SD_{excluded} = 2.13$; $t(4596) = -1.70$, $p = .09$). However, significantly more boys (55.6%) were excluded compared to the percentage of boys in the final sample (50.3%) ($\chi^2(1) = 4.03$, $p < .05$).

Measures

Demographic information—Age, grade and gender were collected from school records.

Non-verbal intelligence (NI)—The Universal Non-verbal Intelligence Test, Symbolic Memory subtest (UNIT-SM) (Bracken & McCallum, 1998) and the Kaufman Assessment Battery for Children, Second Edition, Triangles subtest (KABC-II-T) (Kaufman, 2004) were administered to assess non-verbal intelligence. These tasks target two distinct cognitive skills, namely memory and simultaneous visual processing. They were selected because they use manipulative materials, thought to be engaging for children not familiar with Western testing modes. UNIT-SM uses non-verbal instructions and has 30 items of increasing difficulty (Cronbach's $\alpha = .83$) that require students to look at an array of one to six images of people that differed in age, gender, and color (green, black), and to reproduce this array from memory using tiles with the same images. The UNIT-SM was discontinued after seven consecutive incorrect responses. KABC-II-T includes 27 items (Cronbach's $\alpha = .86$) that require students to use physical foam and plastic shapes, mainly triangles, to reproduce color images displayed to them on an easel. KABC-II-T was discontinued after five consecutive incorrect responses. Sum scores were computed for both tests and were submitted to a principal components analysis (PCA) to extract factor scores from a one-component solution (65.18% of variance explained) for further analyses. A PCA was conducted instead of another composite of both measures (e.g., the average) to obtain a score that has been used in a previous investigation (Hein et al., 2014). Note, however, that the rank order of the factor score and the rank order of the average of both measures are equivalent and lead to the same results.

School environment—Information on the school environment was collected using a survey completed by the head teachers of 29 out of the 36 participating schools. The principals had access to a data collector in case there were any questions. This survey was designed to assess school organization and characteristics of the teacher and student body.

School organization—Seven questions were included in this section: (1) the source of school funding, (2) whether the school has a formal relationship with a church (0 = *no*, 1 = *yes*), (3) whether the school received donations within the last year (i.e., in the school year 2012-2013; 0 = *no*, 1 = *yes*), (4) if there is a preschool in the area that children usually attend before starting at the school (0 = *no*, 1 = *yes*), (5) how long it takes to travel by foot, bike and car to the hospital or a health post, (6) classroom equipment, and (7) school climate.

Head teachers indicated whether the church, government, church and government together, and/or other sources financially supported the school. None of the schools received funds from the church only. The answers were coded as 0 if funds came exclusively from the government, and as 1 if funds came from church and government or from the government and another source (thus reflecting two sources of funding).

Head teachers estimated the time to travel to the nearest hospital, health center, or health post with three separate questions, that is, how many minutes it takes to travel by foot, bicycle and car. Children typically live within walking distance of the schools that they attend, as no system of transportation is available in the study community. Thus, this aspect of school environment is roughly equivalent to the distance between the communities and families and the nearest hospital, health center, or health post. We only included durations by bicycle as they appeared to be the most accurate and reasonable, being based on greater and more consistent experience (cars being uncommon and walking times more prone to subjective variation). We coded the shortest duration to any of the three health facilities (since not all of them might be available in the area where the school is located) into four categories: longer than 61 minutes, between 31 and 60 minutes, between 16 and 30 minutes, and between 1 and 15 minutes. Because of the ordinal nature of this variable, we applied forward difference contrast coding to compare adjacent levels of the categorical variable: (a) "longer than 61 minutes" compared to "between 31 and 60 minutes"; (b) "between 31 and 60 minutes" compared to "between 16 and 30 minutes"; and (c) "between 16 and 30 minutes" compared to "between 1 and 15 minutes".

Head teachers were asked to indicate (yes/no) whether most of the classrooms have or have access (e.g., when the materials are stored in a closet) to the described equipment. Equipment included, for example, books for teachers and children, desks, usable blackboards, classroom library or book corner and bookshelves. One item (i.e., Tonga dictionary) was dropped from the scale because it was answered with "no" by all head teachers. The remaining 15 items were averaged to form a composite of available classroom equipment (Cronbach's α = .85).

Head teachers were asked to answer the question "How would you characterize each of the following within your school?" using six items: (1) Teachers' job satisfaction; (2) Teachers' expectations for student achievement; (3) parental support for student achievement; (4) Students' regard for school property; (5) Students' desire to do well in school; and (6) Students' regard for each other's welfare. The six items had to be answered on a scale from 1 (*very low*) to 5 (*very high)* and were averaged to form a composite of school climate (Cronbach's α = .81).

Teacher and student body—The total number of male and female teachers as well as their educational background and teaching experience, the number of boys and girls in grades 1 through 7, and the number of classes per grade were reported. For teachers' educational background, we were specifically interested in the number of teachers who received some certificate beyond the high school level. For teaching experience, we asked for the teaching experience of the head teacher (in years) and how many teachers had more than 3 years of teaching experience. Using these variables, we computed five variables for further analyses: (1) the teaching experience of the head teacher (in years), (2) the student-teacher ratio (i.e., total number of students in grades 1 through 7 divided by the total number of teachers); (3) the percentage of teachers with a post high school certificate; (4) the percentage of teachers with more than three years of teaching experience; and (5) the average class size across grades 3 to 7.

Treatment of missing data—Partial data for the school-level variables were missing for six schools. Specifically, the information on teaching experience of the head teacher was missing for one school, information on received donations within the last year and the presence of a preschool was missing for one school, the student-teacher ratio, percentage of teacher with a certificate and percentage of teacher with more than 3 years of teaching experience was missing for one school, and the average class size was missing for three schools. To avoid the reduction of available school-level information and potential biases in our results we performed multiple imputations on the school-level data to create five imputed datasets for further analyses (Schafer, 1997). Specifically, we imputed missing values with values generated from multiple bootstrapped samples of the original data using an expectation-maximization algorithm (EM; Schafer & Graham, 2002). All subsequent analyses were run five times and results from these analyses were combined to obtain a single set of results. The overall estimates (e.g., regression coefficients) represent the average of the individual estimates. Corrected standard errors and degrees of freedom were obtained and both values were used for significance tests of regression coefficients (Rubin, 1987).

Procedure

Trained research assistants individually administered assessments and were monitored during data collection. Assessments were given in the local language, Chitonga.

Data Analysis

Hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) was used to estimate the effects of school-level factors on children's non-verbal intelligence and BMI. In three steps, information on both the within- and between-school variability of the students' outcomes was exploited to derive coefficients and correct standard errors for both levels. In a first step (Model 1), the variance of the respective dependent variable was partitioned into the proportion of variance that lies between students in the same school (pooled over schools) and the proportion of variance that lies systematically between the schools (i.e., an unconditional model with no independent variables2). The proportion of variance conditioned by the schools was estimated as the intra-class correlation coefficient (ICC). The higher the ICC, the more homogeneity there is within schools (or the more heterogeneity there is between schools). To consider multilevel methods, the ICC should indicate a substantial amount of the total variance (> 10%) between the schools (Muthen, 1991, 1994; Peugh, 2010).

Note 2 The notation for this unconditional model can be expressed as $Y_{ij} = \gamma_{00} + u_{0j} + r_{ij}$. In this equation, each score Y_{ij} (Y represents non-verbal intelligence test scores or BMI) of student i in school j is modeled as the sum of a grand-mean test score (γ_{00}), a school-specific deviation from the grand mean (u_{0j}) that expresses variability on between-group level, and a residual term (r_{ij}) that reflects individual student differences around the mean of school j (i.e., deviation of a student's score from the school mean). The residual variance of r_{ij} is denoted as σ^2 and the variance of u_{0j} is denoted as τ_{00}.

In a second step (Model 2), we accounted for individual differences in non-verbal intelligence by entering age, gender and BMI as predictors at the student-level to explain variance within schools3. Age and gender were used as predictors of BMI at the student-level. We used grand mean centering to standardize students' age, gender and nutritional status around the entire sample mean. The estimation of this model provides regression coefficients as fixed effects for the predictors of the respective outcome (i.e., random intercepts with age, gender, and BMI as fixed slopes across all schools).

In a third step (Model 3), the proportion of between-school variance in the test scores (adjusted for age, gender and BMI at the student-level) was modeled as a function of school factors by including grand-mean centered school-level variables as predictors4. This model represents a full contextual analysis that contained predictors at both levels. The software Mplus Version 7.2 (Muthén & Muthén, 1998-2012) was used to estimate parameters, utilizing a full information robust maximum likelihood estimator (Satorra & Bentler, 1994) that yields robust estimates of the asymptotic covariance of parameter estimates and χ^2-Tests. Deviance statistics were computed as −2 times the log-likelihood ($-2\log L$) of the model to compare the differences in the unconditional model containing no predictors to the final model containing student-level and school-level variables.

Results

Descriptive statistics

Descriptive statistics of the student- and school-level variables are presented in Table 1. Bivariate correlations showed small to moderate positive relationships between age and BMI (r = .46), age and non-verbal intelligence (r = .30), and between BMI and non-verbal intelligence (r = .23). Descriptive statistics of the school-level variables indicate remarkable differences between schools, particularly for class size, student-teacher ratio and teachers' training and experience.

Continuous school-level variables showed mostly small to moderate intercorrelations. The highest correlations were found between the amount of classroom equipment and the percentage of teachers with a certificate (r = .35), the student-teacher ratio and the percentage of teachers with a certificate (r = .32), and between school climate and the percentage of teachers with more than 3 years of school experience (r = .29). Moreover, as expected, the overall student-teacher ratio at the school was related to the average class size across grades 3 to 7 (r = .44). Schools with a formal relationship with a church had larger class sizes (M = 61.43) compared to schools without a formal relationship (M = 45.26) but

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Note 3 With grand-mean centered age, gender and BMI added to Model 1, the notation for Model 2 can be expressed as $Y_{ij} = \beta_{0j} + \beta_{1j}(Gender_{i}) + \beta_{2j}(Age_{i}) + \beta_{3j}(BMI) + r_{ij}$, with $\beta_{0j} = \gamma_{00} + u_{0j}$; $\beta_{1j} = \gamma_{10}$; and $\beta_{2j} = \gamma_{20}$; and $\beta_{3j} = \gamma_{30}$. In this model, γ_{10} denotes the average fixed effect of gender, γ_{20} denotes the average fixed effect of age, and γ_{30} is the average fixed effect of BMI on NI across all schools. Fixed effects of age and gender were modeled for BMI as a dependent variable.

Note 4 The notation for Model 3 can be expressed as $Y_{ij} = \beta_{0j} + \beta_{1j}(Gender_{i}) + \beta_{2j}(Age_{i}) + \beta_{3j}(BMI) + r_{ij}$, with $\beta_{1j} = \gamma_{10}$ and $\beta_{2j} = \gamma_{20}$ and $\beta_{3j} = \gamma_{30}$ (for NI as a dependent variable). In this model, β_{0j} contains school-level fixed effects that can be expressed as $\beta_{0j} = \gamma_{00} + \gamma_{01}(\textit{Source of funding})_j + \gamma_{02}(\textit{Relationship with a church})_j + \gamma_{03}(\textit{Donations})_j + \gamma_{04}(\textit{Preschool})_j + \gamma_{05}(\textit{Distance to health post, > 60 min vs. 31-60 min})_j + \gamma_{06}(\textit{Distance to health post, 31-60 min vs. 16-30 min})_j + \gamma_{07}(\textit{Distance to health post, 16-30 min vs. 1-15 min})_j + \gamma_{08}(\textit{Equipment})_j + \gamma_{09}(\textit{Climate})_j + \gamma_{010}(\textit{Principal's teaching experience})_j + \gamma_{011}(\textit{Student-teacher ratio})_j + \gamma_{012}(\textit{Class size})_j + \gamma_{013}(\textit{Percentage of teachers with a certificate})_j + \gamma_{014}(\text{Percentage of teachers with more than 3 years of experience})_j + u_{0j}$. The indices $\gamma_{01}, \gamma_{02}, \ldots, \gamma_{014}$ denote regression coefficients of predictors at the school-level.

this difference was not significant after Bonferroni adjustment for multiple comparison of other school-level variables [$t(27) = -2.68$, $p = .013$]. None of the other school factors were significantly related to each other.

Differences between schools

Before examining the effects of school-level variables, we estimated unconditional models for each score (Model 1 in Table 2). Although most of the variance can be attributed to the student-level (i.e., individual differences) the ICCs indicate that a substantial proportion of variation in NI and BMI occurs across schools. Contrary to our expectations, NI showed a high amount (23.5%) of variation conditioned by differences between schools. A considerably smaller proportion of variance (7.7%) in BMI could be attributed to between-school differences.

The grand means (γ_{00}) of scores across the schools were similar to the means at the student-level (see Table 1). For NI, the 95% confidence intervals (CI) for grand means indicate that schools at the upper threshold (i.e., 0.943) were almost two times larger than the grand mean of schools at the lower threshold (i.e., −0.932). The dispersion of BMI between schools was smaller compared to NI, with students in schools in the upper range (i.e., 17.62) having a 1.15 times higher BMI compared to schools in the lower range (i.e. 15.27). These descriptive results indicate a substantial range in test scores of NI scores among the schools, which were unexpected given the relatively uniform configuration of formal schooling in these rural areas.

Next, we estimated five separate multilevel models to examine differences in between-school variation across grades (with average cluster sizes per grade ranging from 21.57 students, for grade 7, to 24.86 students, for grade 4). For NI, there was a higher between-school variation in grade 3 (41%,) compared to grade 4 (31.7%), and similar values for grades 5 (27.3%), grade 6 (28.1%) and grade 7 (26.2%). A parallel pattern was observed for BMI, with a higher degree of between-school variation in grade 3 (14.6%) compared to grade 4 (8.5%), grade 5 (10.5%), grade 6 (8.6%) and grade 7 (11.6%). This finding shows a higher degree of between-school variation among 3rd graders compared to older students; however, it also illustrates that the differences between 4th-7th graders was less substantial.

Student-level predictions

Having partitioned the total variance into student-level and school-level variation, age, gender and BMI were added as predictors to explain the proportion of variations in NI on the student-level (see Model 2 in Table 2). Age, gender and BMI accounted for 12.9% of the variance in NI; age and gender together accounted for 22.4% of the student-level variation in BMI. Older students scored higher on the NI tests as did students with higher BMI, but there were no gender differences. Thus, a 1 *SD* increase in age (i.e., an increase of 2.07 years) and BMI (i.e., an increase of 2.17) was associated with a 0.32 and 0.07 *SD* increase in predicted NI test scores, respectively. Older students and girls also had higher BMI. Specifically, a 1 *SD* increase in age was associated with a 0.47 *SD* increase in BMI. Girls had about 0.07 *SD* higher BMI than boys with age held constant.

School effects on non-verbal intelligence

School-level variables were added to the model to explain between-school variability in NI (see Table 3). Overall, the entire set of school factors accounted for a substantial amount of variance in NI (55.8%). The contrast of being located 16-30 minutes vs. 1-15 minutes by bike from the nearest health care facility was statistically significant, indicating that 16-30 minutes to the nearest health post is related to a 0.53 *SD* increase in NI test scores compared to 1-15 minutes. Moreover, a 1 *SD* increase (i.e., 16.1) in the percentage of teachers with more than 3 years of teaching experience was related to 0.53 *SD* increase in NI test scores. Other school factors did not reach the level of statistical significance in this full contextual analysis.

Given the distinct patterns of between-school variation for students from different grades, we examined which school factors significantly accounted for between-school differences in NI across grades by conducting five separate multilevel models (i.e., one for students from each grade). Figure 1 shows the effect (standardized regression weights) of each of the school factors on NI. Despite the largest amount of observed between-school variation, for 3rd graders, the set of school factors accounted for the 65.6% of the variance at the school level, but none of the factors were significantly associated with NI—despite moderate, but statistically insignificant associations with factors such as the percentage of teachers with more than 3 years of teaching experience (β = .45) and being located 16-30 minutes vs. 1-15 minutes from the nearest health post (β = .45). For 4th graders, the school factors together explained 81.3% of between-school variance, which is the largest amount observed for NI. Specifically, with all other school-level variables held constant, students in schools that received funding from the government and an additional source had, on average, 0.40 *SD* lower NI test scores ($B = -.417$, $p = .010$). Regarding other organizational characteristics, being located 16-30 minutes vs. 1-15 minutes from the nearest health post was associated with a 0.65 *SD* increase in NI ($B = .434$, $p = .004$). Regarding the student and teacher body, a 1 *SD* increase in the principal's teaching experience (i.e., 6.86 years) was associated with a 0.46 *SD* increase in NI ($B = .034$, $p = .033$). A 1 *SD* increase in the percentage of teachers with a certificate (i.e., 19.53%) was related to a 0.43 *SD* decrease in NI ($B = -.011$, $p = .034$). Finally, a 1 *SD* increase in the percentage of teachers with more than 3 years of teaching experience (i.e., 16.1%) was related to a 0.56 *SD* increase in NI ($B = .017$, p = .010). For 5th graders, school factors explained 54.5% of the variance but the percentage of teachers with more than 3 years of experience was the single factor that was significantly related to NI, with a 1 *SD* increase being associated with a 0.62 *SD* increase in NI ($B = .018$, $p = .039$).

For 6th graders, students from schools that received donations within the last year scored 0.39 *SD* higher in NI compared to schools that did not receive donations ($B = .447$, $p = .036$). Similar to 4th graders, being located 16-30 minutes vs. 1-15 minutes was associated with a 0.60 *SD* increase in NI ($B = .384$, $p = .014$). Contrary to our expectations, a 1 *SD* increase in school climate was linked to a 0.44 *SD* decrease in NI ($B = -.332$, $p = .044$). A 1 *SD* higher percentage of teachers with a certificate was linked to a 1.50 *SD* decrease in NI ($B = -.012$, $p = .049$). Finally, a 1 *SD* increase in the percentage of teachers with more than

3 years of teaching experience was associated with a 0.72 *SD* increase in NI. All school factors combined accounted for 61.1% of the between-school variation in NI for 6th graders.

For 7th graders, students in schools with a formal relationship with a church scored 0.35 *SD* higher in NI (B = .389, p = .024). Being located 16-30 minutes vs. 1-15 minutes to a health post was associated with a 0.60 *SD* increase in NI (B = .422, p < .001). Similar to 6th graders, a 1 *SD* increase in school climate was linked to a 0.39 *SD* decrease in NI test scores (B = .314, p = .036). Finally, a 1 *SD* increase in the percentage of teachers with more than 3 years of experience was related to a 0.71 *SD* increase in NI (B = .025, p = .013). All school factors combined explained 75.8% of the between-school variance.

Taken together, some school factors showed expected patterns across grades. In grades 4 to 7, students in schools with teachers with more teaching experience showed higher levels of NI. Unexpectedly, a short distance to a health care facility was related to lower NI scores for students in grades 4, 6 and 7. Also contrary to expectations, better school climate was linked to lower NI scores for 6th and 7th graders, and funding from an additional source beyond the government was linked to lower NI scores for 4th graders. Moreover, 4th and 6th graders in schools with more teachers with some post high school certificate scored lower on NI. We also found inconsistent school effects across grades. The principal's teaching experience had a positive effect on NI only in grade 4, and donations were related to higher NI scores for students only in grade 6. A formal relationship with a church was associated with higher NI scores only for 7th graders. Despite this descriptive finding of differential slopes across grades, the regression coefficients were similar across grades in magnitude as indicated by z-values ranging from 0 to 1.66.

School effects on nutritional status

The school factors accounted for 75.9% in BMI variance conditioned by schools. The presence of a preschool was associated with a 0.45 *SD* lower BMI. Other school factors did not significantly account for between-school variation in BMI—despite moderate, but statistically insignificant associations with factors such as the percentage of teachers with more than 3 years of teaching experience (β = 0.37) and the principal's teaching experience (β = 0.37). Similar to NI, different proportions of between-school variation in BMI were observed across grades. Figure 2 shows the effect (standardized regression weights) of each of the school factors on BMI.

For 3rd graders, the set of school factors explained 77% of between-school variation. Only the distance to the nearest health post (more than 60 minutes vs. 31-60 minutes) was significantly related to BMI, indicating that students from schools that were 31-60 minutes away from a health post had 0.38 *SD* higher BMI (B = −.327, p = .05) compared to schools that were more than 60 minutes away. For 4th graders, students from schools that received donations within the last year had 0.47 *SD* higher BMI (B = .668, p = .033). Preschool presence was associated with a 0.60 *SD* decrease in BMI (B = −.712, p = .006). Moreover, a 1 *SD* increase in student-teacher ratio (i.e., 19.32) was associated with a 0.49 *SD* decrease in BMI (B = −.015, p = .022). The entire set of school factors accounted for 89.3% in between-school variation.

For 5th graders, having a preschool nearby was associated with a 0.56 *SD* decrease in BMI (B = .693, p < .001). Moreover, a 1 *SD* increase in class size (i.e., 16.6) was associated with a 0.53 *SD* increase in BMI (B = .02, p = .024). With 97.3%, all school factors combined accounted for almost all of the between-school variance. For 6th graders, a nearby preschool could be linked to a 0.56 *SD* decrease in BMI (B = −.57, p = .041). Being located 16-30 minutes vs. 1-15 minutes was associated with a 0.69 *SD* increase in BMI (B = .468, p = .043). The school factors explained 85.1% of the between-school variation in BMI.

In grade 7, similar to grade 6, being located 16-30 minutes vs. 1-15 minutes was associated with a 0.35 *SD* increase in BMI (B = .345, p = .046). Also, 7th graders from schools that had a formal relationship with a church had 0.44 *SD* lower BMI (B = −.688, p = .003). Schools that received donations had students with 0.43 *SD* higher BMI compared to schools that did not receive donations within the last year (B = .801, p = .031). Finally, a 1 *SD* increase in class size was associated with a 0.46 *SD* increase in BMI (B = .021, p = .041). The entire set of school factors accounted for 97.9% of between-school variance.

Some of these results were expected, others were surprising or inconsistent across grades. Results showed some expected patterns, such as higher BMI relating to shorter distances to health posts (for grades 3, 6 and 7). Moreover, receiving donations was associated with higher BMI for 4th and 7th graders. Somewhat unexpectedly, students from grades 4, 5, and 6 from schools with a preschool nearby had lower BMI—which is a negative outcome given the already low average BMI in the sample—compared to schools without a preschool in the area. Also unexpectedly, a formal relationship with a church was associated with lower school-level BMI. An inconsistent pattern of results was observed for the student-teacher ratio and class size. A higher number of students per teacher was negatively related to BMI but only for 4th graders, whereas larger class sizes for were associated with higher BMI for 5th and 7th graders. The slopes of the factor "relationship with a church" were different between grades 6 and 7 (z = 2.28, p = .02), as were the slopes of student-teacher ratio (z = 2.32, p = .02). Similar to non-verbal intelligence, other regression coefficients were similar in magnitude across grades as indicated by z-values ranging from 0.06 to 1.81.

Discussion

In the present study we investigated between-school differences in non-verbal intelligence and nutritional status (i.e., BMI) of a large sample of 3rd to 7th graders in rural Zambia. This study extends previous large-scale studies in sub-Saharan Africa that have focused predominately on academic achievement by focusing on two factors that provide a foundation for learning in the classroom and by considering a considerable number of different school factors such as organization and student and teacher body. We found (1) a substantial amount of variation conditioned by the schools, with high between-school variation in non-verbal intelligence (23.5%) and a lower amount in BMI (7.7%); and (2) school contextual factors to account for 55.8% and 75.9% of between-school variance in non-verbal intelligence and BMI, respectively.

These findings echo observations of other studies, such as the impact of teachers' and principals' teaching experience and the positive influence of additional funding via donations. Another finding that may be particular to this study indicates that distances from school communities to health care facilities had a distinct effect on non-verbal intelligence and BMI. However, we also found some unexpected results (e.g., the impact of a preschool and teachers' credentials), which may reflect particularities of the educational culture of rural Zambia. Most importantly, the effects of school factors on student outcomes appear to be grade-specific as indicated by different amounts of between-school variations for students across various grades. Specifically, the proportion of between-school variation in NI and BMI is highest for students in third grade then declines and remains fairly even across subsequent grades. These are important reminders that while many school influences on education may be largely universal, specific aspects of school and cultural may affect education and child development in unexpected ways.

The impact of school organization

Regarding organizational characteristics, 4^{th} and 7^{th} graders of schools that received donations in the past school year had higher BMI compared to schools that did not receive donations. There is some evidence that availability of basic resources in school environments (e.g., blackboards, textbooks, tables and chairs) and improvements in the physical structure (e.g., access to electricity) positively affect students' educational outcomes (Ferguson et al., 2013; Glewwe et al., 2011; Riddell, 2008). However, the effect found here represents the overall impact of donations on indicators of physical health and non-verbal intelligence, making it difficult to identify what factors have a bearing on students' outcomes and how they operate. The tentative evidence points towards the impact of better school physical conditions on teacher satisfaction and retention as well as an overall commitment of the school leadership to provide quality education (see Ferguson et al., 2013; Glewwe et al., 2011, for related studies). However, both infrastructure and resources at schools and access to education have to improve to provide quality schooling (Hanushek, 2013), as, for instance, the absence of safe and clean facilities could discourage students from attending school regularly.

Another finding that may be particular to this study indicates that schools, which were located 16-30 minutes by bike from a health care facility, had students with higher overall scores in non-verbal intelligence (particularly for grades 4, 6 and 7) and higher BMI (for grades 6 and 7) compared to schools that were located between 1-15 minutes from the health post. All other contrasted comparisons were not significant. This is an unusual factor for consideration, however in a developing country such as Zambia, health monitoring (for both teachers and students) and access to quality health care may be crucial factors for students' learning outcomes. In the study region, schools are typically in close proximity to community centers and churches, and factors such as population density, distance to other public facilities and the general quality of the infrastructure determine the location of a school. However, it could be that the nearest health posts and health centers were built close to schools with children from impoverished backgrounds to help them cope with prevalent diseases in the region such as Malaria and HIV, both of which have detrimental impacts on child and adolescent development. This would imply that lower average BMI and non-verbal intelligence of students close to a health care facility is a correlate of potential health problems that require adequate health care in close proximity.

A finding that was unexpected and requires particular further exploration was the presence of a nearby preschool. Preschool presence had a negative impact on BMI, particularly for students in grades 4, 5 and 6. This finding may be related to the fact that Zambia, like many countries, is currently struggling to improve health and education services within a context of limited resources. That is, early childhood education in these countries lack full government support and therefore may be costly, possibly drawing precious family or community resources from one sector (nutrition) to another (education) (Zuilkowski, Fink, Moucheraud, & Matafwali, 2012). Also, quality control and monitoring of early childhood facilities in Zambia are non-existent; while some preschools of high quality may offer a nutritional component (which have been found to increase BMI; Attanasio, Maro, & Vera-Hernández, 2013), others may not (Kaneneka, 2013; Matafwali & Munsaka, 2011; Zuilkowski et al., 2012). Further, it is possible that some of the area preschools are relatively new and were not available for the children included in the study.

The impact of student and teacher body

A larger student-teacher ratio was associated with lower BMI of 4th graders. Student-teacher ratio has been used before as an indirect proxy of a schools' average class size. In the present study, larger class sizes were associated with higher BMI of 5th and 7th graders. As mentioned earlier, the findings regarding the impact of class size are mixed and the literature is inconclusive at best (Borland et al., 2005; Hattie, 2005; Hoxby, 2000; Nye, Hedges, & Konstantopoulos, 2000). The trend in the literature goes towards supporting the effect of small class sizes on student outcomes, presumably because it implies major changes in students' engagement in the classroom (e.g., Finn, Pannozzo, & Achilles, 2003) and more student-directed learning (NICHD Early Child Care Research Network, 2004). However, some have noted that instructional activities significantly improve student outcomes regardless of class size (Milesi & Gamoran, 2006). It has been noted that in sub-Saharan Africa, class size most likely has a negative impact on student outcomes beyond a threshold of about 60 students per teacher (Michaelowa & Wechtler, 2006). A possible reason for the positive effect of class size might be that students with higher BMI are placed in larger classes while students with lower BMI are grouped together in smaller classes to be able to better compensate for potential malnutrition and support their learning. Acknowledging the correlational nature of this study, another explanation for this finding could be that many children with lower BMI come from communities less able to send children to school, which is reflected in smaller class sizes for these children.

The average student-teacher ratio of about 47 students per teacher in these rural Zambian communities is comparable to what has been found for Zambia (about 49 in 2012; UNESCO Institute for Statistics, 2014) but is higher than the average primary student-teacher ratio in sub-Saharan Africa of about 41 students per teacher (UNESCO, 2012). Although many countries have developed and started to implement policies aiming at improving schooling and student enrollment, there is a continuing shortage of teachers. The UNESCO Institute for Statistics has recently approximated the need of an extra 1.6 million teachers in classrooms to achieve universal primary education worldwide by 2015, and an extra 3.3 million by 2030 (UNESCO Institute for Statistics, 2013). This chronic shortage of teachers will not only persist over the next decades, the teacher gap is highest in Sub-Saharan Africa with about 2.1 million of the required 3.3 million teachers to provide basic education and achieve good learning outcomes of students through formal schooling. Because of the increase in primary school enrollment with unmatched influx of resources, the student-teacher ratio can affect the delivery of quality of education in rural Zambia.

One of the most robust effects identified here was that positive impact of teachers' teaching experience on students' levels of non-verbal intelligence. Previous studies in HIC found that the total years of teaching experience and teacher qualification characteristics (e.g., licensing status and educational attainment) were not significant predictors of student achievement gains, but that years of teaching experience at a particular grade level was associated with increased student achievement (Huang & Moon, 2009). One has to keep the correlational nature of the study in mind when interpreting this finding. One the one hand, teachers with more experience in teaching might know better how to promote their students' cognitive skills through a variety of instructional methods. One the other hand, the more "capable" students may be attending schools with more experienced teachers with the underlying motive of preparing them with advanced skills needed to compete on the local and national labor market. Although most students attend the closest community school, it is not uncommon for children in rural Zambia to go to a different school for reasons such as living with extended family members in another community or because another school has a better reputation. Thus, parents might seek out better educational opportunities for more "capable" children.

Limitations and future research

Three limitations have to be mentioned. First, schooling is not the only source of differences in the development of children's cognitive skills. Any research approach should ideally be holistic and span multiple levels of analyses (Bronfenbrenner & Morris, 2006). Although we assessed a broad spectrum of school factors, the design of the study did not permit the investigation of microelements at the classroom level, including actual teaching and learning experiences of students and teachers. The picture of individual and school differences in non-verbal intelligence and nutritional status remains incomplete unless we aim at understanding the educational quality inside classrooms in these rural Zambian communities. Optimistically, the quality of material and human resources should improve on Zambia's journey to education for all. With the improving quality of education comes a larger importance of organization factors that have to be taken into account in future research. Thus, student, classroom and school variables have to be taken into account in our efforts to understand environmental influences on student outcomes (Odden, Borman, & Fermanich, 2004). Moreover, we were not able to control for the influence of family background variables on non-verbal intelligence and BMI, variables that need to be accounted for to accurately isolate the effect of schooling.

Second, school factors have been assessed with the help of principal's ratings of the educational setting. Using this method as the only source of information has been criticized for potentially leading to spurious correlations (Ferguson et al., 2013). Future studies should therefore try to rely on a number of independent observers to evaluate school characteristics. Moreover, while the entire set of contextual variables accounted for a substantial amount of variation in between-school differences, these factors could not explain all variance. There are certainly other factors on the school-level that have to be taken into account. For example, SACMEQ gathers data on how teachers use educational resources (Musonde & Kaba, 2010) as a possibly important factor in explaining student performance. That said, in consideration of the number of associations tested, the number of schools in this study might limit the power to detect additional significant associations. Future studies should aim at replicating the associations between some of the most consistent factors identified in this study (e.g., distance to a health care facility and teachers' teaching experience) or further untangle the impact of other school factors (e.g., the presence of a preschool) using a larger number of schools. Moreover, it has to be acknowledged that the between-school variation in both outcomes across grades was highest for 3rd grade students, but similar for 4th to 7th grade students.

Third, formal education is a nearly universal experience among children in HIC, but at the same time not all children go to school worldwide and may instead develop skills in informal learning environments (e.g., through observation and practice in community events) that are relevant to tasks within their specific cultural community (Hein et al., Forthcoming; Reich, Hein, et al., 2013; Rogoff, 2007). In sub-Saharan Africa, 21.5% of school-age children and adolescents did not attend school in 2012, with 55% unlikely to attend in the future (UNESCO, 2012). Moreover, a lower engagement in education has been observed in rural areas, where the costs of attending are high, many rural households need their children to help during harvest time (placing other demands on their time), and parents with lower levels of education may not value schooling enough or do not perceive enough relevance of the curriculum to send their children to school (Mulkeen, 2005). At the same time, rural schools experience difficulties in providing quality education and rarely adapt the curriculum to the needs of the local community (Mulkeen, 2005). A multilevel perspective spanning household- and region-level factors has to be taken into account to understand primary school enrollment in LMIC (Huisman & Smits, 2009), and how to maximize the benefits of education once children are enrolled in formal schooling.

Conclusions

Identifying and addressing school factors that have a bearing on student outcomes is a vital but challenging task. Not only do we, as a field, need to fine tune our methods to measure specific aspects of student learning and quality of education, the implications of the produced findings will only become tangible for students if they translate into accompanying strategies and policies on the district- and school-level. At least in the area where the present study was conducted, schools form parent-teacher associations that are mandatory for parents to attend and have the potential to raise awareness regarding the value of schooling. Once children are enrolled in formal schooling it is the responsibility of all educators and professionals involved to ensure the best possible appropriate education. Achieving universal primary education is undoubtedly imperative, but the effect of schooling in rural Zambia will be marginal if the school system as a whole does not place more emphasis on improving resources along with incentives for teachers and parents to educate their children.

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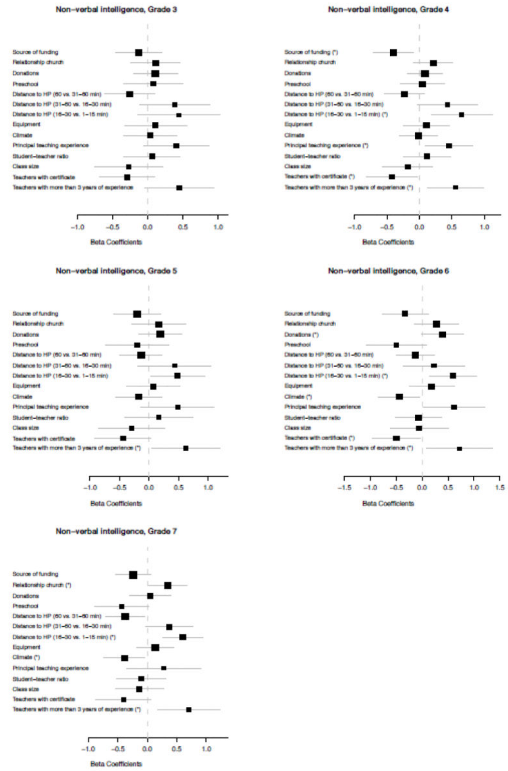

Figure 1.

Standardized regression weights (β) and associated standard errors of school factors for non-verbal intelligence. (*) = unstandardized coefficients of the school factor are significant at $p < .05$.

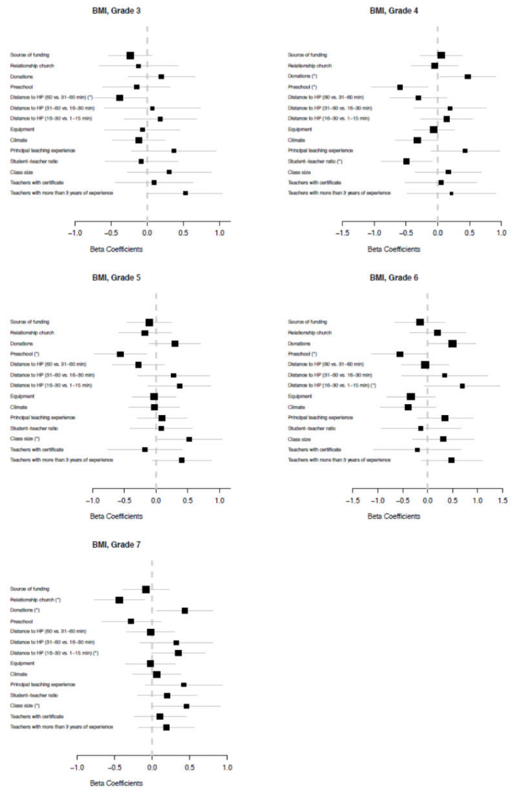

Figure 2.

Standardized regression weights (β) and associated standard errors of school factors for BMI. (*) = unstandardized coefficients of the school factor are significant at $p < .05$.

Table 1

Descriptive statistics of the main variables at the student-level and at the school-level

Variable	*n*	%	Min	Max	*M*	*SD*
Student-level						
Non-verbal intelligence			−2.39	4.12	0	0.98
Age			7.40	23.21	12.73	2.07
BMI			11.69	32.22	16.48	2.17
Grade						
3	870	20.7				
4	895	21.3				
5	840	20.0				
6	844	20.1				
7	755	18				
School-level						
Source of school funds						
Government only	10	34.5				
Government and church	19	65.5				
Relationship with church (yes)	8	27.6				
Donations (yes)	6	20.7				
Preschool (yes)	11	37.9				
Distance to health post (min)						
1-15	8	27.6				
16-30	7	24.1				
31-60	6	20.7				
> 60	8	27.6				
Classroom equipment			0.13	1.00	0.57	0.25
School climate			1	4	2.91	0.63
Principal's teaching experience (years)			3	34.85	22.34	6.86
Student-teacher ratio			21.23	94.80	45.17	19.32
Class size			21.43	97	49.72	16.06
Teachers						
Certificate (%)			17.29	89.65	45.88	19.53
> 3 years of experience (%)			40	100	76.48	16.10

Notes. N = 4204 students nested in 36 schools. The presented school-level information was available for 3495 students from 29 schools. Values represent the rounded average across five imputed datasets.

Table 2

Variance estimates for unconditional models and models containing within-predictors

Parameter	Non-verbal intelligence	BMI
Model 1		
Student-level σ^2	0.747	4.315
School-level τ_{00}	0.229	0.359
Grand mean γ_{00} (95%-CI)	−0.005 (−0.932, 0.943)	16.444 (15.270, 17.618)
ICC	.235	.077
N_C	36	34
M_C	116.78	114.41
Deviance	10830.534	16805.652
Model 2		
Gender (γ10)	−0.021 (.027)	0.297*** (.056)
Age (γ_{20})	0.135*** (.009)	0.480*** (.020)
BMI (γ_{30})	0.030*** (.009)	-
R^2	.129	.224
Deviance	9547.856	15813.73

Notes. NI = nonverbal intelligence. BMI = body mass index. ICC = Intra-class correlation coefficient. N_C = Number of clusters. M_C = average cluster size. Model 1 represents an unconditional model with variance estimates for the student-level (σ^2; within-level) as well as the school-level (τ_{00}; between-level). Model 2 contains gender, age and BMI (for NI) as within-level predictors. Estimates for within-level predictors reflect unstandardized estimates with standard errors in parentheses. Gender was dummy coded with 0 for male and 1 for female. R^2 = variance explained at the within-level. Deviance = $-2\log L$.

* $p < .05$.

*** $p < .001$.

Table 3

Results from full contextual model analysis

Parameter estimates	Non-verbal intelligence			BMI		
	B	***SE***	**β**	***B***	***SE***	**β**
Fixed effects						
Intercept (γ_{00})	−0.07	.058	–	16.423	.057	–
Student-level						
Gender (γ_{10})	−0.01	.03	−.006	0.311 ***	.066	.075
Age (γ_{20})	0.129 ***	.009	.308	0.476 ***	.022	.476
BMI (γ_{30})	0.028 *	.011	.069	–	–	–
School-level						
Source of funding (γ_{01})	−0.208	.163	−.220	−0.054	.167	−.052
Relationship church (γ_{02})	0.150	.168	.151	−0.118	.301	−.179
Donations (γ_{03})	0.105	.166	.098	0.393	.238	.308
Preschool (γ_{04})	−0.067	.214	−.086	−0.482 *	.196	−.446
Distance to health post (60 vs. 31-60 min) (γ_{05})	−0.133	.110	−.196	−0.190	1.37	−.236
Distance to health post (31-60 vs. 16-30 min) (γ_{06})	0.293	.193	.436	0.197	.233	.246
Distance to health post (16-30 vs. 1-15 min) (γ_{07})	0.318 *	.155	.529	0.201	.153	.282
Equipment (γ_{08})	0.183	.396	.098	−0.243	.317	−.109
Climate (γ_{09})	−0.085	.134	−.121	−0.125	.139	−.149
Principal’s teaching experience (years) (γ_{010})	0.029	.020	.428	0.084	.152	.299
Student-teacher ratio (γ_{011})	0.001	.005	.056	−0.005	.007	−.183
Class size (γ_{012})	−0.007	.007	−.243	0.013	.008	.397
Teachers with certificate (γ_{013})	−0.009	.005	−.375	0.000	.006	.027
Teachers with more than 3 years of experience (γ_{014})	0.015 *	.007	.528	0.012	.008	.372
Variance components						
R^2 Within-level	.119 ***	.012		.227 ***	.016	
R^2 Between-level	.588 ***	.158		.759 ***	.115	
σ^2 Within-level	.881 ***	.012		.773 ***	.016	
σ^2Between-level	.412 *	.158		.241 *	.115	

Notes. Gender was coded with 0 for male and 1 for female prior to grand mean centering. All coefficients were centered at the grand mean to measure the impact of a one standard deviation change in the variable on the respective score. The estimates for predictor variables reflect unstandardized regression coefficient (fixed effects). SE = standard error. R^2 = explained variance. σ^2 = Residual variance. Because of grand-mean centering of all predictors, the intercept is interpreted as the school mean of the expected test score for students with grand mean levels of all school-variables.

* $p < .05$.

*** $p < .001$.