EXPLORING THE EFFECT OF MENSTRUAL HYGIENE MANAGEMENT SPACES ON ACADEMIC ACHIEVEMENT: EVIDENCE FROM YOUNG LIVES' SCHOOL SURVEY IN ETHIOPIA

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Table of Contents

Abstract

Background: Ethiopian schools require improved school environments in order to improve educational outcomes. Evidence suggests that a lack of sanitation spaces, specifically private areas to for girls to change and manage menstruation hygienically, comfortably, and with dignity, leads to school absenteeism, distraction, and disengagement.

Objective: The objective of the study was to explore the effects of menstrual hygiene management (MHM) spaces (a private place to wash menstrual rag and/or a place where female student can wash themselves privately) on math and English achievement scores and the extent in which environmental factors at the individual- , home-, and school/community levels can help explain those differences.

Data and Methods: 3844 adolescent girls, between the ages of 14 and 19 years, from the Young Lives 2016-2017 Ethiopian School Survey were included in the study. Math and English test scores were measured at Wave 1 to Wave 2. To account for the change in scores across time and the effect of MHM spaces on math and English scores, a mixed between-within subjects analysis of variance (ANOVA) was used. A mixed between-within subject analysis of covariance (ANCOVA) was used to assess the effects of MHM spaces on math and English scores while accounting for individual- , home-, and school/community factors.

Results and Discussion: The study found evidence that the availability of MHM spaces had a significant, yet very small effect on performance of math and English achievement tests in unadjusted analysis. However, adjusting for individual-, home-, and school- level covariates removed the effect between MHM spaces and achievement scores that were found in unadjusted analysis. While the potential effects of MHM spaces on achievement tests in this study are small, other individual, family, and school characteristics measured in this study were found to be more important.

Conclusion: This study examined MHM spaces and its impact on academic achievement. Though an important first step, providing MHM spaces does not, on its own, enable education for girls to fulfill its transformative potential. The potential for improving the Ethiopian girls' education requires comprehensive consideration and interventions that operate on various environmental levels found in the ecological framework. Further research may expand on the findings of the study by improving the methodologies which include using direct menstruation data, consideration of the quality of MHM spaces, and the use of multilevel linear modeling analyses.

Acronyms and Abbreviations

ANOVA – Analysis of variance

ANCOVA – Analysis of covariance

EDRI – Ethiopian Development Research Institute

ENLA – Ethiopian National Learning Assessment

LMIC – Low and middle income country

MHM – Menstrual hygiene management

SPSS – Statistical Package for the Social Sciences

TVET – Technical and vocational education and training

UNICEF – United Nations International Children's Emergency Fund

WASH – Water, sanitation, and hygiene

WHO – World Health Organization

1. Introduction

1.1 Background

Education plays a major role in the development of children, communities, and countries and is intrinsically linked to other development goals including the eradication of poverty, empowerment, reducing hunger, and improved health (Herz & Sperling, 2004; Nunes, Lee, & O'Riordan, 2016). However, across the developing world, millions of girls are not receiving the basic education needed to achieve these development goals. The United Nations Educational, Scientific and Cultural Organization estimates that 264 million children between the ages of six to fourteen are not in school, nine million of which are girls living in sub-Saharan Africa (UNESCO, 2017). This is particularly worrying as education is critical to economic progress and global poverty reduction with broader implications for foreign policy improvements.

Poverty remains widespread in Ethiopia as a large portion of the Ethiopian population live in rural areas. With an economy that relies on agricultural production there are implications for the education sector. The country's demographic makeup poses a problem of ensuring equitable access to education and the issue of relevance of the school curriculum (Federal Ministry of Education, 2015). Ethiopia's demographic pressures have increased the demand of education, but it falls short. This can be seen in recent years as the country has made great advances in terms of increasing primary school enrollment, it still faces challenges in retention, grade progression, and learning levels (Bow-Bertrand, Briones, & Favara, 2018). From 2010 to 2015 net enrollment has increased from 73 percent to 85 percent, but attainment to higher grades are not apparent as many students leave the system early, reflected in a Grade 8 completion rate of only 47 percent (Ministry of Education, 2015; World Bank, 2019). The Ministry of Education (2015) cites that the share of female students at undergraduate level reached 32 percent in 2014/2015, but those that sat in the Grade 12 examination performed poorly. These stark figures suggest that Ethiopian policy makers should focus not just on increase enrollment but on improving conditions that enhance educational outcomes, such as providing essential facilities to meet the demands of increase enrollment.

There is evidence to suggest schools in Ethiopia lack the necessary facilities to meet the demands of increase enrollment. Inadequate school sanitation facilities have been cited to be a barrier to girls' access to education. The growing anecdotal evidence reveals the gender

discriminatory nature of school environments as female students report challenges managing menstruation in the safety of private places, preventing their abilities to succeed (Herz, Barbara; Sperling, Gene, 2004; Mason et al., 2013). Thus, research suggests that education for girls can be supported and fostered by incorporating private spaces for girls to manage menstruation.

Menstrual hygiene management (MHM) is defined by the United Nations International Children's Emergency Fund (UNICEF, 2014) as the "use of clean material to absorb or collect menstrual blood and this material can be changed in privacy as often as necessary for the duration of the menstrual period. MHM includes soap and water for washing the body as required, and access to facilities to dispose of used menstrual management materials" (p. 16). In the context of this thesis, MHM is in direct reference to private spaces in which girls can wash menstrual rags and themselves. Previous studies have used small sample sizes, relying on qualitative, self-reported data to report barriers related to MHM, which include poverty, hygiene taboos, inadequate information on menstrual management, poor social support, and insufficient water, sanitation, and hygiene (WASH) facilities in schools (Marni Sommer et al., 2016; Marni Sommer, Hirsch, Nathanson, & Parker, 2015; Marni Sommer & Sahin, 2013).

The growing qualitative research suggests that adequate sanitation facilities/infrastructure in schools as it relates to MHM may improve student participation or cognitive function, particularly for girls at the onset of menstruation (Alexander et al., 2014; Long et al., 2013; Sommer, Hirsch, Nathanson, & Parker, 2015; UNICEF, 2011); however, the quantitative literature has recently begun to explore this association. Of these studies, educational outcomes typically address absenteeism, with few studies assessing sanitation at the school level using cognitive development measured by test scores as an outcome (Grant, Lloyd, & Mensch, 2013; Sclar et al., 2017; Shallwani, 2015; Tegegne & Sisay, 2014; Zegeye, Megabiaw, & Mulu, 2009). A lack of studies assessing sanitation, specifically the role of gendered spaces at the school level, using achievement scores as an educational outcome highlights a gap this study aims to fill.

Quantitative studies have explored the health impact of sanitation by focusing on anthropometric outcomes or on infectious diseases (Sclar et al., 2017). However, The World Health Organization (WHO, 1978) defines health beyond disease or infirmary, as "a state of complete physical, mental, and social well-being" (p. 1). Additionally, as stated in the Ottawa

Charter (WHO, 1986), “Health is a positive concept emphasizing social and personal resources, as well as physical capacities… is not just the responsibility of the health sector, but goes beyond healthy life-styles to well-being (p. 1). Therefore, sanitation related to the provision of MHM spaces has the potential to address not only disease but also other aspects of well-being, such as the ability to attend school and the development of cognitive abilities, measured by academic achievement.

1.2 Study Aim

Using secondary data from The Young Lives Project, the present study aims to examine the effect of MHM spaces, on academic achievement and the extent in which environmental factors at the individual- , home-, and school/community levels can help explain those differences among Ethiopian school girls. Exploring the effect of MHM can have important policy implication and encourage national and state governments to allocate resources in an appropriate and effective manner to improve health and education, and, thus economic progress and global poverty reduction in Ethiopia.

1.3 Research Questions

The study is guided by the following research questions:

1. To what extent do adolescent girls’ math and English academic achievement differ by schools that provide MHM spaces and those that do not provide MHM spaces?
2. Is there a significant difference in academic achievement scores for individuals who attend schools with MHM spaces and those that do not provide MHM spaces while controlling for characteristics at the individual, home, and school/community?

2. Theoretical Framework

An ecological perspective guided the present study, which was originally proposed by Bronfenbrenner in 1977 in his human development framework (Bronfenbrenner, 1977). The ecological perspective is designed to draw attention to the dynamic interrelations among various personal and environmental factors in health (Mclaren & Hawes, 2005). In the earliest formulation of the ecological perspective, Bronfenbrenner posits that "the ecological environment is conceived as a set of nested structures, each inside the other like a set of Russian dolls" (Bronfenbrenner, 1979, p.3). Bronfenbrenner's metaphor suggests that an individual's development is affected by, and affects, multiple systems/levels originally described in abstract terms of micro-, meso-, exo-, and macro- systems. These systems support and guide an individual's development, but each system is specific to an individual's life offering diverse possibilities of growth trajectories.

Illustrated in Figure 1, at the most intermediate level is the *microsystem.* Microsystems include intrapersonal and interpersonal influences on an individual, which occur in the family, school, amongst peers, etc. This is the system in which an individual has direct contact with his or her immediate setting, and influences are strongest. The *mesosystem* involves the connection and interaction between two or more settings. This is the system connecting two or more environments in which an individual is a part of. It can be seen as a "system of microsystems" (Bronfrenbrenner, 1979, p. 25). For instance, the connection of time from home to school merges two settings (school and home influences) which fall in the mesosystem. The next system is the *exosystem,* which an individual does not have immediate contact, such as institutional infrastructures involving politics, law, economics etc. While individuals do not have direct involvement with larger social systems, they feel the effects of what happens. For instance if a parent loses a job due to political turmoil, an individual would feel the financial repercussions in his or her life. Finally, the *macrosystem* refers to the broader patterns of culture or subculture which shape ideologies and give meaning to institutions and systems, thus ultimately influences an individual's environment (Bronfenbrenner, 1979). Overall, Bronfenbrenner's ecological theory of development posits that to understand an outcome, it is necessary to identify the parts related to the whole.

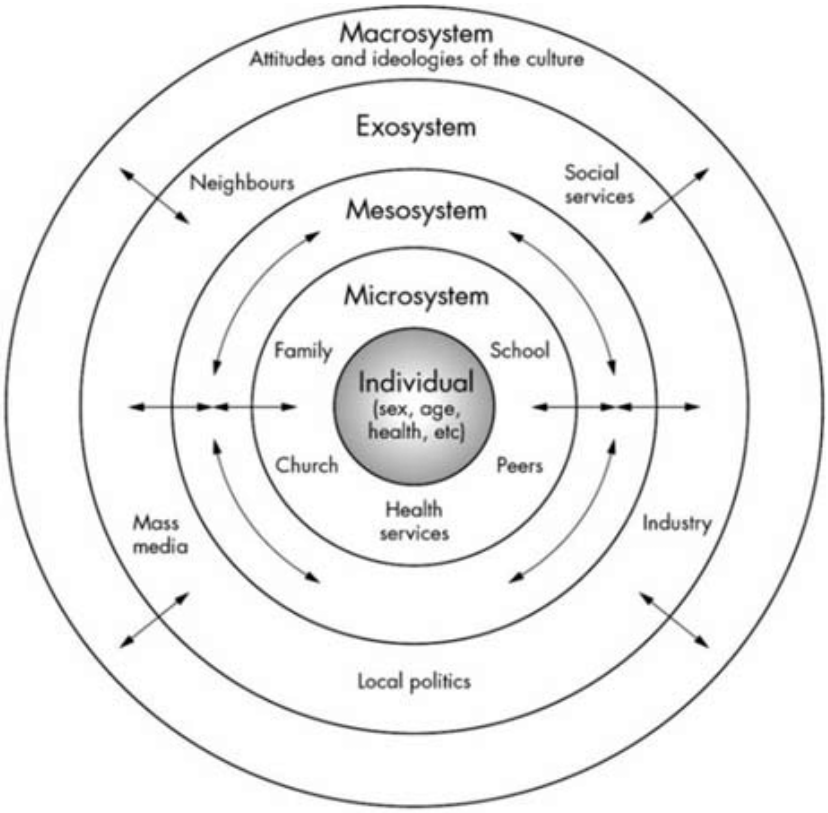

Figure 1. Bronfenbrenner's ecological theory of development (adapted from Santrock et al, as cited in Mclaren & Hawe, 2005)

In health promotion, the ecological framework draws attention to individual and environmental determinants of behavior at different levels of influences (Mclaren & Hawe, 2005). There are two guiding principles of the ecological perspective. The first is the assumption of interaction and causal reciprocity among levels, underscoring the importance of interventions that are targeted and evaluated at different levels; the second being that appropriate changes in the environments will lead to changes in the individuals (Mclaren & Hawe, 2005). This suggests that for students to achieve academically in schools, their environment needs to be appropriate and supportive of the desired outcome. Based on this framework it is suggested that the provision of MHM spaces will result in better learning outcomes and that individual characteristics, support of family and school/community environment will play a role in academic achievement.

In applying this framework, the present study considered academic achievement as the outcome of interactions among factors at three levels— the individual-, home-, and school-level within the micro- and meso-systems. The framework is applicable to this study because it treats the interaction between factors at different environment levels with equal importance

and provides a comprehensive understanding of environmental factors that influence student achievement.

3. Literature Review

The literature used in this thesis is peer-reviewed and published in academic databases found through Oria. Searched terms include ‘water’, ‘sanitation’, ‘WASH’, ‘schools’, ‘education’, ‘academic achievement’, ‘menstruation’, ‘menstrual health management”, “MHM”, ‘Ethiopia’, and ‘health’. As MHM is an emerging topic, findings from the grey literature have also been cited.

3.1 Menstrual Hygiene Management in Schools

MHM has recently emerged as a development issue and both qualitative and quantitative studies suggest that poor MHM leads to school absenteeism, distraction, and disengagement (Hennegan & Montgomery, 2016). To begin, strong evidence from girls’ narratives regarding challenges with MHM in schools have been widely reported in the literature, particularly in low and middle income countries (LMIC) across sub-Saharan Africa, Asia, and South America (Sommer, Hirsch, et al., 2015). Feelings of fear, shame, and embarrassment in managing menstruation and a lack of guidance prior to the onset of menstruation are often reported (Mahon & Fernandes, 2010; Mason et al., 2013; McMahon et al., 2011; Sommer, 2010; Thakur et al., 2014). Studies have indicated girls lack clean, safe, and private spaces with access to water and soap to clean the body and menstrual materials (Alexander et al., 2014); adequate time to manage menstruation (Fehr, 2011); and hygienic menstrual products (Long et al., 2013; Mason et al., 2013). While there is growing qualitative evidence suggesting the gendered impacts of inadequate WASH facilities on the participation of girls in school, quantitative studies have recently emerged studying this association.

Studies demonstrating quantitative casual associations of the challenges girls face in managing menstruation is lacking (Hennegan & Montgomery, 2016; Sclar et al., 2017; Sommer et al., 2016). Identified studies of MHM have focused on health and educational outcomes (Sumpter & Torondel, 2013). Studies focused on health outcomes have looked at reproductive tract infection, laboratory confirmed bacterial vaginosis, or self-reported vaginal discharge using self-reported menstrual management as the exposure (Ali, Sami, & Khuwaja, 2007; Balamurugan & Bendigeri, 2012; Younis et al., 1993). These studies show that access to improved sanitation through provision of hardware interventions, such as WASH infrastructure, can lower rate of sanitation-related illnesses, which may lead to healthier states to attend school and, therefore, better cognitive abilities. Other studies have explored the impacts of adequate

sanitation in schools which promotes comfortable learning environment and, therefore, a desire to attend schools. The identified studies which have assessed educational outcomes have focused on school absence, often term absenteeism, and have reported mixed results for the effect of sanitation (Dreibelbis et al., 2013; Freeman et al., 2012; Grant et al., 2013). For instance, Freeman et al. (2012) conducted a study in Kenya assessing the impact of school based WASH intervention (schools receiving hygiene promotion training and water treatment versus schools receiving hygiene promotion training, water treatment, and sanitation [provision of latrines]) on primary school children's attendance. They found that after stratified analysis by gender, both interventions were effective in reducing absence among girls than boys compared to the control (Freeman et al., 2012). Although this study found that WASH interventions could be effective in reducing gender disparities, it does not clearly identify the mechanism by which girls benefit more, such as the role of private spaces. A study that assessed perception of private spaces with menstruation related absenteeism was conducted by Grant et al. (2013) in Malawi. They found that perceived lack of privacy in the school toilet area was associated with 2.64 greater odds of absence during the last menstrual period ($p < .05$); but overall, they did not find evidence for school level variance in menstruation related absenteeism (Grant et al., 2013). Further, a hardware intervention study exploring the effect of the menstrual cup, an improved sanitary technology, on attendance, reported a significant and negative, yet small effect that menstruation could have on attendance (Oster & Thornton, 2011). While the qualitative literature reports the many challenges that girls face in managing menstruation in school, the latter two studies (Grant et al., 2013; Oster & Thornton, 2011) cast doubt on the supposition that menstruation may be associated with absence. It is likely that absence and learning outcomes correlate, but not necessarily.

3.2 Menstrual Hygiene Management and Academic Achievement

Limited studies have explored cognitive development using measures of academic achievement as an educational outcome in assessing the influence of sanitation. As MHM relates to sanitation the following review addresses studies that address sanitation in general. Of studies assessing sanitation and cognitive development identified in a systematic review by Sclar et al. (2017), four studies investigated sanitation at the household or community level, while only one study assessed sanitation at the school level. The manner of assessment of cognitive measures varied for each study which include: child development questionnaires administered by parents, the Raven's Progressive Matrices, Wechsler Pre-School and Primary Score Intelligence, and

national education reports with a majority of studies following a cross-sectional design (Cameron Manisha Olivia, Susan, 2013; Maika et al., 2013; Santos et al., 2008; Spears, 2012). At the school level, Shallwani (2015) used Agna Khan Foundation achievement test in early primary school in Pakistan but found no association between quality of school toilets and water facilities and student achievement test scores. A lack of studies assessing sanitation, specifically the role of gendered spaces for girls, at the school level using achievement tests scores as an outcome highlights a gap in the literature this study aims to fill.

3.3 Factors Associated with Educational Outcomes

Until recently, educational outcomes have been under researched due to the absence of achievement data, but in 2000, with the introduction of the Ethiopian National Learning Assessment (ENLA), progress on understanding children's educational outcomes in relation to wider socio-economic trends have been made (UNICEF, 2015). The following section presents influences on educational outcomes organized around how three levels of environmental influences that interact to affect children's educational trajectories. The following section elaborates on these factors in detail and draws on the empirical literature in order to provide face validity of the variables used in the present study.

3.3.1 Individual characteristics

Child health

There is extensive literature suggesting that the role of health plays a role in cognitive development. Studies indicate that a child's health may affect the ability to attend school, and thus, develop better cognitive abilities (Ali et al., 2007; Balamurugan & Bendigeri, 2012; Younis et al., 1993). Other studies have reported menstrual pain as a reason for girls to be absent from school, while other studies report that the presence of disease within a school due to improper sanitation has caused parents to be reluctant to send their children to school (Colclough, Rose, & Tembon, 2000; Hennegan & Montgomery, 2016; Snilstveit et al., 2016; Tamir, 2015). Further, stomach pains is amongst the most cited illness reported by Ethiopian students (Colclough, Rose, & Tembon, 2000). Thus, health as it relates to menstrual stomach pains, may affect attendance at school and the development of cognitive abilities and, therefore, be related to test score results.

3.3.2 Family characteristics

Household wealth/parental education

Household wealth is an important factor in determining access to education as schooling incurs a range of upfront and hidden costs (Hunt, 2008). Previous studies conducted in developing countries consistently report that household wealth improves a child's education (Admassu, 2015; Woldehanna, Ferede, Girma, Alemu, & Getachew, 2012). This relates to MHM as challenges in managing menstruation via effective menstrual management products is often tied to poverty and the ability to purchase hygienic menstrual solutions. To illustrate, due to low cost and easy availability, most menstruating girls in Ethiopia report cloth, soft paper, and rags as commonly used menstrual protection materials (Tamir, 2015). The issue around low-cost menstrual management solutions is the increased risk of menstrual leakage and stained clothing, which can affect girls' concentration and attention in school. Of the identified studies on household associations and educational outcomes, studies have used large-scale national surveys, such as the Ethiopia Rural Household survey, and have used proxy measures of socio-economic status (Admassie & Bedi, 2003; Weir, 2011). Factors at the family level that have shown significant positive effects on educational outcomes include parental education and household wealth (Admassie & Bedi, 2003; Weir, 2011).

3.3.3 School/community characteristics:

School locality/ travel time to school

There is substantial evidence from the ENLA to support various school disadvantages effects educational outcomes. Identified school factors that have a significant effect on children's achievement on ENLA test scores include the distance and time it takes to travel to school, and the availability and condition of school facilities (Jebena, 2013). Findings from Round 1 Young Lives school survey in Ethiopia reported that a quarter of rural schools have children that travel too far for them to stay in school for a full day, suggesting that travel time is an important cause of underachievement in certain areas (Frost & Rolleston, 2013). A study of menstrual patterns of secondary school adolescents in northwest Ethiopia concluded that better socioeconomic status for girls attending urban schools may put them at an advantage as they do not have to deal with stress that accompanies having to travel long distance to school every day, experienced by rural girls (Zegeye et al., 2009). The literature also cites that if schools are located too far parents/guardians are more reluctant to send their child to school as girls are seen as vulnerable to sexual harassment enroute (Colclough et al., 2000; Hunt, 2008).

With increased attention on educational attainment in relation to MHM, this study will contribute to the literature in two ways. First, with a large number of studies focusing on absenteeism, little is known about the effects of sanitation, especially MHM spaces, on cognitive development. Therefore, studying cognitive development using achievement test scores will add to the fairly, new emerging literature. Additionally, while most of the literature has focused on the home environment in relation to child development, the study aims to investigate the effect of MHM space on performance on cognitive math and English tests, and whether differences are attenuated by adjusting for individual-, family-, and school/community level characteristics.

4. Methods

4.1 The Young Lives Project

The current study analyzed secondary data using the Young Lives international longitudinal study of childhood poverty from the 2016-2017 Ethiopia school survey, and adopts a post-positivist paradigm in that knowledge can be produced through approximation of empirical evidence (Neuman, 2011). Unless otherwise noted, all factual information from the following section is from Young Lives (Rossiter, Azubuike, & Rolleston, 2017).

The Young Lives study is a longitudinal study of childhood poverty conducted in 4 developing countries, including Ethiopia, since 2002 and traces the lives of 12,000 children in two age groups, the 'Younger Cohort' born in 2001-2002 and an 'Older Cohort' born in 1994-1995. Young Lives have followed these children spanning a period of 15 years, collecting data at the household and community level. In 2010 and 2012-2013, Young Lives conducted a school survey to explore a subset of the younger cohort children's experiences of schooling and education in depth, examining issues of school quality and effectiveness at the primary level. In 2016-2017 a school survey was conducted at the upper primary level.

4.1.1 Young Lives sampling strategy

The first school survey conducted in 2010 followed the Younger Cohort children and included 20 core sites across the regions of Addis Ababa, Amhara, Oromia, Southern Nations, Nationalities, and People's Region (SNNP), and Tigray that were purposely selected in 2001, which "ensured cultural and geographic diversity of the country, including urban-rural differences, but with a pro-poor bias and a focus on areas with food insecurity" (Outes-Leon and Sanchez, as cited in Rossiter & Azubuike, 2017, p. 6) . The second school survey in 2012-2013 included the same 20 sentinel sites but was extended to 10 additional sites in the emerging regions of Somali and Afar, following the same criteria as the original sites (see Figure 1). In 2016-2017, in collaboration with the Ethiopian Development Research Institute (EDRI), Young Lives surveyed the same 30 sites in the 2012-2013 survey, but used a census including all schools within the site's geographic boundaries, irrespective of ownership. All Grade 7 and 8 students (Young Lives cohort children and their peers) were included in data collection. Thus, the 2016-2017 school survey sampling approach is statistically representative of the sites sampled.

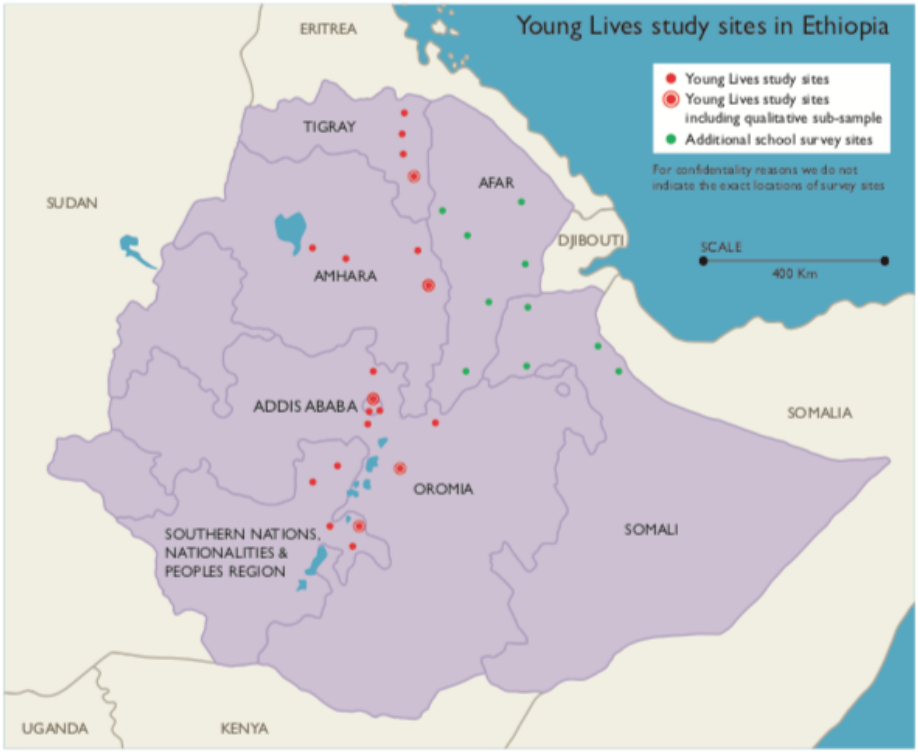

Figure 1. Map of 2016-2017 school survey sites (Rossiter et al., 2017)

4.1.2 Survey instruments

Survey instruments used in this study include student and school level questionnaires (includes information on math and English sections) and school facilities observations. The survey was administered in two waves, Wave 1- at the beginning and Wave 2- at the end of the school year, by trained fieldworkers from EDRI. Additionally, students' learning levels were assessed via math and English cognitive tests at both study waves. All math and English items were pre-piloted and tested for reliability and validity by Young Lives researchers using techniques from Classical Test Theory and Item Response Theory (Azubuike, Moore, & Iyer, 2017). All students present at Wave 1 were included in the sample and followed up at Wave 2, without replacement of absentees.

4.1.3 Data quality

The data hold a high quality for several reasons. Having students re-measured on achievement at two time-points provides a comparison on how much schools contribute to a student's progress and improvements from one testing period to the next. A second measure of children's achievement on a subject improves the reliability and robustness measuring academic achievement as the test and re-test design provides an analytical advantage when

assessing learning quality, particularly in LMIC where less is known about the educational context (Iyer & Moore, 2017).

4.2 Study Sample

The sample for the following study was selected based on several criteria. As the impact of MHM is gender specific, 5958 female respondents were eligible. However, only female students enrolled in the same section/school between test waves were retained. Additionally, only female respondents considered adolescents (14 to 19 years) were kept using age as a proxy measure of menstruation, based on the literature finding that the median age of menstruation is 14.8 years (13.9-15.3) in Northwest Ethiopia and WHO's definition of adolescents (WHO, 2001; Zegeye et al., 2009). The final sample included 3844 adolescent girls between the ages of 14 and 19 years (M = 14.86, SD = 1.02).

4.3 Study Variables

4.3.1 Dependent variables

Math and English test scores at Wave 1 and Wave 2 were the academic achievement measures used, totaling four dependent variables. Measuring English literacy and math levels is pertinent for the study context because Ethiopia strives to be a middle-income country and improved literacy and math levels are needed in the application of science and technology, which are driving instruments of wealth (Federal Ministry of Education, 2015). Often achievement levels are used as a check against learning criteria, as seen by the Ethiopian National Learning Assessment. However, measuring how students test at one single point in time leads to substantial bias as achievement is associated with a student's socioeconomic status and her learning to date. Additionally, with non-random sorting of students into schools and classrooms, there is risk that educational outcomes are systematically correlated with school and classroom inputs and processes. Therefore, by accounting for how much improvement a student makes from one testing period to the next, there can be less biased estimates of how much background characteristics and school factors affect a student's learning (Azubuike et al., 2017).

Young Lives' math tests reflect the curricular expectations for Grades 7-8 and was developed in consultation with the Ministry of Educations' Mathematics and Science Improvement Centre. It included eight content domains: 1) basic number competency, 2) integers, rational

numbers, powers and bases, 3) fractions, decimals, ratios and percentages, 4) area, perimeter, volume and surface area, 5) geometry and shapes, 6) algebra, 7) measurement, charts, and graphs, 8) reasoning, problem solving, and applications in daily life.

The English language test is a reflection of transferrable skills that can be used in Ethiopia with relevance for continuing education, labor market opportunities and social mobility (Graddol as cited in Rossiter & Azubuike, 2017). English is also the language of instruction for all secondary-level subjects, therefore, assessing students' English ability provides a good indication of future achievements. The English test covers content that upper primary grade students are expected be familiar with after learning English from Grade 1 and will need in secondary schools. The four domains of the English test include: 1) word identification, 2) word meaning and contextual vocabulary, 3) sentence construction and comprehension 4) reading/comprehension.

Both math and English tests involved 40 multiple choice items with a sub-set of items that were common in both test waves. The value labels of the each test items were *0 = incorrect/blank and 1 = Correct.* For each subject, the raw score at Wave 1 and Wave 2 was provided in the Young Lives dataset.

4.3.2 Independent variables

Independent variables were pulled from school facilities observations and student background questionnaires, which included home and family background and life experience outside of school.

4.3.2.1 Main independent variable

Menstrual hygiene management variable (MHM group)*:* Among the various WASH measures available in the school survey, WASH measures that were gender/menstruation-specific to females were chosen. Two items fell under MHM spaces:

1) Place for girls to wash menstrual rags: "*Is there a place for washing out menstrual rags (for female students close to the toilet facility)?"* coded *1 = yes; 2 = no*
2) Private space for girls to wash "*Is there a place where female student can wash themselves privately away from boys and male teachers?"* coded *1 = yes; 2 = no*

The two items were transformed into a categorical variables. Students were allocated to two conditions based on availability of MHM spaces at the attended school *1) None 2) MHM* available (schools that provided either/or both MHM spaces); coded *0 and 1*, respectively.

The survey also included an item regarding ***separate toilets for girls/boys:*** "Are there separate toilets for male and female students", and ***toilet type***: "what type of toilet for use by students is most common" with flush toilet, pit latrine/dry latrine, other, and no toilets as options. However, most sampled students (96.6 percent) attend schools that provide separate toilets for girls and boys, with pit latrines/dry latrines being the prominent toilet type (90.5 percent). Low variability of these measures makes assessing separate toilets and toilet type impractical; therefore, these measures were not included in the study.

4.3.2.2 Individual level covariates

Age was a self-reported continuous variable captured by the question *"What age are you?"*

Child health was measured via several questions in the Young Lives survey. However, a proxy question of "Do you have any health problems (stomach problems) that regularly affect you in school?" was chosen as stomach problems could be interpreted to be related to menstrual pains. This item was coded *0 = Yes, 1 = No*.

4.3.2.3 Family level covariates

Household wealth was measured by questions on students' household durable assets through the question of "*Which of the following do you have at home?*" with the following options: table, chair, bed with mattress, radio, telephone, fridge, bicycle, and car or truck. Answers were coded 0= *yes* and 1= *no.* For the purpose of this study, it was decided to use ownership of a bicycle as a proxy measure of household wealth as owning a bicycle represents wealth accumulation and can serve as an income-generating asset and as a mean of transporting individuals to school (Grant et al., 2013).

Mother's education was assessed through the question***:*** *"What is your mother's highest level of education?"* with the following categories: never been to school, Up to Grade 4, Up to Grade 8, Up to Grade 10, technical and vocational education and training (TVET) or Diploma, Up to Grade 12, University, and I don't know. After running descriptive statistics, only a small percent

of the sample had mothers who had TVET or diploma (5.6 percent), attended school up to grade 12 (6.1 percent), or completed university education (4.5 percent). Thus, it was decided to collapse these levels into the one category 'higher education or vocational training.' Responses to 'I don't know' was considered missing data. This variable was coded as follows *0 = Never been to school, 1 = basic education, 2 = general primary education, 3 =general primary secondary education, 4 = higher education or vocational training.*

4.3.2.4 School level covariates

Travel time to school was a self-reported continuous variable captured by the question *"How many minutes does it usually take you to get to school?"*

School geographic area measured by 'locality', coded *0 = Rural, 1 = Urban.*

4.4 Data Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 25. All analyses excluded cases pairwise with no replacement for missing data (see Section 5.1). A statistical significance level (α) of .05 was used for each statistical analysis.

The first part of the analysis included descriptive analysis of the data and coding of variables as described above. Descriptive statistics were obtained for all variables and were presented using standard statistical parameters such as frequencies, percentages, means, and standard deviations (See Table 1 and 2 in the Results chapter). Outliers classified as 'extreme' by SPSS were investigated. However, outliers were retained given that they did not have a strong influence on the mean. Second, a one-way between groups analysis of variance (ANOVA) was conducted between the main independent variable (MHM group) with all dependent variables. This was followed by bivariate analyses between all dependent variables and various independent covariates at the individual-, family-, and school- level using independent sample t-tests, Pearson Product-Moment Coefficient (r), and one-way between groups ANOVA.

To address the study's first research question, a mixed between-within subject ANOVA was conducted for each outcome (math and English scores). To address the second research question, a mixed between-within analysis of covariance (ANCOVA) was conducted between the MHM variable and each subject outcome, controlling for variables (covariates) that were found to be significant in bivariate analysis.

4.5 Ethical Consideration

This thesis utilized existing data from the Young Lives school survey, so no direct contact was made with study participants. The use of secondary data saves times, money, and resources; however, the concerns with secondary data use is the potential harm to study participants due to the varying amounts of identifying information that may be provided and the fact that the original data was not collected to address the present research questions (Tripathy, 2013). In order to use Young Lives' secondary data, a project request was sent to UK Data Archives for non-commercial use and was approved in April 2018. The data was provided with no identifying information of participants ensuring data protection, anonymity, and confidentiality of study participants. The data was used solely for the intended purpose outlined in the project request and was under the direct supervision of researchers at the University of Bergen.

Ethical approval for the original protocol and data collection rounds of the Young Lives study was received from the London School of Hygiene and Tropical Medicine Research Ethics Committee and six other partner ethics committees including the College of Health Sciences in Ethiopia. Young Lives follows the ethics guidance of the Department of International Development, University of Oxford, Association of Social Anthropologies of the Commonwealth, and Save the Children Protection Policy (Young Lives, 2019). Additionally, Young Lives' local in-country research and policy team of economists, educationalist, social anthropologists, developmental psychologists, epidemiologists, nutritionists, social workers, sociologists and political scientists actively discussed ethics in order to develop a shared understanding of research in the study context (Morrow, 2013). While working with local teams to address ethical challenges may reduce 'stranger involvement' and power dynamics between researchers and participants, it does not completely eliminate them (Morrow, 2013). It is important to recognize that social differences, including social class and social divisions of gender and age, between researchers and participants are likely to affect research participation.

Ethics is a fundamental part of research. In collecting data on children, Young Lives researchers obtained informed consent from parents or caregivers, and from children at each round of fieldwork (Morrow, 2013). Due to the country context, children may be taught from an early age to obey adults or authoritative figures, which makes it difficult from them to refuse to participate in a study, but Young Lives made efforts to ensure that no adverse consequences would results in non-participation. Ethical consideration was also addressed through the following provisions: 1) fieldworkers were provided with training in research ethics and provided with fieldwork manuals that contained ethics guidance 2) survey researchers and fieldworkers were required to report cases of ethical difficulties to supervisors in order resolve them (Morrow, 2013).

5. Results

5.1 Univariate Analysis

Descriptive analyses of all variables were conducted on the study sample to provide an overview of the data (N = 3844). Of the sample, a majority of respondents, 66.4 percent (n = 2553) attended schools that did not provide any MHM spaces, whereas 33.6 percent (n = 1291) of respondents attended schools that provided either a private space to wash menstrual rags or a private space to wash themselves.

Most of the sample attended schools in urban localities (78.5 percent), and 84.8 percent did not indicate a predisposition to stomach problems while attending school (.1 percent missing). Less than 30 percent of respondents had mothers who completed general secondary education or obtained higher education (missing 12.8 percent). Seventy-eight point four percent of respondents did not own a bicycle, which served as an income-generating asset and as a mean of transporting individuals to school (missing .1 percent). See Table 1 for descriptive statistics of all categorical variables.

Table 1

Frequency of Categorical Variables, N=3844

	Frequency	Percent (Valid Percent)
Main independent variable		
MHM group		
None	2553	66.4 (66.4)
MHM available	1291	33.6 (33.6)
Total	3844	100.0
Child level variables		
Child health- stomach problems		
Yes	579	15.1(15.1)
No	3259	84.8 (84.9)
Total	3838 (missing n=6)	99.9 (missing .1)
Family level variables		
Mother's highest level of education		
Never been to school	1044	27.2 (31.3)
Basic education	585	15.1 (17.4)
General primary education	753	19.6 (22.5)
General secondary education	463	12.0 (13.8)
Higher education/TVET or diploma	509	13.3 (15.2)
Total	3354 (missing n=490)	87.2 (missing 12.8)
Wealth item- Bicycle		
Yes	827	21.5 (21.5)
No	3013	78.4 (78.5)
Total	3840 (missing n=4)	99.9 (missing .1)
School/community level variables		
Locality		
Rural	827	21.5 (21.5)
Urban	3017	78.5 (78.5)
Total	3844	100.0

In the study sample, Wave 1 math and English scores ranged from 2 to 40, with a mean of 16.48 (*SD* = 6.17) and 19.44 (*SD* = 6.73), respectively. Wave 2 math scores ranged from 2 to 40 (*M* = 19.08, *SD* = 7.03) while English scores ranged from 5 to 40 (*M* = 20.42, *SD* = 6.85). Time to travel to school ranged from one minute to 180 minutes. The mean travel time was 24.94 minutes (*SD* = 20.41). See Table 2 for descriptive statistics of continuous variables.

Table 2

Descriptive Statistics of Continuous Variables

	N	Missing	Min	Max	Mean	Std. Deviation	Skewness		Kurtosis	
							Statistic	Std. Error	Statistic	Std. Error
Math- Wave 1	3844	0	2	40	16.48	6.17	0.62	0.04	0.27	0.08
Math- Wave 2	3222	622	2	40	19.08	7.03	0.41	0.04	-0.44	0.08
English- Wave 1	3726	118	2	40	19.44	6.73	0.42	0.04	-0.32	0.08
English- Wave 2	3346	498	5	40	20.42	6.85	0.28	0.04	-0.48	0.08
Age	3844	0	14	19	14.86	1.02	1.25	0.04	1.27	0.08
Minutes it takes to get to school	3812	32	1	180	24.94	20.41	2.08	0.04	7.18	0.08

When reviewing the distribution of the data in order to meet the assumption of normality, it was found that the skewness and kurtosis values for achievement scores deviated from the normal value of 0 (see Table 2). However, an inspection of the shape of the distribution of scores for each achievement test showed scores to be reasonably distributed (see Figures 2-5 in appendix).

5.2 One-Way Between Groups ANOVA: Effect of MHM Group on Achievement Scores

One-way between groups ANOVA was conducted to explore the impact of the MHM group on academic achievement, as measured by Wave 1 and Wave 2 math and English test scores. Participants were divided into 2 groups according to the availability of MHM spaces at their schools (Group 1: None, Group 2: MHM available). See Table 3 for the means and standard deviations for each of the academic achievement variables by MHM group.

Table 3

Descriptive Statistics of One-Way ANOVA for the Effect of MHM Group on Achievement Scores

						95% *CI*			
		N	*M*	*SD*	*SE*	*LL*	*UL*	Min	Max
Math- Wave 1	None	2553	16.34	6.23	0.12	16.10	16.58	2	40
	MHM available	1291	16.74	6.06	0.17	16.41	17.07	3	37
	Total	3844	16.48	6.17	0.10	16.28	16.67	2	40
Math-Wave 2	None	2192	18.88	6.94	0.15	18.59	19.17	2	40
	MHM available	1030	19.51	7.20	0.22	19.07	19.95	5	40
	Total	3222	19.08	7.03	0.12	18.84	19.33	2	40
English- Wave 1	None	2475	18.94	6.75	0.14	18.68	19.21	2	40
	MHM available	1251	20.41	6.59	0.19	20.05	20.78	5	38
	Total	3726	19.44	6.73	0.11	19.22	19.65	2	40
English- Wave 2	None	2232	20.13	6.86	0.15	19.85	20.42	5	40
	MHM available	1114	21.00	6.79	0.20	20.60	21.40	5	38
	Total	3346	20.42	6.85	0.12	20.19	20.65	5	40

Note. CI = confidence interval; LL = lower limit; UL = upper limit

Welch's F test was used as Levene's test indicated a violation of assumption of homogeneity of variance for Wave 2 Math scores, ($p < .05$) (See Table 4). The one-way ANOVA of students' average score on Wave 2 math test revealed a statistically significant main effect, indicating there is a difference between the MHM groups on average mean scores, *Welch's* $F(1, 1950) = 5.54$, $p = .02$.

Table 4

Levene's Test of Homogeneity of Variances

		Levene Statistic	*df1*	*df2*	Sig.
Math- Wave 1	Based on Mean	0.00	1	3842	.947
	Based on Median	0.00	1	3842	.988
	Based on Median and with adjusted df	0.00	1	3831	.988
	Based on trimmed mean	0.02	1	3842	.887
Math- Wave 2	Based on Mean	5.94	1	3220	.015
	Based on Median	5.78	1	3220	.016
	Based on Median and with adjusted df	5.78	1	3216	.016
	Based on trimmed mean	5.89	1	3220	.015
English- Wave 1	Based on Mean	0.01	1	3724	.905
	Based on Median	0.13	1	3724	.715
	Based on Median and with adjusted df	0.13	1	3689	.715
	Based on trimmed mean	0.04	1	3724	.852
English- Wave 2	Based on Mean	0.02	1	3344	.882
	Based on Median	0.05	1	3344	.821
	Based on Median and with adjusted df	0.05	1	3338	.821
	Based on trimmed mean	0.06	1	3344	.811

One-way ANOVA results for the remaining test scores indicated that student's average score on each measure of academic achievement revealed a statistically significant main effect, indicating there is a significant difference between MHM groups on average mean scores, however the calculated effect sizes using eta squared were very small (see Table 5).

Table 5

One-Way Between Groups ANOVA Summary Table for the Effect of MHM Group on Achievement Scores

		SS	*df*	*MS*	*F*	*p*	η^2
Math- Wave 1	Between Groups	137.26	1	137.26	3.60	.054	.00
	Within Groups	146341.73	3842	38.09			
	Total	146478.99	3843				
English- Wave 1	Between Groups	1801.14	1	1801.14	40.19	<.001	.01
	Within Groups	166881.54	3724	44.81			
	Total	168682.68	3725				
English- Wave 2	Between Groups	551.59	1	551.59	11.792	<.001	.00
	Within Groups	156416.39	3344	46.78			
	Total	156967.99	3345				

5.3 Bivariate Analysis of Covariates

5.3.1 Independent-samples t-tests

Independent samples t-tests were used to compare all waves of mathematic and English academic achievement test scores with the following dichotomous variables: child health (stomach problems), wealth item (ownership of bicycle), and school locality.

Starting with child health, there was a significant difference in Wave 1 English scores for individuals who reported stomach issues (M = 18.72, SD = 6.51) from those who did not (M = 19.58, SD = 6.76), t (3718) = -2.79, $p < .01$, two-tailed. A significant difference is also seen in Wave 2 English scores for those who reported stomach problems (M = 19.58, SD = 6.70) from those who did not report stomach problems (M = 20.57, SD = 6.86), t (3339) = -3.02, $p <$ .001 (two-tailed). While the difference in means were significant (wave 1 mean difference = -0.86, 95% *Cl:* -1.46 to -0.26; wave 2 mean difference = -.99, 95% *Cl*: -1.64 to -.35, two-tailed) both findings represented a small effect (d = 0.13 and 0.15). There was no statistically significant difference in scores for individuals who reported stomach problems and those who did not have stomach problem for math achievement scores. See Table 6 for more details.

Table 6

T-Tests: Achievement Score Differences Between Groups That Reported or Did Not Report Stomach Problems

	Yes- stomach problems		No- stomach problems					95 % *CI*		
	M	*SD*	*M*	*SD*	*df*	*t*	*p*	*LL*	*UL*	Cohen's *d*
Math - Wave 1	16.67	6.07	16.45	6.19	3836	0.79	.430	-.033	0.77	0.04
Math - Wave 2	18.86	6.81	19.13	7.07	3214	-0.76	.450	-0.94	0.42	0.04
English- Wave 1	18.72	6.51	19.58	6.76	3718	-2.79	.010	-1.46	-0.26	0.13
English- Wave 2	19.58	6.70	20.57	6.86	3339	-3.02	<.001	-1.63	-0.35	0.15

On average, individuals who owned a bicycle (M = 20.44, SD = 6.71) scored significantly higher on English achievement tests at Wave 1 than those who did not own a bicycle (M =19.17, SD = 6.94; t(3720) = 4.75, $p < .001$). The mean difference between groups was 1.27 scores higher (95% *Cl:* .75 to 1.79) with a small effect size (d = 0.19). The relationship was also significant for Wave 2 English achievement tests. Those who owned a bicycle at Wave 2 had a mean of 21.67 (SD = 6.96) while individuals who did not own a bicycle had a mean of

20.08 (*SD* = 6.78; *t(*3342) = 4.75, *p* < .001). The effect size was large (*d* = 0.23) with a mean difference of 1.59 (95% *Cl:* 1.02 to 2.15, two-tailed). There was no statistical significance of for Wave 1 and Wave 2 math test score means. See Table 7 for more details.

Table 7

T-Tests: Achievement Score Differences Between Groups That Reported Ownership of Bicycle or Non-Ownership of Bicycle

	Owns a bicycle		Does not own a bicycle					95 % *CI*		Cohen's
	M	*SD*	*M*	*SD*	*df*	*t*	*p*	*LL*	*UP*	*d*
Math - Wave 1	16.47	6.28	16.48	6.15	3838	-0.08	.940	-0.49	0.46	0.00
Math - Wave 2	19.27	7.35	19.03	6.94	3217	0.80	.420	-0.35	0.84	0.03
English- Wave 1	20.44	6.71	19.17	6.94	3720	4.75	<.001	0.75	1.79	0.19
English- Wave 2	21.67	6.96	20.08	6.78	3342	5.50	<.001	1.02	2.15	0.23

Differences in math and English academic achievement test scores were significant across all test waves for school locality. The magnitude of the differences was moderate for mathematic scores at Wave 1 (mean difference = .22; 95% CI: -3,60 to -2,79; *d* = 0.56) and Wave 2 (mean difference= -. 26; 95% CI: -4.40 to -.034; *d = 0*.59), but was large for English scores at Wave 1 (mean difference = -.86; 95% CI: -6.45 to -5.65; *d* = 1.06) and Wave 2 (mean difference = -.99; 95% CI: -6.56 to -5.68; *d* = 1.26). See Table 8

Table 8

T-Tests: Achievement Score Differences Between Groups That Attend Schools Located in Rural Versus Urban Locality

	Rural		Urban					95 % *CI*		Cohen's
	M	*SD*	*M*	*SD*	*df*	*t*	*p*	*LL*	*UL*	*d*
Math - Wave 1	13.97	5.00	17.16	5.00	1614	-15.35	<.001	-3.60	-2.79	0.56
Math - Wave 2	16.05	6.07	19.92	7.05	1251	-14.34	<.001	-4.40	-0.34	0.59
English- Wave 1	14.46	4.59	20.74	6.64	1828	-29.77	<.001	-6.45	-5.65	1.06
English- Wave 2	15.65	4.91	21.77	6.72	1590	-27.36	<.001	-6.56	-5.68	1.26

5.3.2 Pearson's product-moment correlation coefficients

The relationship between math and English achievement scores with continuous variables (age and time traveled to school) were investigated using Pearson's product-moment *r*. There was a weak, negative correlation between age and Wave 2 mathematic achievement scores ($r = -.05$, $n = 3222$, $p < .01$) with higher scores associated with lower ages. Time to travel to school was a significant correlate of academic achievement across both subjects and all test waves, with higher scores associated with shorter travel time to school. The relationship between age and Wave 1 math scores and age with Wave 1 and Wave 2 English test scores were not significant correlates. See Table 9 for details.

Table 9

Pearson Product-Moment Correlations Between Continuous Variables and Academic Achievement Measures

	Math		English	
Variable	Wave 1	Wave 2	Wave 1	Wave 2
Age	-0.03	-0.05*	-0.02	-0.03
Travel time to school	-0.07*	-0.08*	-0.10*	-0.13*

*. Correlation is significant at the 0.01 level (2-tailed)

5.3.3 One way-between groups ANOVA

A one-way- between groups ANOVA was used to explore differences in means of academic achievement for each dependent variable between groups based on mother's education. The independent variable represented the mother's education level: 1) never been to school 2) basic education 3) general primary education 4) general secondary education 5) and higher education/TVET or diploma. Notably, average means for both subject and test wave increased as the level of mother's education increased. See Table 10 for the means and standard deviations for each of the 5 groups.

Table 10

Descriptive Statistics from One-Way ANOVA of Effects of Mother's Education on Academic Achievement

						95% CI			
		N	*M*	*SD*	*SE*	*LL*	*UL*	Min	Max
Math-Wave 1	Never been to school	1044	15.36	5.62	0.17	15.02	15.70	3	39
	Basic education	582	15.86	5.99	0.25	15.37	16.35	4	37
	General primary education	753	17.13	6.37	0.23	16.67	17.58	2	40
	General secondary education	463	17.07	6.18	0.29	16.51	17.64	4	36
	Higher education/TVET or diploma	509	18.01	6.86	0.30	17.41	18.61	5	40
	Total	3351	16.48	6.21	0.11	16.27	16.69	2	40
Math-Wave 2	Never been to school	850	18.09	6.85	0.24	17.63	18.55	2	40
	Basic education	487	18.35	6.62	0.30	17.76	18.94	4	37
	General primary education	647	19.53	7.06	0.28	18.98	20.07	5	40
	General secondary education	392	19.94	6.89	0.35	19.25	20.62	5	37
	Higher education/TVET or diploma	427	20.70	7.72	0.37	19.97	21.44	3	40
	Total	2803	19.12	7.07	0.13	18.86	19.39	2	40
English-Wave 1	Never been to school	1005	17.44	6.08	0.19	17.07	17.82	2	36
	Basic education	562	18.10	6.36	0.27	17.57	18.63	5	39
	General primary education	739	20.50	6.61	0.24	20.02	20.97	6	40
	General secondary education	449	20.94	6.67	0.32	20.32	21.56	4	39
	Higher education/TVET or diploma	493	22.22	7.22	0.33	21.58	22.86	3	39
	Total	3248	19.46	6.76	0.12	19.23	19.69	2	40
English-Wave 2	Never been to school	902	18.69	6.35	0.21	18.27	19.10	5	40
	Basic education	512	19.33	6.59	0.29	18.76	19.90	5	40
	General primary education	660	21.39	6.53	0.25	20.89	21.89	6	39
	General secondary education	414	21.63	6.83	0.34	20.97	22.29	6	39
	Higher education/TVET or diploma	430	22.42	7.39	0.36	21.72	23.12	5	39
	Total	2918	20.38	6.82	0.13	20.13	20.63	5	40

Levene's test indicated a violation of assumption of homogeneity of variance, therefore *Welch's F* test was used. As such, the one-way ANOVA of student's average score on the measures of academic achievement revealed a statistically significant main effect, indicating

that mother's education level resulted in different average scores on measures of academic achievement (see Table 11).

Table 11

One-Way ANOVA Results- Welch's F Test

	Statistic[a]	*df1*	*df2*	*p*
Math- Wave 1	20.90	4	1443	<.001
Math- Wave 2	12.79	4	1231	<.001
English- Wave 1	61.34	4	1402	<.001
English- Wave 2	34.62	4	1263	<.001

a. Asymptotically F distributed.

Post hoc comparisons, using the Games Howell post hoc procedure was conducted to determine which pairs of education level means differed significantly. These results are given in Table 12. Effect sizes were small for all significant results. Post hoc comparison of results of Wave 1 math scores indicated that students with mothers who have completed secondary (M = 17.07; SD = 6.18) and higher education (M = 18.01, SD = 6.87) had significantly higher average scores than students with mothers who have had no education (M = 15.36, SD = 5.63). Additionally, students with mothers who have completed basic education *(*M = 15.86, SD = 5.99) scored significantly lower than their counterparts who have mothers that completed general primary (M = 17.13, SD = 6.37), general secondary education and higher education. Similar results can be seen across all achievement tests. However, statistical significance was not found with English Wave 2 between students who have mothers who have had basic education and those with mothers that have general secondary education.

Table 12
Post Hoc Results for Achievement Scores by Mother's Education

Achievement Test	Mother's Education	Mean	Mean Difference (Effect sizes are indicated in parentheses- Cohen's *d)*				
			1	2	3	4	5
Math- Wave 1	1. Never been to school	15.36	x				
	2. Basic Education	15.86	-0.50	x			
	3. General primary education	17.13	-1.77	-1.27* (0.03)	x		
	4. General secondary education	17.07	-1.71* (0.04)	-1.27* (0.03)	0.05	x	
	5. Higher education/TVET or diploma	18.01	-2.65* (0.05)	-2.15* (0.04)	-0.88	-0.94	x
Math- Wave 2	1. Never been to school	18.09	x				
	2. Basic Education	18.35	-0,27	x			
	3. General primary education	19.53	-1.44* (0.02)	-1,18* (0.02)	x		
	4. General secondary education	19.94	-1.85* (0.03)	-1.59* (0.02)	-0.41	x	
	5. Higher education/TVET or diploma	20.70	-2.61* (0.23)	-2.35* (.23)	-1.17	-0.76	x
English- Wave 1	1. Never been to school	17.44	x				
	2. Basic Education	18.10	-0,66	x			
	3. General primary education	20.50	-3.05* (0.24)	-2.40* (0.00)	x		
	4. General secondary education	20.94	-3.50* (0.05)	-2.84* (0.29)	-0,45	x	
	5. Higher education/TVET or diploma	22.22	-4.77* (0.07)	-4.12* (0.30)	-1.72* (0.30)	-1.28* (0.02)	x
English-Wave 2	1. Never been to school	18.69	x				
	2. Basic Education	19.33	-0.64	x			
	3. General primary education	21.39	-2.70* (0.06)	-2.06* (0.03)	x		
	4. General secondary education	21.63	-2.94* (0.05)	-2.30	-0.24	x	
	5. Higher education/TVET or diploma	22.42	-3.73* (0.07)	-3.09* (0.04)	-1.03	-0.79	x

* $p < .05$

5.4 Mixed Between-Within Subjects ANOVA

Two mixed between-within subjects ANOVAs were conducted to investigate differences in adolescent girls' academic achievement by schools that provide no MHM spaces and schools that provided MHM space(s) using mathematic and English test scores, across two time points (Wave 1 and Wave 2). Individuals were divided into two groups: 1) attending schools with no MHM, 2) attending schools with MHM spaces. Dependent variables used were: Wave 1 and Wave 2 test scores for each separate subject (math and English).

See Table 13 for the means and standard deviations for the two MHM groups by subject and test wave. Analyses of grouped data by variable MHM revealed mean math and English scores increased between tests waves across schools that provided no MHM spaces and schools that provided MHM spaces. However, means were higher at schools that provided MHM spaces compared to no MHM spaces at both test waves.

Table 13

Means and Standard Deviations from Mixed ANOVA Analysis: Effect of MHM Group on Academic Achievement

		No MHM		MHM available		
Variable	N	*M*	*SD*	*N*	*M*	*SD*
Math- Wave 1	2192	16.64	6.28	1030	17.11	6.19
Math- Wave 2	2192	18.88	6.94	1030	19.51	6.94
English- Wave 1	2172	19,07	6.69	1085	20.45	6.64
English- Wave 2	2172	20.24	6.86	1085	21.02	6.78

A mixed between-within subjects ANOVA of student's average mean math scores revealed a non-statistical significant interaction between test wave and MHM group, Wilks' Lambda = 1.00, $F(1, 3220) = .57$, partial eta squared .00. There was a substantial main effect across test wave, Wilks' Lambda 0.87, $F(1, 3220) = 465.93$, $p < .001$, partial eta squared =.13, with both groups showing increase mean averages. There was a main effect on mathematic achievement by the MHM variable. Students attending schools that did not provide MHM spaces scored lower on mathematic achievement ($M = 17.76$) compared to students attending schools that

provided MHM spaces (*M* = 18.31), *F* (1, 3220) = 25267, *p* < .001, partial eta squared .002). Though the main effect was statistically significant, the partial eta squared indicates a small effect. See table 14 for estimated marginal means.

Table 14

Estimated Marginal Means of Math and English scores by MHM Group

				95% Confidence Interval	
Subject	MHM group	Mean	Std. Error	Lower Bound	Upper Bound
Math	None	17.76	0.13	17.51	18.01
	MHM	18.31	0.19	17.94	18.68
English	None	19.65	0.13	19.40	19.91
	MHM	20.73	0.18	20.37	21.09

For English test scores, there was a statistical significant interaction between MHM space and test wave, Wilks' Lambda = .99, *F*(1, 3255) = 7.19, *p* <.01, partial eta squared .002. Figure 2 suggests that that there was a sharper increase in average mean score between Wave 1 and Wave 2 for the group that did not have MHM spaces. There was a main effect on English achievement by the MHM variable. Students attending schools that did not provide MHM spaces scored lower on mathematic achievement *(M* = 19.65) compared to students attending schools that provided MHM spaces (*M* = 20.73), *F*(1, 3255) = 22.82, *p* < .001, partial eta square .007. Though the main effect was statistically significant, the partial eta squared indicates a small effect.

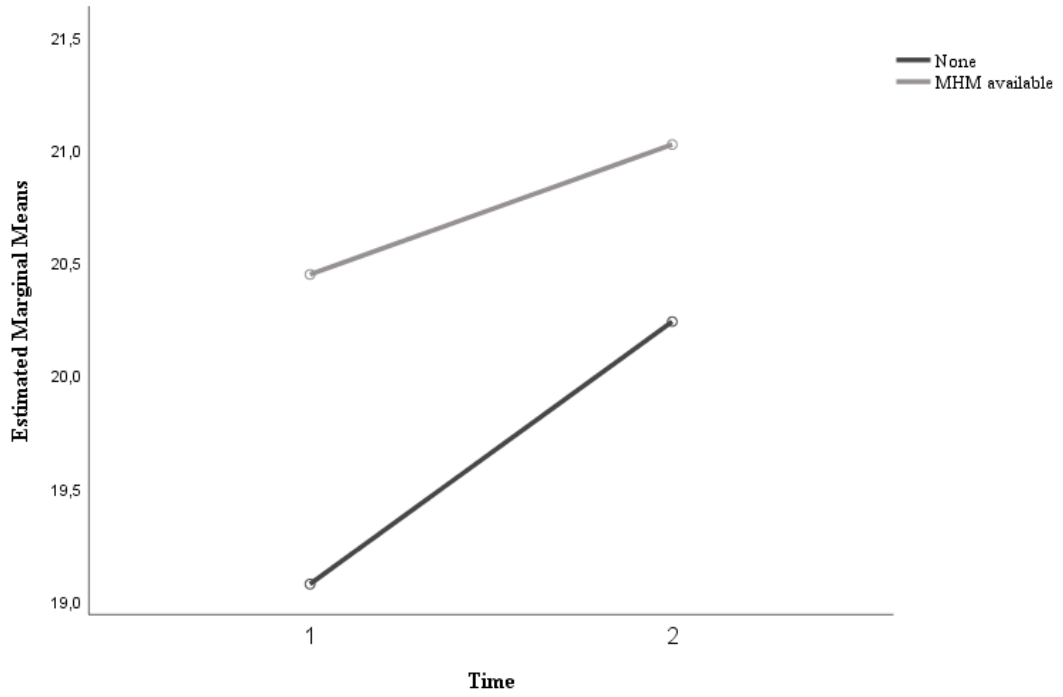

Figure 2. Estimated marginal means of English academic achievement scores across test wave and availability of MHM spaces

5.5 Mixed Between-Within Subjects ANCOVA

Two mixed between-within subjects ANCOVA was conducted to assess the effectiveness of the availability of MHM group while controlling for individual, family, and school characteristics that were found to be significant in bivariate analysis for math and English outcomes, separately (section 4.2). Age, mother's education, time traveled to school, and school locality were used as covariates for mathematic outcomes, whereas additional covariates of child health and wealth asset were accounted for in English outcomes. The assumption of homogeneity of variances was met using Levene's Test of Equality of Variances. The adjusted means and standard error for the two groups are provided in Table 15. An inspection of these means indicate that after covariates are adjusted for, students who attended schools with MHM spaces scored higher in both subjects compared to students who did not attend schools with MHM spaces.

Table 15
Mixed Between-Within Subjects ANCOVA: Adjusted Means of Math and English Scores

Subject	MHM group	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Math	None	17.94[a]	0.134	17.675	18.203
	MHM available	18.06[a]	0.196	17.674	18.444
English	None	19.88[b]	0.126	19.632	20.127
	MHM available	20.28[b]	0.179	19.925	20.628

a. Covariates appearing in the model are evaluated at the following values: What age are you? = 14.79, Mother's education = 1.6634, How many minutes does it usually take you to get to school? = 24.47, Locality = .78.
b. Covariates appearing in the model are evaluated at the following values: What age are you? = 14.80, Mother's education = 1.6517, How many minutes does it usually take you to get to school? = 24.52, Locality = .77, Which of the following things do you have at home? Bicycle = .78, Do you have any health problems that regularly affect you in school? Stomach pain = .846.

5.5.1 Math outcome

After adjusting for child, family, and school characteristics, the interaction effect between time and MHM group was not significant, Wilks' lambda = 1, $F(1, 2775) = .22$, $p = .63$, partial eta squared .00, but there was a main effect across time, Wilks' Lambda =.99, $F(1, 2775) = 20.45$, $p < .001$, partial eta squared = .007.

Between subject effects revealed there was no significant difference in mathematic achievement scores by the MHM variable, suggesting MHM spaces do not make a difference on students mathematic achievements after covariates are considered. However, the main effects of all covariates, except for travel time to school $p = .06$, were significant with small effect sizes. The individual effect of age explained .2 percent of the variance in math scores, with .7 percent of the variance explained by mother's education. School characteristics explained 4.6 percent of the variance in scores with a statistically significant contribution from school locality (4.5 percent, $p < .001$). See table 16 for between subjects ANCOVA results of math outcome.

Table 16

ANCOVA Results of Math Outcome- Tests of Between Subjects Effects

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Intercept	8642.94	1	8642.94	127.276	<.001	0.044
Age	402.63	1	402.63	5.929	.015	0.002
Mother's Education	1416.19	1	1416.19	20.855	<.001	0.007
Travel Time to School	241.35	1	241.35	3.554	.060	0.001
School Locality	8849.76	1	8849.76	130.322	<.001	0.045
MHM group	17.05	1	17.05	0.251	.616	0.000
Error	188441.69	2775	67.91			

5.5.2 English outcome

The interaction effect between time and MHM group was significant after adjusting for covariates at the individual, family, and school level, Wilks' lambda = .99, $F(1, 2803) = 7.97$, $p < .05$, partial eta squared .003. However, similar to math outcomes, there was no significant differences in English achievement scores for the MHM variable: F (1, 2803) = 3.23, p =.07, partial eta squared = .001.

Four of the covariates were significantly associated with English academic achievement: age, mother's education, travel time to school, and school locality. The remaining covariates (child health and wealth asset) provided no statistically significant unique adjustments. Individual characteristics account for .3 percent of the variance in scores, with 2.1 percent explained by mother's education at the family level. School characteristic accounted for 12.5 percent of the variance. See Table 17 for a summary of ANCOVA results.

Table 17

ANCOVA Results of English Outcome - Test of Between Subject Effects

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Intercept	7968.27	1	7968.27	134.51	<.001	0.046
Age	289.19	1	289.19	4.88	.027	0.002
Child Health	110.76	1	110.76	1.87	.172	0.001
Mother's Education	3582.84	1	3582.84	60.48	<.001	0.021
Wealth Asset	32.26	1	32.26	0.54	.461	0.000
Travel Time to School	699.72	1	699.72	11.81	.001	0.004
School Locality	23818.08	1	23818.08	402.06	<.001	0.125
MHM group	191.57	1	191.57	3.23	.072	0.001
Error	166050.66	2803	59.24			

6. Discussion

6.1 Discussion of Findings

This study examined access to MHM spaces to determine if the dimensions of individual's physical environment were associated with performance of math and English tests. The study's findings are consistent with the ecological framework that shaped the study's approach. The framework suggests that much of the potential of improving the Ethiopian girls' experiences of menstruation at school and its effect on academic achievement comes from a comprehensive consideration of a multitude of environmental resources and vulnerabilities. Using data from Young Lives' 2016-2017 school survey, the study found evidence that the availability of a private place to wash menstrual rags and/or a place for Ethiopian students to privately wash themselves in school had a significant, yet very small effect on performance on math and English tests of cognition in unadjusted analysis. However, adjusting for covariates removed the effect between MHM spaces and achievement scores that were found in unadjusted analysis. While the potential effects of MHM spaces on achievement tests in this study are small, other individual, family, and school characteristics measured in this study were found to be more important.

6.1.1 MHM spaces and academic achievement

This quantitative study assessing the effect of MHM spaces on academic achievement is significant in that it contributes to the literature regarding the benefits of providing private spaces for girls to manage menstruation in schools. While there is a growing consensus of the beneficial impact of WASH in school, MHM in schools has been a neglected public health and educational issue (Geertz, Iyer, Kasen, Mazzola, & Peterson, 2016; Sommer, Hirsch, et al., 2015). Findings of this study give prominence to this issue and reveal important new insights. Specifically, the presence of MHM spaces in Ethiopian upper primary schools were not sufficient, evident by the fact that two-thirds of students attend schools that do not provide either a space for girls to privately wash menstrual rags or a place for girls to wash themselves. A lack of MHM spaces can be explained by a lack of MHM policies in place, financial constraints, and social norms and taboos related to MHM.

Applying the ecological framework, enablers and barriers to safe, dignified MHM require consideration of interconnected factors. The Ethiopian government (exosystem level) has

taken steps to address MHM, demonstrated by National MHM guidelines currently under development, but budgetary allocation for MHM efforts and prioritization of other needs pose challenges for the implementation of these policies (Federal Democratic Republic of Ethiopia Ministry of Health, 2016). Ethiopia's geographic location creates a challenge as it is prone to droughts and a lack of infrastructure to hold water during rainfall season which effects water security (Fehr, 2011). This can contribute to MHM efforts in that offering a place for girls to wash menstrual rags would not be beneficial if water is not readily available. Additionally, given the strong presence of discriminatory social norms (macrosystem), education and awareness on MHM is needed to address social taboos and eliminate the shame and embarrassment that girls feel when they menstruate, and to also normalize the subject so that Ethiopian students do not feel uncomfortable or refrained from using school latrines because they were afraid of being seen. All things considered, the findings of this study resonate with the anecdotal and growing empirical literature of the challenges that females face in their pursuit of education at the individual, family, and school level (micro- and meso- system).

The study's finding that the presence of MHM spaces was associated with higher math and English scores, highlights the impact private spaces for girls can have on educational outcomes. Unlike previous studies which assess the association between resource provision (provision of sanitary materials and menstruation knowledge) on students' enrollment rates and absenteeism (Fehr, 2011; Grant et al., 2013; Mahon & Fernandes, 2010; Montgomery, Ryus, Dolan, Dopson, & Scott, 2012; Sommer, Ackatia-Armah, Connolly, & Smiles, 2015; UNICEF, 2011), this study examines the association between the availability of MHM spaces (private spaces) and students' test scores. The decision to examine test scores is valuable to the literature as it is an indicator of how well student may adjust and succeed in his/her environment whereas, absenteeism does not give a picture of how a student can succeed in light of his/her environment. Thus, the contribution in examining academic achievement using test scores is valuable providing a different outlook on how differing school conditions may affect school quality and effectiveness.

It is interesting to note that average mean mathematic test scores were lower than average mean English scores for students attending schools that provided and did not provide MHM spaces. Lower mathematic achievement can be explained by what Baker & Jones (1993) refer to as gender stratification, a concept which attributes opportunity structures to socialization processes that shape performance. It is argued that in collective patriarchal societies such as in

Ethiopia, "...female students, faced with less opportunity, may see mathematics as less important for their futures and they may be told so in a number of ways by teachers, parents, and friends" (Baker & Jones, 2016, p. 197). Additionally, differences in math achievement may be systematically related to attitudes towards the subject. Compared to male counterparts, Zeleke & Semel (2017) found that females scored significantly lower in self-confidence, enjoyment, motivation, and value when it comes to math attitudes, which further support gender stratification and the differences in scores seen by subject. Considering Ethiopian's cultural context, differential treatments and resources available to females in education, such as MHM spaces, may attribute to these opportunity structures.

6.1.2 Other factors associated with academic achievement

6.1.2.1. Individual characteristics

In the analysis, individual level characteristics of child health and age were expected to affect achievement scores but showed inconsistent or no associations in the sample. Students often report menstrual stomach pain as a reason of distraction or absence from school (Colclough et al., 2000; Grant et al., 2013). However, reported stomach pain in the data had no effect on achievement scores. In the study data, it is unclear whether reported stomach pains in the sample was directly related to menstrual cramps or pain. Additionally, in the context of the data, it was not possible to interpret reports of stomach pain as a constant health issue student's deal with over the course of the school year, which may negatively contribute to their school experience.

Further, the individual characteristic of age was found to significantly explain a small percent of the variance in achievement scores for math and English. Bivariate analysis showed that higher achievement scores were associated with lower age. It is possible that the role of discriminatory social norms affect decisions on schooling for older female students. For instance, it is cited that post-menarche, parents and family members often seek to control a girls' emerging sexuality and mobility as Ethiopian girls are encouraged to not leave the house in order to avoid sexual relations or encouraged to marry early, deprioritizing education (Geertz et al., 2016; Sommer, Ackatia-Armah, et al., 2015). Therefore, it is recommended that future research account for cultural practices and beliefs, as it will contribute to the holistic understanding of the effects of menstruation on educational outcomes.

6.1.2.2. Family characteristics

Achievement gaps have been consistently cited to be strongly shaped by household-level factors (Murray, 2012). In this study, it is not surprising that household level factors of parental education had an effect for both math and English achievement scores. It has been reported that children living in households headed by a person with secondary and above education, risk of school dropout substantially decreases (Admassu, 2015). While this study does not test the effect of dropouts, school dropouts may be an effect of a lack of MHM spaces. While the study's ANCOVA results do not disaggregate levels of parental education (as it only shows that mother's education has a significant effect on achievement), the study's bivariate analysis corroborates this finding.

In terms of the variable assessing household wealth, it was found that household ownership of a bicycle does not significantly explains variation in the achievement scores. This result is similar to Grant et al. (2013) study's finding which also used household ownership of a bicycle as sociodemographic control variable, but examines menstruation-related absenteeism. However, using household ownership of a bicycle may not adequately represent household wealth nor does it tell us if the students in the sample are actually using this a method of transportation to school. Other wealth measures may be of interests. For instance, a study by Woldehanna (2012) used ownership of land and animal as wealth measures in Ethiopia and reported positive effects on educational outcomes (dropouts).

6.1.2.2 *School characteristics*

Of the school-level variables, school locality significantly explained the highest variance in scores when individual, family, and school characteristics are accounted for. Mean average scores for math and English tests were lower in rural areas than urban areas. The achievement gap that exists between urban-rural divisions is not surprising and speaks for the need for the consideration of education improvement strategies. This resonates with the study by Admassu (2015) which found that primary school dropout rates were three times higher in rural areas than in urban areas in Ethiopia with girls showing higher rates than boys in rural areas. While specific conditions between rural and urban schools were not examined here, MHM problems may be exacerbated for girls attending rural schools that do not have the same level of quality and number of WASH facilities that urban schools have and improvement to school facilities may make a significant contribution to the quality of life for students. It may reduce the stress

of MHM and enhance students' ability to concentrate on schoolwork and improve achievement outcomes.

6.2 Methodological Strengths

This study has a number of strengths. First and importantly, this study begins to fill the gaps in the many areas within the literature, including exploring the effect of MHM spaces, an aspect not previously explored in quantitative studies, on achievement scores- an outcome rarely used due to a lack of achievement data. In addition, the power of the study lies in the use of a mixed between-within subjects design and the ecological approach. In a mixed design, the consideration of a repeated measure accounts for two testing points which helps to keep variability low and provides information on how groups change over the passage of time. In addition, applying the ecological approach treats the interaction between factors at different environment levels with equal importance; therefore, provides a comprehensive understanding of how multiple environmental factors influence students' achievement in school.

6.3 Methodological Limitations and Future Work

Interpretation of the results should be made with caution since the results come with several flaws due to the study design. For instance, a lack of randomization of students/schools in the MHM groups, unequal sample sizes, missing data, and operationalization of variables pose issues for the internal validity of the study. The following sections expand further on these limitations.

6.1.1 Lack of Randomization/ Nesting

The study design did not account for the randomization of students into the MHM group. Students are said to be nested within the MHM group as student were not randomly assigned to schools, which provide or do not provide MHM spaces. In this regard, students attending schools that provide MHM spaces are apt to be more alike and share similar socio-demographic characteristics than students in schools that do not provide MHM spaces. However, the study design did not account for the multilevel structure of the data due to the limitations of a 30-credit thesis. The analysis conducted for this thesis, therefore, has decreased power as the unit of analysis is the group rather than the individual (Tabachnick &

Fidell, 2013). It is recommended that future studies account for this through multilevel linear modeling analyses.

6.1.2 Unequal group size

The study's internal validity was compromised due to unequal group sizes. Unequal group sizes reflect that true differences of the dataset and to manipulate the data to equalize the differences results in a loss of generalizability (Tabachnick & Fidell, 2013). This results in unequal variances between samples, affecting statistical power and type 1 error (Tabachnick & Fidell, 2013). However, steps were taken to limit the discrepancy of sample sizes within the MHM variables by collapsing MHM groups which originally had three categories (None, 1 of 2, and 2 or 2 MHM spaces) to two categories (None vs MHM space). In doing so, this did not allow the study to differentiate if the availability of one or having both MHM spaces contributes to scores on academic achievement tests, but the findings still provide relevant and interesting insights. Additional measures were taken to handle unequal variance, such as using Welch's F test and Games-Howell pairwise comparison tests.

6.1.3 Missing data

It is important to note that data for the mother's education variable had more than 10% missing. However, missing data was handled using pairwise comparison. Handling missing data in any other way was beyond the scope of the current thesis. It is with awareness that there are better options for handling variables with substantial proportions missing as the impact of missing data can bias estimates of parameters, decreases statistical power, increase standard errors, and weaken generalizability of findings (Dong & Peng, 2013).

6.1.4 Operationalization of variables

The operationalization of variables in this study was limited to variables in the Young Lives 2016-2017 school survey. The dataset lacked actual menstruation data and, therefore, the study relied on a proxy measure of menstruation using age as an indication of whether a girl has begun puberty. However, to account for this the study used the average age of menstruation in Ethiopia reported in the literature (Zegeye et al., 2009). Additionally, stomach pains for child health and ownership of a bike for household wealth as proxy measures does not accurately capture the reality of the Ethiopian students' experiences as it is theorized to relate to MHM. Therefore, the findings in this study is only generalizable to a hypothetical

population. It is recommended that future studies collect specific menstrual data similar to Grant et al. (2013).

Additionally, the use of observational data of school facilities results in a potential for unmeasured confounding variables. For instance, measuring the availability of MHM spaces does not provide a complete picture of how MHM spaces relate to menstruation during the course of a school year as it does not take into account for the actual condition or use of spaces. The reported challenges girls face within the school environment are identified in the literature as both physical and social, in addition to gender discriminatory. Sommer, Ackatia-Armah, et al. (2015) have reported that while latrines are provided in Ethiopian schools, they are often found to be unclean and inadequate, lacking doors and locks, with some schools limiting access to water on select times of the day. Additionally, girls describe the challenges of boys utilizing their latrines, limiting their own access, indicative of a reinforcement of societal gendered power dynamics within schools (Sommer, Ackatia-Armah, et al., 2015). This study does not account for this due to the availability of data in the Young Lives school survey. Thus, future research should take into consideration the challenges girls may face regarding quality of school-based MHM spaces to understand and identify interventions at the peer, family, school, and policy level.

6.4 Implication for Health Promotion and Development

Despite the limitations of the study, the literature and findings from this study provide insights into the complexity of the problems girls face when they begin menstruating. The issues related to local cultural practices and broader social-economic constraints pose significant challenges for health promotion and require an integrated ecological approach that can be used to empower both families and communities to advocate for the changes needed for the adoption of safe MHM and advocacy for MHM spaces in schools. It is then that girls' educational experience can improve and strides in can be made in achieving the sustainable development goals set by the United Nations. Moreover, the Ottawa Charter states that improvement to health requires ensuring that prerequisites of health are met and cannot be ensured by the health sector alone (WHO, 1986). It requires coordinated action by all concerned, emphasizing the importance of integrated efforts between multiple settings.

The literature and the finding of this study has demonstrated that issues around menstruation are not adequately addressed or recognized, which leads to negative implications for girls' health and education. In order to address sensitive issues such as MHM an approach that is mindful and respectful of community beliefs is needed. This will inevitably require time and a foundation of trust and respect between community members and health promoters in order to create dialogue addressing MHM. Secondly, collaboration between national and local government is needed in order to build infrastructure needed to create supportive environment for health. This includes creating intersectoral policies and programs to not just address financial and poverty reduction measures and the provision of MHM spaces, but to improve water and sanitation in schools and in the community. Finally, menstrual awareness interventions, not just for females but for males, is needed in order to destigmatize and eliminate the taboo around menstruation. However, this would only be effective if the broader determinants defined above were addressed (Lahme, Stern, & Cooper, 2018).

6.5 Conclusion

The benefits between girls' education and key public health and economic measures have become increasing evident over the last decade, with governments, donors, and private sectors focusing attention to menstruation as a potential barrier to educational achievement (Sommer et al., 2016). Despite growing initiatives to improve WASH in school and its impact on girls' attendance and dropouts, this is the first known study to examine MHM spaces and its impact on academic achievement. In light of some methodological limitations, this study found that in unadjusted analysis, attending schools that provide MHM spaces has a greater impact on students' achievement test scores compared to attending schools that did not provide MHM spaces. Though an important first step, this study's finding suggest that providing MHM spaces does not, on its own, enable education for girls to fulfill its transformative potential. Educational gaps related to location, wealth and parental education are shown to have a stronger impact on children's education trajectories. Overall, the findings suggest the importance of applying the ecological model to address the challenges of menstruation for girls in order to improve academic achievement. However, it is recommended that future studies build on the findings of this study by consideration of multilevel linear modeling, using a more precise sample of menstruating girls, and collecting actual MHM data including information on quality of school sanitation facilities.

To conclude, the potential for improving the Ethiopian girls' experiences of menstruation in school will require comprehensive interventions that operate on various levels indicated in this study and the literature. This includes increasing girls' knowledge and changing attitudes and behavior towards MHM, family and community support, improved/provision of sanitation/MHM spaces in school, and policy implementation. While the effect of MHM spaces on academic achievement requires further research, it is without doubt that incorporating MHM spaces in school has the potential to promote positive development and healthy behaviors that moves beyond disease prevention to enabling students to improve their physical and mental capacities. It is then that girls can feel empowered as they transition to womanhood.

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8. Appendix

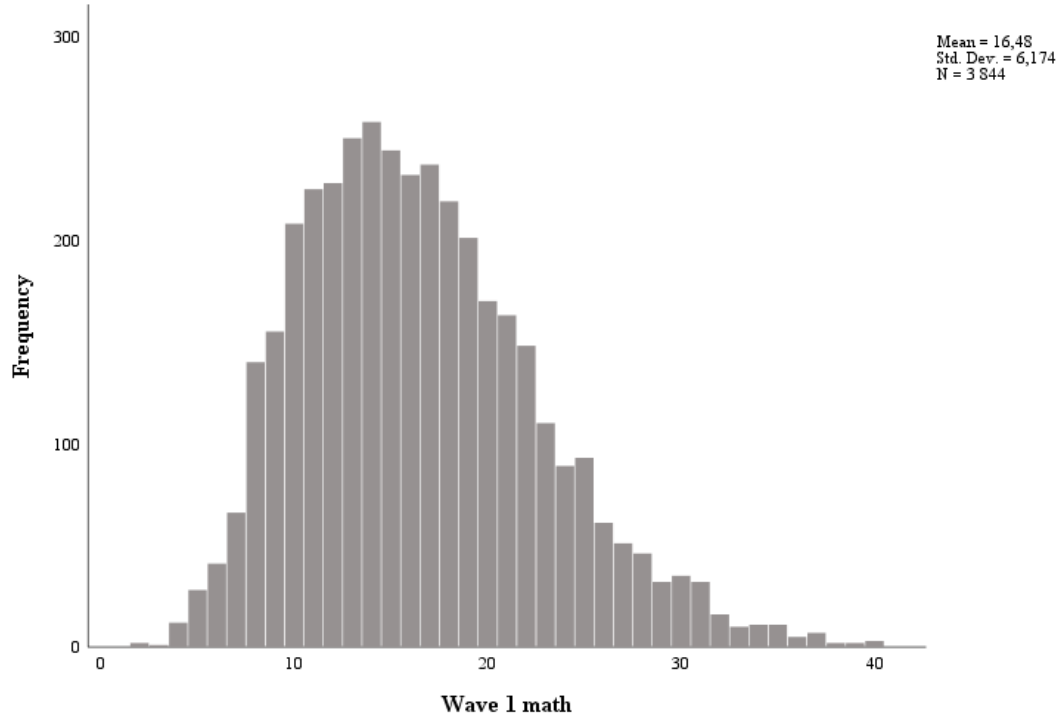

Figure 2. Distribution of scores for Wave 1 math achievement test

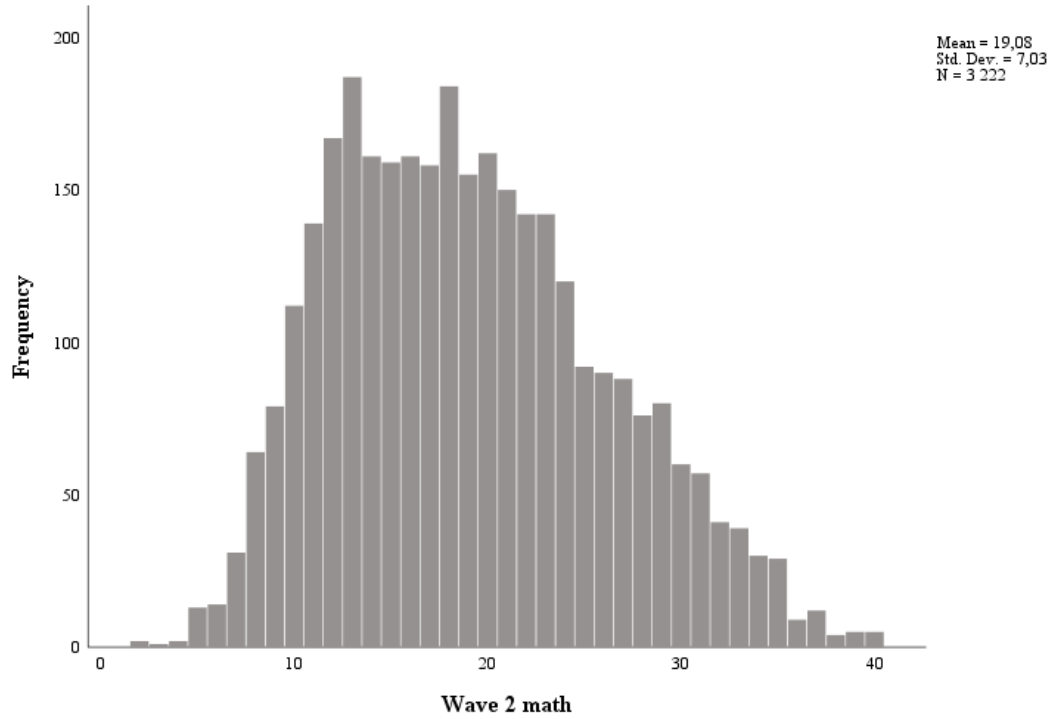

Figure 3. Distribution of scores for Wave 2 math achievement test

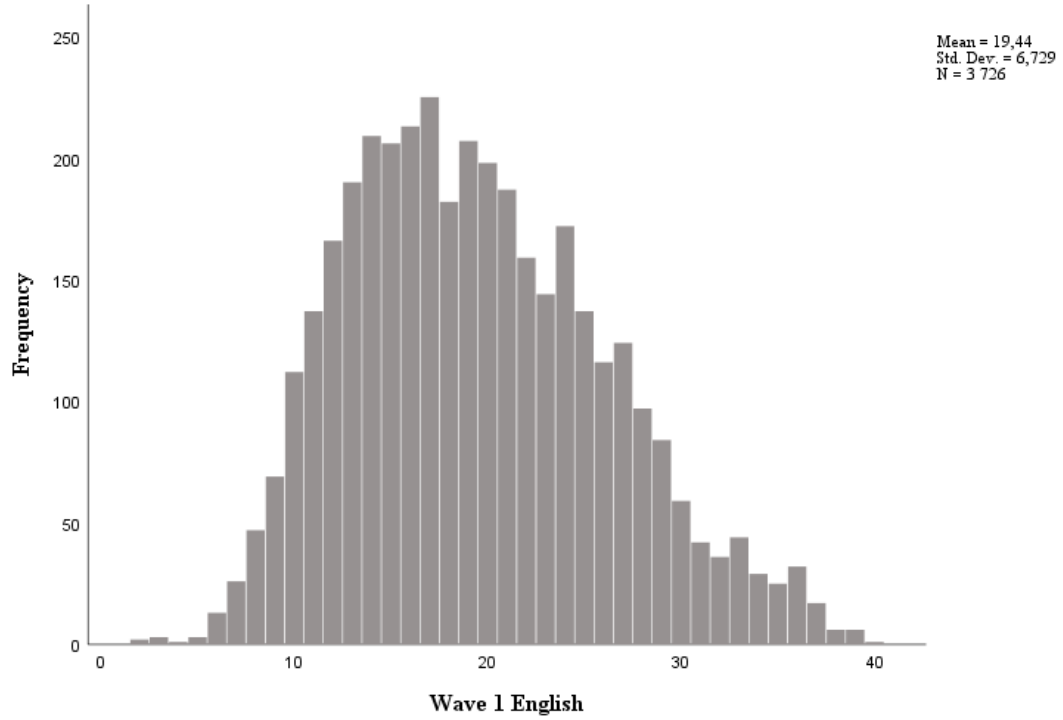

Figure 4. Distribution of scores for Wave 1 English achievement test

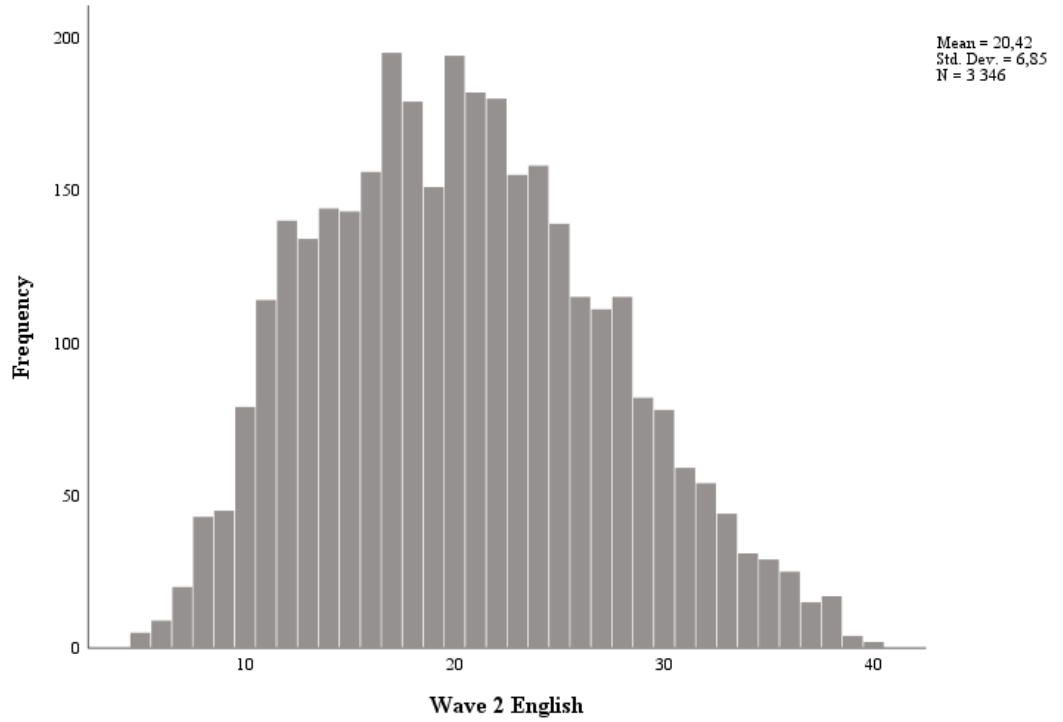

Figure 5. Distribution of scores for Wave 2 English achievement test