Optimizing community health workers and non-biomedical approaches to assess the burden of soil-transmitted helminthiasis in a school-aged population in rural Rwanda

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Abstract

Background:

Soil-transmitted helminths (STHs) remain a major public health problem in many low- and middle-income countries, especially among children. The conventional methods for diagnosing STHs require well-equipped laboratories and trained personnel, often scarce or inaccessible in rural and remote settings. Algorithmic non-biomedical screening tools are a potential strategy for CHWs to ensure rapid detection and referral of children with possible STH infection. We aimed to evaluate the feasibility of a community health worker-led screening program in rural Rwanda. We also sought to describe the *Knot*, a model leveraging community health workers (CHWs) as school-based health agents (SBHAs) to facilitate the screening, referral, and follow-up of children with presumptive STH, as well as the engagement of teachers and community members in preventive interventions.

Methods:

We conducted a cross-sectional study among 746 school-aged children in Musanze district, Rwanda, between August 2021 and November 2022. We used Beta CommScreen, an algorithmic non-biomedical screening tool that collects socio-demographic, anthropometric, and symptomatic data, as well as water, sanitation, and hygiene (WASH) indicators, to assess the risk of STH infection. The SBHAs engaged teachers and community members in developing a bundle of interventions, such as deworming campaigns, WASH education, and targeted home visits. We used multivariate logistic regression analysis to identify factors associated with presumptive STH infection. We analyzed the data using Stata version 15.1.

Results:

Of 746 children screened by the SBHA, 322 (43%) reported signs of STH infections, and 220 (29%) were referred to the clinic for treatment, the rest of children (102, 14%) were provided with deworming medication at school. Having a CHW for routine monitoring and not walking barefoot were associated with lower risk of STH symptoms (OR = 0.36, 95% CI: 0.21,0.64) and (OR = 0.49, 95% CI:0.08,3.11), respectively. Not washing hands before eating and after using the toilet were not significantly associated with possible STH infections (OR = 7.40, 95%CI:0.79,68.94) and (OR = 3.82, 95%CI:0.37,39.37). Other factors, including the place of residence and age, were also not associated with STH symptoms.

Conclusions:

We found the CHWs were able to use a simple algorithmic screening tool to identify a high burden of symptoms of possible STH. This CHW-based approach to carry out school-based screening of STH infections builds on the strong CHW system in Rwanda, although strengthening referrals to ensure all symptomatic children receive treatment is needed. Strengthening the connection between schools and community-based health services can further expand disease prevention and treatment, furthering Rwanda's success in improving health and wellbeing.

Background

Globally, 1.5 billion people, or 24% of the world's population, suffer from intestinal infections due to soil-transmitted helminths (STHs), considered a neglected tropical disease (NTD) that disproportionately impacts low- and middle-income countries (LMICs)[1]. Each year, over 135,000 people die due to these infections. Approximately 1.9 million years lived with disability are attributable to soil-transmitted helminths[2]. The three most common parasitic worms include *Ascaris lumbricoides* (Ascaris), *Ancylostoma duodenale* (hookworm), *Necator americanus* (hookworm), and *Trichuris trichiura* (whipworm)[3]. The signs and symptoms of these parasitic infections vary from itching and localized rashes when the larvae penetrate the skin to abdominal pain, diarrhea, and weight loss[4].

In LMICs, parasitic worms are often responsible for acute and chronic malnutrition among school-aged children[5]. Their long-term impact includes developmental and cognitive impairment, resulting in poor school performance and overall quality of life[6]. Previous studies have demonstrated an association between STHs and malnutrition. In Rwanda, where 33% of children are stunted, STHs represent a significant health challenge[7]. *Ascaris lumbricoides*, *Trichuris trichiura*, and *A. duodenale* (hookworm) are the most prevalent STHs in the country[8].

While the epidemiological distribution of STHs in Rwanda varies, higher rates are often observed in rural areas where access to clean water and sanitation facilities is limited. The prevalence of STHs was exceptionally high at 40–60% in districts with poor socioeconomic status and inadequate hygiene practices[9–10]. The previous nationwide survey had reported that over 50% of primary school children were infected with one or more species of intestinal worms. Ascariasis and whipworm were found to be the most prevalent[11].

Barriers to STH detection among children in rural and remote regions

Biomedical approaches such as the Kato-Katz method, which uses microscopic fecal smears to identify the eggs, remain the most used test for clinical diagnosis and assessing the prevalence of STHs[8, 11]. All biomedical approaches require well-equipped laboratories and highly trained personnel. However, accessing this test requires visiting health centers that are often inaccessible in rural and remote settings or present other access issues. Further, several studies reported the failure of the Kato-Katz method to detect hookworm, mainly due to the rapid degeneration of the eggs, which increases the risk of reporting false negative results and hinders the timely initiation of the treatment[12]. Khurana *et al.* described the most recent advances, including more sensitive molecular diagnostics, quantitative polymerase chain reaction (qPCR), and loop-mediated amplification assay, which maximize the level of precision in detecting STHs. However, such advanced techniques are unavailable or inaccessible in rural and remote communities[13].

While performing laboratory work using the Kato-Katz method or sophisticated techniques remains the most recommended approach to diagnose STHs, little is known about the feasibility of using signs and symptoms as a basis for routine screening of STHs in highly endemic and rural regions. The World Health Organization (WHO) has defined standard signs and symptoms associated with STH infections including diarrhea and abdominal pain, malnutrition, impaired growth and physical development.[14]

Leveraging community health workers and algorithmic approach for STH case detection

To assess the prevalence of STHs in rural Rwanda, Move Up Global designed Beta ComScreen, a tablet-based CommCare application used by community health workers. Beta ComScreen is an algorithmic symptomatic screening tool developed based on the WHO's guideline on prevention and control of intestinal parasitic infections. The Beta ComScreen can be found as Supplementary Table S1. While teachers and other school-based personnel are often the first to identify preventable conditions among students and families, they are often limited by the health workforce shortage or lack of linkage between schools and local health facilities.

To address the need for healthcare workers to carry out screening, Move Up Global designed the Knot (Ipfundo) model, which equips CHWs to serve as liaisons between schools and local health facilities (Fig. 1). The Knot model is based on the premise that schools can serve as potential hubs for sparking change and improving community outcomes. A Community Advisory Council composed by the representatives of parents, teachers, and community health workers was established to inform all components of the Knot framework.

We also sought to assess the feasibility and acceptability of a community health worker-led screening program in rural Rwanda. We also determined the prevalence of possible STH infections among screened school-aged children using a novel algorithmic-based screening tool. We also described a novel approach (the Knot) that leverages CHWs as SBHA to facilitate the screening, referral, and follow-up of children with STH symptoms, as well as the engagement of teachers and community members in preventive interventions.

Methods

Study setting

This study was conducted at Nyabirehe Primary School, located in Musanze district, one of the five districts in the Northern Province of Rwanda. Musanze is the most populated district, with 476,522 residents in 2022. About 57% of the resident population of Musanze is under 25 years old[15]. The population aged 17 and under represent 43% of the district's total population, 16-30 years represents 29%, and the working-age population 16 years and above represent 61.5 % of the same population. The majority of the study population lives under the poverty line. The primary sources of income are agriculture and tourism, as the district is home to the Volcanoes National Park and the famous mountain gorillas[16].

Like other Rwandan districts, Musanze's school system operates on a 6-3-3-4 system: six years of primary school, three years of lower secondary school, three years of upper secondary school, and four years of university bachelor's degree[17]. The official languages of instruction are Kinyarwanda in primary school (P1-P3) and English from 4th year in primary (P4) through university. In public primary and secondary schools, French and Swahili are taught as elective or supplementary subjects.

Nyabirehe Primary School is one of the public schools that offer preschool to 9th-grade education. It is staffed by 25 teachers with high school certificates known as A2 level. The school has an enrollment of 1,229 students, of which approximately 6% are still in pre-school. The school follows the national curriculum and uses English as the language of instruction from P4 onwards.

Rwanda's School Health Profile

The government of Rwanda has developed a national school health policy and a strategic plan to promote the health and well-being of students and teachers in schools. The policy emphasizes the need for inter-sectoral collaboration among various ministries, agencies, partners, and stakeholders to ensure effective implementation and monitoring of school health activities. The major components of Rwanda's school health programs include 1) health education, covering various topics such as hygiene, nutrition, HIV/AIDS prevention, sexual and reproductive health, and gender equality 2) school health services such as periodic deworming and screening for malnutrition, 3) school feeding, 4) physical environment of schools to make them safe, healthy and conducive for learning, and 5) ensuring that schools are free from violence, abuse, harassment, and discrimination[18].

Currently, the national school health policy does not integrate CHWs. At Move Up Global-supported schools, SBHAs serve as an interface between local health facilities and schools. In addition to screening students for STH infections, SBHAs provide first aid, psychosocial support, and health education to students and their families. The National School Health Strategic Plan acknowledges the lack of a dedicated school nurse or health worker, the weak coordination and collaboration among stakeholders, the insufficient resources and capacity, and the low awareness and participation of students and parents in school health activities.

To ensure the timely identification of children with signs of STH infections, we implemented the following components of the Knot model, which consists of the following:

- Select, orient, and appoint existing CHWs as school-based health agents (SBHAs) who systematically screen malnutrition, NTDs, and other conditions affecting education and overall health outcomes.
- The SBHAs serve as an interface between schools, health facilities, and communities. They facilitate referrals, counter referrals, and follow-ups for children with signs of STH infection.
- SBHAs ensure the proactive engagement of teachers and other community members in designing and validating bundled interventions to address STH infections.
- SBHAs provide students with practical skills through simulations or real case reviews to build competencies to detect signs and risk factors of STH infections.
- SBHAs facilitate referrals to the nearest health facilities and collaborate with the existing public health system to prevent and treat NTDs, malnutrition, and other poverty-related conditions. SBHA addresses the common public health needs by providing teachers and students with the necessary skills, tools, and support to implement effective school health interventions. They also enhance the participation and engagement of students and parents in their own health and well-being through school-based health education sessions and home visits. SBHAs use hands-on skills building approaches including simulations and case scenarios.

Streamlining school-based screening and referral pathways

SBHAs screen students for NTDs and malnutrition using the Beta ComScreen at the schools. They also provide children with Albendazole 400mg twice a year to prevent STH infections. If the child is identified as having severe signs of STH infection, they are referred to the local primary care center for consideration for deworming medication (primarily Albendazole), which is free. In addition, SBHA coordinated with parents to arrange a visit to the local health post or center to have a complete check-up. The SBHA conducts a home visit a few weeks after the initial screening to ensure treatment is received if the child is improving, and if there is anything else the child or the family needs to support and maintain the child's health. Further, SBHA checked if the community-wide mass drug administration (MDA) had occurred and liaised with community health nurses from the nearest health center nurses to organize an MDA campaign. During routine screening, SBHA confirmed that the children and their siblings had received deworming medications as recommended.

The SBHA also brings health education materials to describe the best prevention methods for NTDs (for example, water treatment interventions) and leaves informational packets at the household. Fig. 2 illustrates the pathway the SBHA uses to effectively evaluate and refer children with signs of STHs (Figure 2).

In addition to performing systematic screening and administering deworming medications, the SBHA provides hands-on health education and helps families improve hygiene and sanitation during their home visits. This includes using and cleaning toilets and the basics of water treatment, including water chlorination.

To avoid disruption of their routine activities as CHWs, SBHAs visit to schools before and after carrying out their existing community-based health interventions. During holidays, SBHAs increase their home visits to follow up on children identified with signs of STHs and intensify community-based health education. A community advisory board, composed of the representatives of parents, school administration, and community representatives, decides the SBHA's stipend covered by the local implementation partner. The advisory committee also reviews and provides feedback on the SBHA's priorities.

Data collection

A school-based screening was initiated as a strategy to identify and refer children with STH infections. An existing CHW with over five years of experience in integrated community-based case management was selected and trained to use BetaComScreen to screen children for Ascaris, whipworm, and hookworm. All children were invited to visit the SBHA's office for routine screening of STH infections.

The screening consisted of collecting socio-demographic data, anthropometric measurements (weight, height), and self-reported symptoms of STH infections (pain, itching, diarrhea, vomiting, fatigue, etc.) within the last 72 hours or presently. Community health workers also assessed the availability and use of water, sanitation, and hygiene (WASH) facilities and practices at home and school (soap, toilet, handwashing, footwear, etc.). We defined possible STH as the presence of at least five signs of STH infection at the time of screening or within 72 hours before the screening. Using a tablet-based version of the BetaComScreen, the SBHA screened children for STH infections. With the guidance from the community health nurse, the SBHA administered Albendazole tablets to children with at least five symptoms of STH infections. Children with STH symptoms lasting more than three days after taking Albendazole were referred to the local health center for further investigations. All children received health education and counseling from the SBHA.
A total of 746 students were screened between August 2021 and November 2022. The data was securely stored on the tablets and uploaded to a CommCare cloud server after each screening session.

Ethics approval and consent to participate

The Rwanda National Ethics Committee approved this study (N°302/RNEC/2022). We obtained informed consent from the parents or guardians of the students and permission from the students themselves before screening. Names and other personal identifiers were excluded from datasets extracted for the analyses.

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Data analysis

We analyzed the data using Stata version 15.1 (College Station, TX). We performed descriptive statistics to summarize the characteristics of the study population and the prevalence of STH infections. We performed bivariate analysis to examine the association between each independent variable and the outcome variable (STH, defined as self-reported symptoms STHs). We used chi-square tests for categorical variables and t-tests for continuous variables.

We performed multivariate logistic regression analysis to identify the predictors of reporting signs of possible STH. We included all the variables that were significant in the bivariate analysis. We checked for collinearity among the predictor variables. In covariates identified as strongly collinear using Pearson's correlation test (r >0.8), the variable more strongly correlated with the possible STH variable was retained. We used the manual backward elimination method to remove the variables that were not significant in the multivariate model. A p-value < 0.05 was considered statistically significant for model building. We reported the odds ratios (ORs), p-values, and 95% confidence intervals (CIs).

Results

Overall, 746 children participated in the study; 307 (41%) were under seven, 372 (50%) were between 8 and 14, and 67 (9%) were over 15 years old (Table 1). Almost one-half (322, 43%) of the children who participated in this study reported symptoms of STH infection. A total of 220 (29%) were referred to the clinic for treatment. The rest of the children (102, 14%) were provided with deworming medication at school. Bivariate analysis reported several factors associated with symptoms, including walking barefoot (p<0.001), not having soap at home (p<0.001), not washing hands before eating (<0.001), and not washing hands after using the toilet (p<0.001). Other factors, including the place of residence and age, were not associated with STH symptoms (p=0.29) and (p=0.38), respectively.

Table 1. Bivariate relationships between demographic characteristics and possible STH infection.

Characteristics	N	%	OR	95%CI	P-Value
Age group					0.860
< 7 years old	307	41	1.00		
8-14	372	50	1.08	[0.79,1.46]	
15-21	67	9	1.12	[0.66,1.90]	
Residence					0.671
Remote villages	28	4	1.00		
Local villages	718	96	1.18	[0.55,2.56]	
BMI					0.640
≤18.5	444	60	1.00		
>18.5	301	40	0.93	[0.69,1.25]	
Walking barefoot					<0.001
No	66	8.85	1.00		
Yes	680	91.15	13.62	[4.90,37.85]	
Bar soap at home					<0.001
Yes	60	8.04	1.00		
No	686	91.96	25.36	[6.14,104.64]	
Handwashing before eating					<0.001
Yes	67	8.98	1.00		
No	679	91.02	28.96	[7.04,119.26]	
Handwashing after using toilet					<0.001
Yes	67	9	1.00		
No	679	91	28.97	[7.04,119.26]	
Recent sickness					0.457
No	417	56	1.00		
Yes	329	44	1.12	[0.83,1.50]	
Ascariasis					<0.001
No	520	70	1.00		
Yes	226	30	3.02	[2.19,4.18]	
Hookworm					<0.001
No	649	87	1.00		
Yes	97	13	2.28	[1.47,3.53]	
Whipworm					0.003
No	726	97.32	1.00		
Yes	20	2.68	4.09	[1.47,11.39]	
Referred to the clinic					<0.001
No	526	70.51	1.00		
Yes	220	29.49	3.81	[2.73,5.31]	
Under CHW monitoring					<0.001
No	338	45.31	1.00		
Yes	408	54.69	0.27	[0.20,0.36]	

In the multivariate analysis, most of the factors remained significantly associated with a positive screen on the app: Having a CHW for routine monitoring and not walking barefoot were associated with lower risk of STH symptoms (OR=0.36, 95% CI: 0.21,0.64) and (OR=0.49, 95% CI:0.08,3.11), respectively. Not washing hands before eating and after using the toilet were no longer had a statistically significant association with possible STH infections (OR=7.40, 95%CI:0.79,68.94) and (OR=3.82, 95%CI:0.37,39.37). Other factors, including the place of residence and age, were also not associated with STH symptoms. (Table 2).

Table 2. Multivariate logistic regression model with odds ratios, P-value, and confidence intervals for children with possible STH infection.

Characteristics	OR	P-Value	95%CI
Age			
<7 years old	1.00		
8-14	1.23	0.235	[0.87,1.75]
	1.37	0.303	[0.75,2.52]
Under CHW monitoring			
No	1.00		
Yes	0.36	<0.001	[0.21,0.64]
Walking barefoot			
No	1.00		
Yes	0.49	0.450	[0.08,3.11]
Bar soap at home	1.00		
Yes	1.00		
No	5.41	0.080	[0.82,35.72]
Handwashing before eating			
Yes	1.00		
No	7.40	0.079	[0.79,68.94]
Handwashing after using toilet			
Yes	1.00		
No	3.82	0.260	[0.37,39.37]
Ascariasis			
No	1.00		
Yes	2.06	0.006	[1.24,3.43]
Hookworm	1.00		
No	2.47	0.001	[1.42, 4.29]
Yes			
Whipworm			
No	1.00		
Yes	3.36	0.050	[1.00,11.29]
Referred to the clinic			
No	1.00		
Yes	1.02	0.933	[0.58,1.81]

Discussion

We found that CHWs could use a simple digital-based algorithm to screen school children for symptoms suggestive of STH. This study's findings suggest using an algorithmic non-biomedical screening tool as a practical approach for CHWs to carry out routine STH screening in highly endemic regions to identify children who need further assessment for treatment.

As such, instead of collecting stool samples and analyzing them in a lab, training CHWs and screening children at schools enabled an accessible option to identify children with signs of STH infection. Furthermore, CHW-led screening enhances community awareness of public health challenges and messaging. This approach also promotes ownership and community empowerment. Although bi-annual MDA campaigns are recommended, the health center's outreaches to schools remain irregular. SBHAs liaise with local health centers to follow up on MDA implementation plans and provide support with school-based distribution.

To avoid disruption of their regular work as CHWs, SBHAs were asked to present to the school before or after completing the community-based assignments. This facilitated a proactive identification of children with signs of STHs or children whose families need particular attention.

As many countries explore strategies to improve universal health coverage, leveraging schools and CHW-led screening could accelerate the pace toward eliminating STHs and other conditions that affect health and overall quality of life. For example, CHWs can have school rotations, be available to children needing screening and medications, and facilitate referral to a local health facility. This model can also build confidence between the local community and public health systems.

The CHW training and the provision of standardized screening tools have been critical in ensuring high-quality and consistent screening. Prior relationships with the community and CHW experience enabled the implementation of this study as the SBHA was a member of the community. Previous studies have reported Rwanda's success with CHW-led interventions to improve community case management of childhood illness. [19,20] In developed countries, recent studies highlighted the role of CHWs in school-based interventions for children.[21, 22]

Almost half of the study's population reported signs of STH infection, which increased the need to visit the clinic, decreasing their time in class. The results of this study are consistent with those of previous studies that reported a high prevalence of STH infections[23,24]. This puts a burden on families and weighs on teachers who have to coordinate students' visits to the clinic. Donkoh *et al.* found that children at the schools were negatively impacted by STHs[25]. Our study's findings suggest the importance of better strategies for preventing and identifying infections with intestinal worms among school-aged populations.

This study's findings are consistent with other studies that reported high rates of STH infections in resource-limited settings[7,11]. Our findings are similar to prior studies that assessed geographical distributions of STH infections and their risk factors in Rwanda. For example, in a recent population survey in North-Western regions of Rwanda, Ruberanziza, E *et al.* found that *Ascaris lumbricoides and Trichuris trichiura* were the most prevalent STH parasite, 37% and 23%, respectively[7]. Kabatende J *et al.* reported that prevalence of STH infections among school children was 77.7%. The most prevalent were *Trichirus trichiura* (66.8%), *Ascaris lumbricoides* (49.9%), and hookworms (1.9%)[11].

Unsurprisingly, children who did not wash hands before eating or after using toilets were more likely to have symptoms of STH infection. This could be related to the fact that most people in the study area have minimal clean water access. Most of the population surrounding the Volcanoes National Park uses untreated rain, streams, or ponds. Not washing their hands, cleaning food, or showering with clean water may have exposed them to STH infections.

Given the multifaceted contribution of social, economic, and demographic factors, STH elimination will require a holistic consideration of health determinants, including innovations to break the cycle of poverty and diseases, especially in rural and remote regions.

This study has a number of limitations. First, we relied on self-reported symptoms from children with no further diagnostic processes to determine possible infection. However, the assessment tool was based on WHO's diagnostic guidelines and protocols[1]. Studies are needed to determine the sensitivity and specificity of the algorithm in this and other populations.

Conclusion

In resource-limited settings where human resources for health remain a pressing challenge, CHWs constitute a promising workforce to implement a school-based screening of childhood illnesses and eliminate STH infections and other life-threatening conditions. However, their success depends on practical and easy-to-use screening tools, training and mentorship, and a strong problem-solving system.

Community-defined and driven interventions are critical to accelerate the pace toward achieving Universal Health Coverage targets. As per the Knot model, enhancing the linkage between schools and communities can expand the scope of work of the CHWs and promote the prevention of STH infection and timely detection and referral of children with signs of STHs. SBHAs are well-placed to carry out family-centered interventions on health education, surveillance, and disease prevention.

Further studies are underway to investigate the impact of implementing the Knot model and SBHA-driven interventions on health, academic performance, and overall quality of life. Further studies are needed to assess the cost-effectiveness of such a model and draw policy recommendations.

Abbreviations

CHW: Community Health Workers

SBHAs: School-Based Health Agents

NTDs: Neglected Tropical Diseases

WHO: World Health Organization

STH: Soil-transmitted Helminths

Declarations

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Authors' contributions

AM conceived the study. JN and ON collected the data. AM, BK, and DN participated in the data analysis and interpretation. AM, BK, NE, DN, JN, ON, and LH participated in the manuscript preparation. All authors read and approved the final manuscript.

Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of interest

Authors declare no conflict of interest.

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Competing interests

The authors declare that they have no competing interests.

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Figures

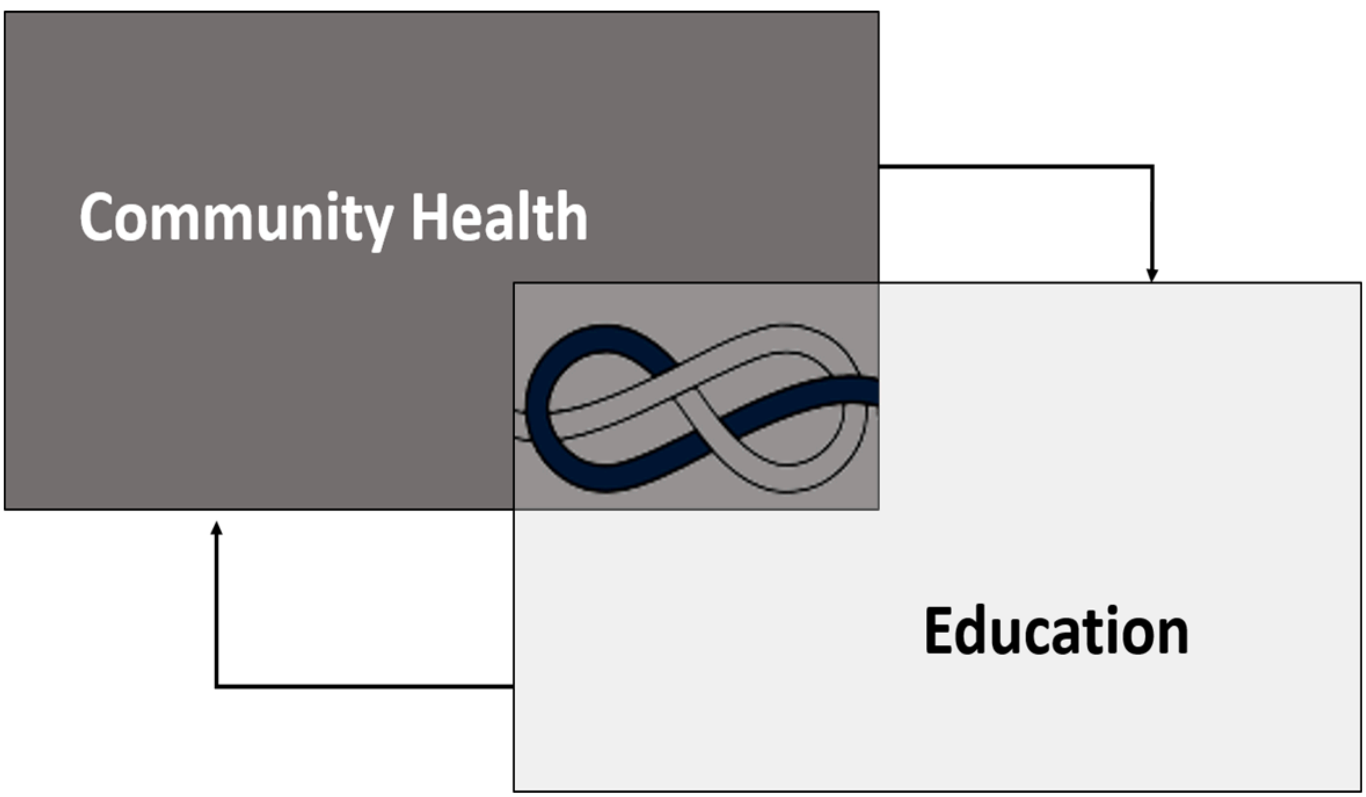

Figure 1

Legend not included with this version.

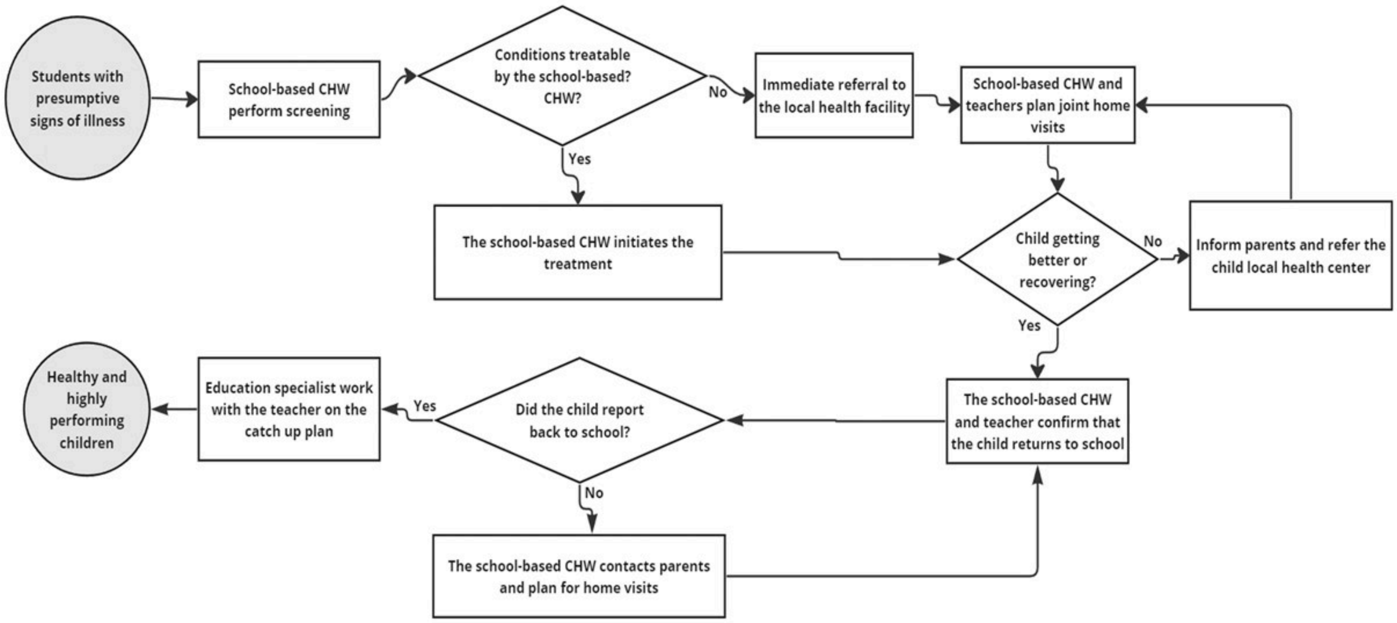

Figure 2

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