

# Creation of the gender-equitable school index for secondary schools using principal components analysis

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Received 28 January 2020; revised 21 March 2020; editorial decision 30 May 2020; accepted 8 June 2020

**Background:** Higher schooling attainment for girls is associated with improved maternal and child health outcomes. In low- and middle-income countries, girls drop out of school at higher rates than boys beginning in early adolescence due to factors such as son preference and lack of access to menstrual supplies.

**Methods:** Using principal components analysis, we created a gender-equitable school (GES) index with data from 159 secondary schools in Nepal to measure school-level factors that may influence girls' secondary school pass rates.

**Results:** A component describing girls' safety and hygiene was positively associated with school-wide pass rates for girls, and to a lesser degree for boys.

**Conclusions:** The GES index has diagnostic and programmatic utility in programs aimed at supporting girls' education and health.

**Keywords:** education, girls' education, hygiene, principal components analysis, Nepal, sexual and reproductive health.

## Introduction

Expanding girls' access to schooling in low- and middle-income countries has featured in efforts to improve health and to reduce poverty,<sup>1</sup> given the positive downstream effects of increased schooling attainment for women, including improved maternal and child health.<sup>2</sup> Despite substantial progress towards achieving gender parity at the primary school level, secondary schooling attainment for girls still lags behind that of boys due to greater attrition beginning in early adolescence.<sup>1</sup> In Nepal, as elsewhere, a complex set of interrelated social and structural barriers cause irregular attendance and increased attrition among girls, including son preference, menstrual restrictions and limited access to private toilets and menstrual supplies.<sup>3,4</sup> Recommendations from the health and development sectors to reduce girls' differential attrition include gender-sensitive pedagogy, comprehensive sexual and reproductive health (SRH) education and the expansion of access to menstrual hygiene.<sup>1</sup> To understand the factors that contribute to a more equitable school environment for girls, we created the gender-equitable school (GES) index for secondary schools and assessed its relationship with girls' grade 8 pass rates.

## Methods

This analysis used baseline survey data collected from July to September 2018 in 159 mostly public (62%), mostly urban/periurban (69%) secondary schools in the Nuwakot and Tanahun districts of Nepal as part of an evaluation of a girls' education program (Supplementary Table 1). Trained interviewers conducted face-to-face interviews with school administrators covering school characteristics including student population, policies, infrastructure, pass rates and student attrition, based on modules designed by Emory University and the Gender and Adolescence: Global Evidence consortium. Sixteen school characteristics related to gender were considered for inclusion in the GES index, which was created using principal components analysis (PCA), a statistical procedure for consolidating the variance of several correlated input variables into a set of uncorrelated component scores. We removed input variables with insufficient variance and those that were highly correlated with other variables measuring similar constructs, leaving nine input variables. Table 1 shows the items retained in the GES index, their distributions and their loadings on each of the retained components. An additional PCA was performed to create a measure of school

**Table 1.** Distributions and component loadings of input variables, characteristics of the gender-equitable school index components 1 and 2 at 159 secondary schools in the Tanahun and Nuwakot districts of Nepal<sup>a</sup>

Variable	Type	Mean	SD	Min.	Max.	Component 1 Loading	Component 2 Loading
Room to change pads	Proportion	0.42	0.50	0	1	0.1872	<b>0.4588<sup>b</sup></b>
Girls-only clubs	Proportion	0.06	0.24	0	1	<b>0.4405</b>	0.1092
Extra hours of SRH instruction	Continuous	5.60	8.00	0	40.00	<b>0.3737</b>	<b>0.3135</b>
Girls traveling safely to school	Proportion	0.89	0.32	0	1	-0.2998	<b>0.4743</b>
Retention policies for girls	Proportion	0.06	0.23	0	1	<b>0.3514</b>	0.1968
Girls-only toilets	Proportion	0.46	0.13	0	0.67	-0.1578	<b>0.5098</b>
Girls enrolled	Proportion	0.51	0.08	0.04	0.71	<b>0.3419</b>	-0.0262
Retention rate for girls	Proportion	0.98	0.03	0.86	1	-0.3982	<b>0.3467</b>
Female teachers	Proportion	0.51	0.17	0.11	0.86	-0.3492	-0.2574
Outcome: girls' grade 8 pass	Percent	68.50	34.08	0	100	-	-
Outcome: boys' grade 8 pass	Percent	66.99	34.42	0	100	-	-
Eigenvalue						1.91	1.35
Proportion of variance explained						0.21	0.15
Regression coefficient for girls' grade 8 pass rate (unadjusted) [95% CI]						-1.60 [-5.21 to 2.00]	11.29* [6.87 to 15.71]
Regression coefficient for girls' grade 8 pass rate (adjusted) [95% CI]						-0.84 [-4.39 to 2.70]	9.74* [5.31 to 14.17]
Regression coefficient for boys' grade 8 pass rate (unadjusted) [95% CI]						-3.70 [-7.41 to 0.00]	9.47* [4.92 to 14.01]
Regression coefficient for boys' grade 8 pass rate (adjusted) [95% CI]						-2.85 [-6.48 to 0.77]	7.73* [3.21 to 12.25]

SRH, sexual and reproductive health

<sup>a</sup>156 schools were used in the regression as three schools were missing data on girls' grade 8 pass rates.

<sup>b</sup>Bold indicates component loadings >0.3.

\*Significant at  $p < 0.05$

economic condition (SEC) as a covariate, the inputs for which and their distributions are presented in Supplementary Table 2. All analyses were performed in STATA version 15 (StataCorp, 2017).

Based on the scree plot visualizing the proportion of variance in the input variables accounted for by each component,<sup>5</sup> we retained the first two components of the GES index. Only the first principal component in the SEC index was used to score schools, based on prior research demonstrating that a single component is sufficiently informative in measures of economic condition.<sup>6</sup>

We chose grade 8 pass rate as a proxy measure of girls' achievement that is closely related to attrition<sup>4</sup> and showed wide variation within the sample (mean 68.50, SD 34.08). Grade 8 marks the end of compulsory education and is a key transition from lower to upper secondary school that coincides with early adolescence.<sup>4</sup> To explore the association between the percentage of girls passing the grade 8 exam and the GES index score, we split the two components into tertiles, testing for significant differences among schools with low, moderate and high GES index scores using ANOVA. We then performed linear regressions of the relation of girls' grade 8 pass rate with each component, unadjusted and adjusted for SEC.

## Results

Component 1 of the GES index was a generalized measure, accounting for 21% of the variance in the input variables (Table 1). Girls-only clubs, hours of SRH instruction, proportion of female students and retention policies loaded strongly onto this component, with proportion of female teachers and girls' retention rate loading negatively. Component 2 captured safety and hygiene and accounted for another 15% of the total variance, showing high loadings for the proportion of female toilets, whether girls could travel safely to school, availability of a room to change pads, girls' retention rate and hours of SRH instruction. The SEC index accounted for 21% of the variance in input variables of the PCA and had high loadings for repairs needed, roof material and availability of soap (Supplementary Table 2).

Grade 8 pass rate for girls was positively associated with the tertile for GES Component 2 (girls' safety and hygiene), but not for general Component 1 (Supplementary Table 3). In regression models, girls' pass rate had a significant, positive relationship with Component 2, for which a one-point increase was associated with an 11% increase in the pass rate (Table 1). Adjusted for SEC, this

association was attenuated to just under 10%, but remained significant. Component 2 score also showed a significant, positive relationship with boys' pass rates, albeit of a smaller magnitude.

## Discussion

To our knowledge, the GES index is the first such measure of gender equity at the school level. Our research adds to a growing body of evidence highlighting the importance of safety and hygiene in adolescent girls' academic success, suggesting that efforts to improve SRH education and access to menstrual hygiene may be promising ways to increase girls' academic achievement<sup>1</sup> and also may contribute to boys' academic success. SRH education in particular loaded strongly onto both components of the GES index, suggesting that such efforts are key to creating an equitable environment. Significant negative Component 1 loadings for retention rate and proportion of female teachers warrant further scrutiny in future studies; for example, there may be greater representation of female teachers at under-resourced schools. Gender equity at the school level also may be associated with child-centered policy and infrastructure generally, explaining the positive association with boys' pass rates. However, some limitations warrant consideration, chief among which is that the index derived from the sample may not be widely generalizable. Its wider utility should be assessed and the index may be tailored to include contextually relevant input variables to track and compare schools within a district or region.

The GES index has diagnostic utility beyond that of school economic condition in identifying schools for programs aimed specifically at improving educational outcomes for girls. For example, governments and international non-governmental organizations may use either or both component scores to identify schools that are underperforming on particular dimensions, allowing for more strategic allocation of resources to needier or more inequitable schools. Also, health and development practitioners may use the component scores to monitor school-level trends in gender-sensitive pedagogy, policy and infrastructure. Finally, governments and practitioners may use scores to monitor schools on characteristics that are associated with girls' schooling attainment.

## Supplementary data

Supplementary data are available at *International Health* online.

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**Author's contributions:** KMY conceived the study and designed the study protocol. IB performed the principal components analysis. IB and KMY contributed to interpretation of the components. IB performed and interpreted ANOVA and regression analysis. IB and ECJ drafted the manuscript. KMY critically revised the manuscript. All authors read and approved the final manuscript. KMY and IB are guarantors of the paper.

**Acknowledgements:** The authors thank the staff of Emory University, CREHPA and the GAGE offices for their support, in particular Cari Jo Clark, Kusum Wagle, Mahesh Puri, Dev C. Maharajan and the field team.

**Funding statement:** This project was funded by an award from the Overseas Development Institute through the Gender and Adolescence: Global Evidence consortium, ID 0000048036 (Yount PI).

**Competing interests:** The authors have no conflicts of interest to declare.

**Ethical approval:** This study was approved by the Emory University Institutional Review Board [IRB00103052] and the Nepal Health Research Council [237/2018]. All adult participants gave informed consent. Participants under 18 gave informed assent with consent of a parent or guardian.

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