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Effects of the Informed Health Choices secondary school intervention: A prospective meta-analysis

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Abstract

Aim: The aim of this prospective meta-analysis was to synthesize the results of three cluster-randomized trials of an intervention designed to teach lower-secondary school students (age 14–16) to think critically about health choices.

Methods: We conducted the trials in Kenya, Rwanda, and Uganda. The intervention included a 2- to 3-day teacher training workshop, digital resources, and ten 40-min lessons. The lessons focused on nine key concepts. We did not intervene in control schools. The primary outcome was a passing score on a test (≥9 of 18 multiple-choice questions answered correctly). We performed random effects meta-analyses to estimate the overall adjusted odds ratios. Secondary outcomes included effects of the intervention on teachers.

Results: Altogether, 244 schools (11,344 students) took part in the three trials. The overall adjusted odds ratio was 5.5 (95% CI: 3.0–10.2; $p < 0.0001$) in favor of the intervention (high certainty evidence). This corresponds to 33% (95% CI: 25–40%) more students in the intervention schools passing the test. Overall, 3397 (58%) of 5846 students in intervention schools had a passing score. The overall adjusted odds ratio for teachers was 13.7(95% CI: 4.6–40.4; $p < 0.0001$), corresponding to 32% (95% CI: 6%–57%) more teachers in the intervention schools passing the test (moderate certainty evidence). Overall, 118 (97%) of 122 teachers in intervention schools had a passing score.

Conclusions: The intervention led to a large improvement in the ability of students and teachers to think critically about health choices, but 42% of students in the intervention schools did not achieve a passing score.

Faith Chesire, Michael Mugisha, and Ronald Ssenyonga contributed equally.

KEYWORDS
adolescents, critical health literacy, critical thinking, health education, individual participant-level data meta-analysis, prospective meta-analysis, secondary school

1 | INTRODUCTION

There is a massive amount of health information online, in addition to information disseminated through other channels of communication. Much of it is misinformation.[1,2] This problem was exacerbated by the COVID-19 pandemic, which was accompanied by an "infodemic"—an overload of information including false or misleading information.[3] In the context of health, the skills people need to decide what to believe or do are sometimes referred to as critical health literacy.[4,5] Although both critical thinking and health are widely included in primary and secondary school curricula,[6–8] critical thinking about health or critical health literacy is not—at least not in Kenya, Rwanda, Uganda, and Norway.[9–12]

Many people find it difficult to make decisions about what to believe or do regarding "health actions" (things they can do to care for their health or the health of others). Being able to understand and apply basic principles or concepts is essential for using reliable information appropriately and avoiding being misled by unreliable information. This includes concepts regarding claims, comparisons (research evidence), and choices (Table S1).[13]

Until now, few educational interventions to improve people's understanding and use of such concepts have been rigorously evaluated.[14–16] To help address this gap, we developed educational resources to teach some of these concepts in lower-secondary schools.[17] We started by prioritizing nine concepts (Table 1),[18] and analyzing the context in which the resources will be used in three countries: Kenya, Rwanda, and Uganda.[9–11]

We developed the *Be Smart about Your Health* resources using human-centered design—an iterative process of idea generation, prototyping, feedback and observation, and improvements.[17] We did this collaboratively with teachers, students, and curriculum developers in all three countries. The resources were digital to minimize printing and distribution costs. We designed the resources for use in settings with minimal information and communication technology (ICT) infrastructure and unstable Internet connectivity and electricity. They are usable online and downloadable. Teachers can access and use them via a web browser on a smartphone or computer. There are two versions of each lesson plan: a projector version for classrooms with a projector, and a blackboard version for classrooms with only a blackboard, whiteboard, or flipchart. The resources are freely available.[19]

Randomized trials to evaluate the effects of the IHC secondary school intervention in each country used a common set of outcome measures. The aim of this prospective meta-analysis was to synthesize the findings of the three trials. Our objective was to estimate the effects of the IHC secondary school intervention—compared to no intervention (the standard curriculum in the context where each trial was conducted)—on the ability of students and teachers to think critically about health choices. Process evaluations are ongoing,[20–22] and 1-year follow-up studies are planned in each country.[23–25]

2 | METHODS

2.1 | Study design

This was a prospective meta-analysis. The studies were included, and hypotheses and analysis strategies were specified before any results were known.[26] The three randomized trials that were included were planned collaboratively to ensure a common set of outcome measures and the availability of data to conduct the analyses using individual participant data.[23–25] Each trial was conducted in a different country (Kenya, Rwanda, and Uganda).

Prospective meta-analyses are like a large multicenter trial.[26] The advantage of a prospective meta-analysis is the ability to design, report, and interpret the results of each trial in the context of the country where it was conducted. As described below, there were important differences between the three countries. At the same time, collaboration on the design of the trials enabled investigation of potential effect modifiers, as well as estimating overall effects across the three trials.

2.2 | Data sources and inclusion criteria

The eligibility criteria for this meta-analysis are shown in Table S2. Because the intervention was not yet available to other investigators, it was not necessary to search for other studies.

2.3 | Study settings

Context analyses included detailed descriptions of the three trial settings.[9–11] The settings are summarized in Box 1. Critical thinking about health was not explicitly included in the secondary school curriculum and was not being taught in any of the three countries, and resources for teaching critical thinking about health were unavailable.

2.4 | Participant characteristics

In each trial, schools were randomly selected and randomly allocated 1:1 to the intervention or a comparison group using block stratified random sequences. Table S3 summarizes the eligibility criteria for schools, teachers, and students and the stratification variables for each of the trials.

TABLE 1 Participant characteristics.

School		Control schools 122	Intervention schools 122
Country			
	Kenya	40 (32.8%)	40 (32.8%)
	Rwanda	42 (34.4%)	42 (34.4%)
	Uganda	40 (32.8%)	40 (32.8%)
Ownership			
	Public	15 (12.3%)	11 (9.0%)
	Government aided*	19 (15.6%)	26 (21.3%)
	Private	8 (6.6%)	5 (4.1%)
Schools		**Control schools**	**Intervention schools**
Teachers		122	122
Completed tests		122 (100.0%)	122 (100.0%)
Country			
	Kenya	40 (32.8%)	40 (32.8%)
	Rwanda	42 (34.4%)	42 (34.4%)
	Uganda	40 (32.8%)	40 (32.8%)
Education			
	Diploma	30 (24.6%)	24 (19.7%)
	Bachelor's degree	89 (73.0%)	96 (78.7%)
	Master's degree	3 (2.5%)	1 (0.8%)
	Missing	0 (0.0%)	1 (0.8%)
Years of experience†		9.5 (4–13)	10 (3–12)
Sex‡			
	Female	25 (31.3%)	30 (37.5%)
Students enrolled at the start of term		5466	5927
Completed tests§		5431	5913
Country			
	Kenya	1499 (27.6%)	1863 (31.5%)
	Rwanda	1556 (28.7%)	1573 (26.6%)
	Uganda	2376 (43.7%)	2477 (41.9%)
Median completed tests per class (IQR)		48 (38–65)	52 (41–69)
Sex			
	Female	3076 (56.6%)	3059 (51.7%)
Mean age (SD)		15.8 (1.2)	15.7 (1.2)

Note: Data are *n*, *n* (%) unless indicated otherwise.
*Public and government aided are the same in Uganda and are counted as government aided.
†Data for the Rwanda and Uganda trials only.
‡*n* (%) for Kenya and Uganda only. Data missing for Rwanda.
§Some students that enrolled after the start of the term completed the test in the Kenyan trial (43 in control schools and 66 in intervention schools). Whereas in Uganda and Rwanda, some students that were enrolled at the start of the term did not complete the test (78 in control schools and 80 in intervention schools).

2.5 | Intervention characteristics

Characteristics of the intervention are described using the *Guideline for reporting evidence-based practice educational interventions and teaching* (GREET) checklist (Appendix 1).[27]

We offered teacher training workshops to teachers in the intervention schools prior to the school term during which they taught the IHC lessons. The workshops lasted 2–3 days. Teachers who participated in pilot testing the resources or were in the national teacher network that helped to develop the resources facilitated the workshops. The

Be Smart about Your Health resources include 19 presentations that the facilitators used at the workshops. The facilitators reviewed the presentations together with members of the research team prior to the workshops.

The resources include ten 40-min lesson plans, designed to be taught over a single school term. For each lesson plan there is an overview and background information for teachers. The overviews include learning goals, key terms, teaching strategies, and optional printouts. The lesson plans include an introduction, an activity, and a wrap-up. There are two versions of each lesson plan: a blackboard version and a projector version for teachers using a projector. The background sections include a description of what the lesson is about, common misunderstandings, and closely related content that is not included in the lessons because there was not enough time to cover it in 40 min. In addition, the resources include a teachers' guide and a glossary.

2.6 | Outcomes

The Critical Thinking about Health (CTH) test (Appendix 2) was administered after the intervention. The test includes 18 multiple-choice questions (MCQs), two for each of the key concepts included as learning goals in the IHC secondary school resources. A description of how we developed and validated the test,[28] and determined cut offs for a passing score and a mastery score[29] are published elsewhere. The primary outcome was the proportion of students with a passing score on the CTH test (at least 9 of 18 MCQs answered correctly). Secondary outcomes are described in Table S4. Students and teachers in both the intervention and comparison schools took the test after completion of the last lesson in the intervention schools.

In all three trials, teachers were asked to report any serious adverse events during the trials. We did not ask them to monitor specific events. We also will explore potential adverse effects in the process evaluations conducted together with each trial,[20–22] and a qualitative evidence synthesis.[30] Potential adverse effects identified through the process evaluations will be measured quantitatively in the 1-year follow-up study.

2.7 | Statistical analysis

2.7.1 | Inverse variance-weighted random effects meta-analyses

We used inverse variance-weighted random effects meta-analysis to estimate overall adjusted odds ratios for students and teachers achieving passing and mastery scores and adjusted differences in students' and teachers' mean scores. We estimated trial-level (aggregate) intervention effects using the same data and analyses as for the original trials. In particular, the trial-level estimates for students accounted for the cluster design using random intercepts at the level of school (the unit of randomization). Because there is a one-to-one relationship between teachers and schools, no such adjustment is necessary for outcomes measured on teachers. Odds ratios were meta-analyzed on the log odds ratio metric. Estimates of intervention effect are presented as forest plots that also show point estimates of between-trial variance (τ^2), I^2 values to quantify heterogeneity, the results of χ^2 tests of homogeneity, and, for passing and mastery, estimates of trial-level and overall adjusted differences.

2.7.2 | IPD meta-analyses using generalized linear mixed models

We used generalized linear mixed models to perform individual participant data (IPD) meta-analyses, using the original data from the three trials. We estimated adjusted odds ratios for students and teachers achieving passing and mastery scores (logistic regression: logit link, Bernoulli errors) and adjusted differences in students' and teachers' mean scores (linear regression: identity link, normal errors), assuming common intervention effects across the trials. We adjusted for school ownership (public or government-funded vs. private), use of a projector (vs. blackboard) and school performance as fixed effects to account for the stratification used in the original trials as planned. We could not adjust for school location as planned because these data were only collected in the Kenya trial.

2.7.3 | Hierarchical random intercepts, reexpression of odds ratios, and handling of missing data

For outcomes measured on students, we used hierarchical random intercepts to account for clustering of student within school and school within trial (country). For outcomes measured on teachers, we used random intercepts to account for clustering of teacher within trial (because there is a one-one relationship between teachers and schools there is no clustering of teacher within school). To aid interpretation, we reexpressed odds ratio estimates as adjusted differences, accounting for uncertainty of the control odds as well as the odds ratios. Missing test answers were counted as wrong answers. All children and teachers who completed the test were included and analyzed in the arms to which they were randomized. We planned to use multiple imputation if complete case data were not available for more than 5% of participants, but this was unnecessary.[31]

We performed IPD meta-analyses to estimate odds ratios comparing students' ability to correctly answer both multiple-choice questions for each of the nine concepts. We presented these results as a forest plot, reexpressing the odds ratios as adjusted differences as before.

2.7.4 | Addition of interaction terms to the IPD meta-analysis models

We added interaction terms to the IPD meta-analysis models described above to estimate interactions between the intervention and four potential modifiers of the intervention effect for passing, mastery, and

Box 1: Descriptions of the contexts in which the trials were conducted

Kenya

The Kenyan trial included a representative sample of public and private secondary schools in Kisumu County that followed the national curriculum. There are 4 years of secondary school education in Kenya (following 8 years of primary school), with three school terms each year. Each term is normally 10–13 weeks. Students typically enroll when they are about 14 years old and graduate when they are about 18. Class size in public secondary schools is generally 40—59 students per class.

About 63% of Kisumu secondary schools had at least one laptop or desktop computer, 35% of the schools owned a projector, and 17% had Internet access. Students had limited access to computers and few students owned phones.

Teachers in Kenya qualify after undergoing training by an accredited university or training institute. Nearly 95% of secondary school teachers hold a bachelor's degree and about 2% have a post-graduate degree.

The curriculum was knowledge-based. Teaching was exam-oriented and critical thinking was not assessed in national examinations. Health was a topic in nine different subjects. The government plans to implement a new, competency-based curriculum by 2024. "Critical thinking and problem solving" are one of seven core competencies in the framework for the new curriculum. The core competencies cut across subjects. In the proposed curriculum, health education is a subject.

Rwanda

The Rwandan trial included a representative sample of public, private, and government-aided secondary schools in two districts from each of the five provinces of Rwanda (10 districts total). There are 6 years of secondary school in Rwanda (following 6 years of primary school). The first 3 years are lower-secondary. There are three school terms each year. Each term is 12–14 weeks. The official age range is 13–18 for secondary school and 13–15 for lower-secondary. The average number of students per classroom in secondary schools is 39.

Most secondary schools had computers (86%) and grid electricity supply (77%). Two-thirds had "smart classrooms," which included student computers, a projector, smart boards, and Internet access.

Lower-secondary teachers must have at least a Diploma in Education—a credential earned after 3 years of post-secondary study that prepares them to teach two subjects. Upper-secondary school teachers must have a 4-year bachelor's degree in education.

A competence-based curriculum was implemented in Rwanda in 2016. All subjects include generic competences for higher order thinking. The generic competences in the curriculum are critical thinking, creativity and innovation, research and problem solving, communication, cooperation, interpersonal relations, life skills, and lifelong learning. Health is a topic in three subjects: biology and health sciences, home science, and English (in which health topics are used as a context for teaching English).

Uganda

The Ugandan trial included a representative sample of public and private secondary schools that followed the national curriculum in six districts of Uganda (Luweero, Wakiso, Mpigi, Mukono, Kampala, and Kayunga). Secondary education in Uganda is 6 years (following 7 years of primary school). Lower-secondary ("Ordinary Level") is 4 years. There are three school terms each year that normally last about 12 weeks. The official entry age of lower-secondary education is 13 years. The average class size is 69.

Most schools had at least one computer (87%) and hydroelectric power (71%), and 40% had a projector. Most schools did not have Internet access.

Teacher training at National Teachers Colleges requires 2 years of study. Successful trainees are awarded Diplomas in Secondary Education. Universities also offer undergraduate teaching programs of 3–4 years in length. The government is currently phasing out teaching diplomas in favor of a bachelor's degree in education.

Uganda's National Curriculum Development Centre introduced a new competence-based curriculum for lower-secondary school students in 2020. Critical thinking is one of seven generic skills in the new curriculum. Several others, such as problem solving, are related to critical thinking. The generic skills are taught across subjects. Health is a topic in biology, physical education, and nutrition and food technology.

score for students: use of a projector (vs. blackboard), class size (number of students, a continuous variable), performance (low vs. moderate or high), and sex (female vs. male). We specified the first three in the protocol with the hypotheses and rationales shown in Table S5. We did not have an a priori hypothesis for sex, which was not specified in the protocol.

We repeated the analyses for each trial to estimate trial-specific interactions. We did not prespecify these analyses, which we did to inform judgments about the credibility of the effect modifier analyses. It was not possible to estimate all trial-specific interactions: none of the control schools in Kenya used the projector version of the lesson plans; all schools in Rwanda used the projector version; and none of the control students in Rwanda who attended low-performing schools achieved mastery scores.

Finally, we performed prespecified subgroup analyses to estimate intervention effects for passing, mastery, and score in students lacking English reading proficiency. We had planned to present graphs showing the relationship between the intervention effect and average attendance, but we were unable to collect attendance data.

2.7.5 | Confidence intervals and *p* values

We report 95% confidence intervals and two-sided *p* values, where appropriate, throughout. All statistical analyses were performed using Stata 16 (StataCorp LLC, College Station, Texas, USA).

2.8 | Risk of bias and certainty assessment

Two researchers (see Acknowledgments) independently assessed the risk of bias in each trial using the revised Cochrane Collaboration's tool for assessing risk of bias in cluster-randomized trials.[32] They were not involved in the design, implementation, interpretation, or reporting of the three trials or this meta-analysis. The same two researchers assessed the certainty of the evidence for each outcome using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system.[33,34] The authors assessed the credibility of subgroup differences (potential effect modifiers) using the Instrument to assess the Credibility of Effect Modification Analyses (ICEMAN).[35]

3 | RESULTS

The three trials, conducted during the same academic year, between April and August 2022, included a total of 244 schools with one teacher at each school (Table 1). All the teachers and 11,344 students completed the CTH test (5431 in the control schools and 5913 in the intervention schools). There was no loss to follow-up in Kenya and some students that took the test enrolled after the start of the term (43 in control schools and 66 in intervention schools). In Rwanda, 33 students in control schools (2.1%) and 38 students in the intervention schools (2.4%) did not complete the test. In Uganda, 45 students in control schools (1.9%) and 42 in intervention schools (1.7%) did not complete the test.

Overall, the median class size was 70 in control schools and 72 in intervention schools. The mean age of the students was 16.0 in the control schools and 15.8 in the intervention schools. The proportion of girls was 56.6% in the control schools and 51.7% in the intervention schools.

The overall adjusted odds ratio for the primary outcome—the proportion of students with a passing score (≥ 9 of 18 correct answers)—was 5.5 (95% CI 3.0–10.2) (Figure 1). Reexpressed as an adjusted difference, this corresponds to 32.8% (95% CI 25.5–40.1) more students having a passing score. Overall, 3482 out of 5912 (58.0%) of the students in the intervention schools had a passing score. Although the odds ratios were heterogeneous across the three trials (I^2 = 85.5%, χ^2 = 11.3, p = 0.0036), the adjusted differences were similar. This is because the smaller odds ratios corresponded to larger proportions of students with a passing score in the control schools.

The results of meta-analyses using individual participant data are shown in Table S6. These analyses estimate fixed effects, whereas the meta-analyses using effect estimates from the individual trials estimate random effects. The fixed effect estimates of the odds ratio (5.7; 95% CI 4.5–7.4) and adjusted difference (33.3%; 95% CI 28.7%–37.8%) for the primary outcome are slightly larger than the random effects estimates.

The overall adjusted odds ratio for the proportion of students with a score indicating mastery (≥ 14 of 18 correct answers) was 25.9 (95% CI 6.8–98.8) (Figure 2). Reexpressed as an adjusted difference, this corresponds to 18.4% (95% CI 15.6–21.2) more students mastering the prioritized key concepts. Overall, 1157 out of 5912 (19.6%) of the students in the intervention schools had a score indicating mastery. As with the passing scores, the odds ratios for mastery were heterogeneous (I^2 = 89.4%, χ^2 = 15.7, p = 0.0004) and the adjusted differences were similar.

The overall adjusted difference in the average score (percent correct answers) on the CHT test was 17.1% (95% CI 13.4–20.8) (Figure 3). The adjusted differences were heterogeneous (I^2 = 68.4%, χ^2 = 6.2, p = 0.046) but consistently in favor of the intervention schools, ranging from 14.1% in Kenya to 20.8% in Rwanda. The average score for students in the intervention schools varied from 52.4% in Uganda to 55.4% in Kenya.

Students in the intervention schools answered both questions correctly more often than control students for all nine key concepts (Figure 4). However, both the relative and absolute effects of the intervention on each of the nine key concepts varied.

The overall odds ratio for teachers with a passing score was 13.7 (95% CI 4.6–40.4) (Table S6). Reexpressed as an adjusted difference, this corresponds to 31.9% (95% CI 25.5–40.1) more teachers having a passing score. Overall, 118 out of 122 (96.7%) of the teachers in the intervention schools had a passing score.

The overall odds ratio for teachers with a mastery score was 51.9 (95% CI 17.4–154.4). Reexpressed as an adjusted difference, this corresponds to 76.3% (95% CI 57.9–94.7) more teachers having a mastery score. Overall, 102 out of 122 (83.6%) of the teachers in the intervention schools had a mastery score. The overall adjusted difference in the mean score for teachers was 31.5% (95% CI 23.0–40.1).

Based on self-report, if someone claimed that a treatment might help them get better, students in the intervention schools were more likely to find out if the claim was based on a research study comparing treatments (OR 1.5, 95% CI 1.4–1.7; adjusted difference in the proportion who responded likely or very likely 10.75; 95% CI 8.3–13.0) (Table S7). There was little difference between the intervention and control students in how likely they would be to find out what the claim was based on or to say "yes" if invited to participate in a controlled trial.

Intervention students also were more likely than control students to respond that they found it easy or very easy to know if a claim about a treatment is based on a controlled trial (OR 1.7, 95% CI 1.5–1.9;

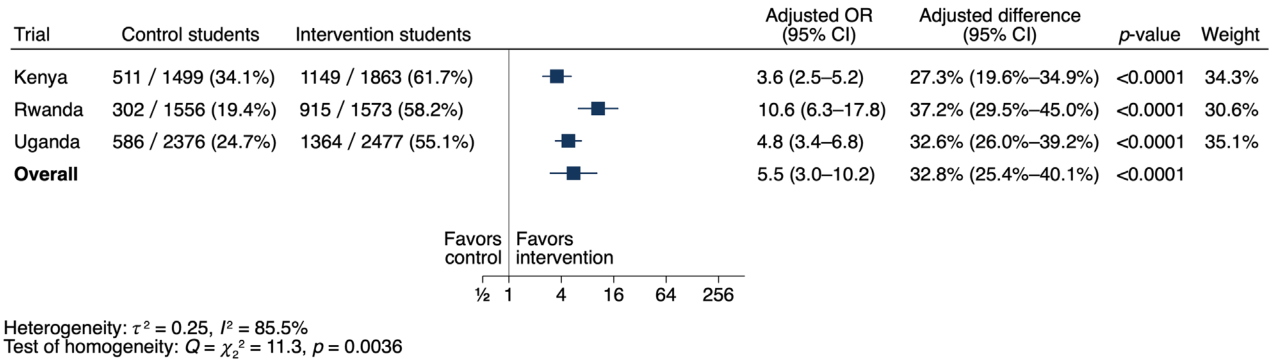

FIGURE 1 Student with a passing score.

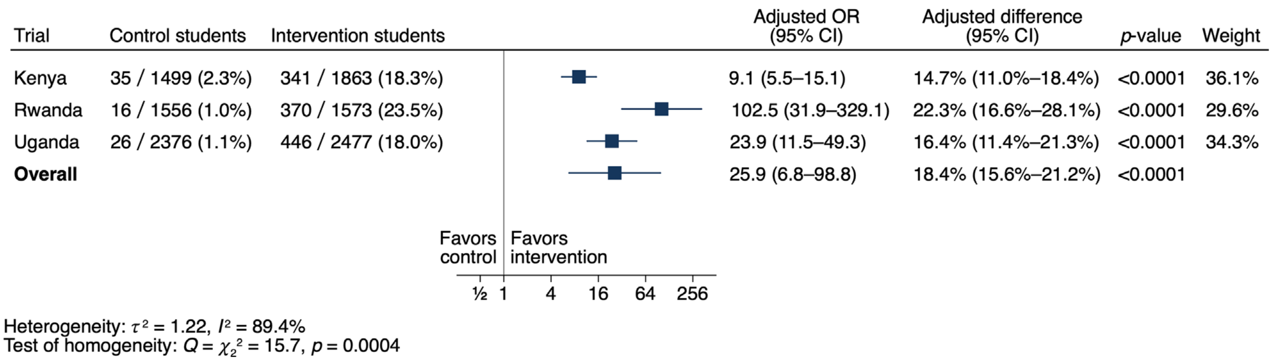

FIGURE 2 Student with a mastery score.

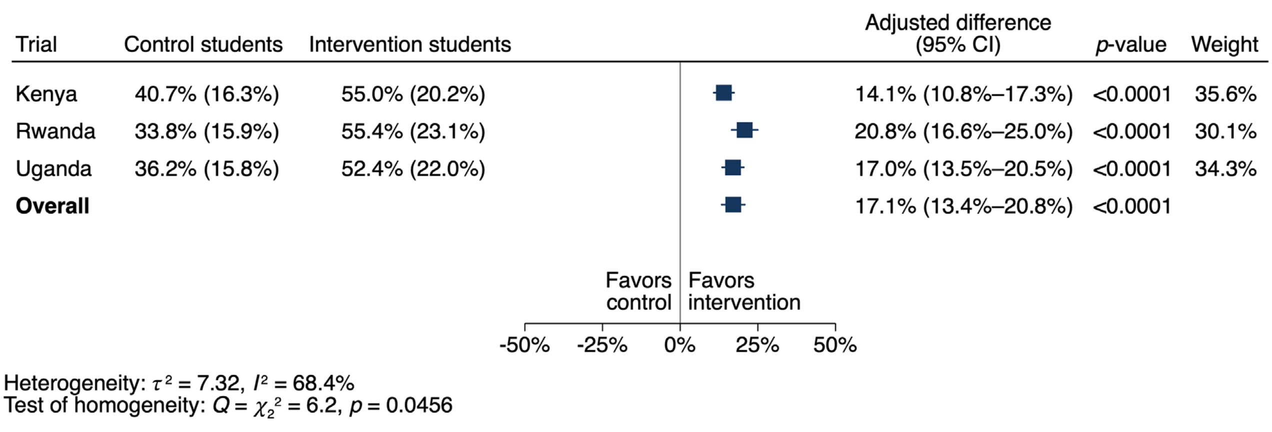

FIGURE 3 Students' mean score.

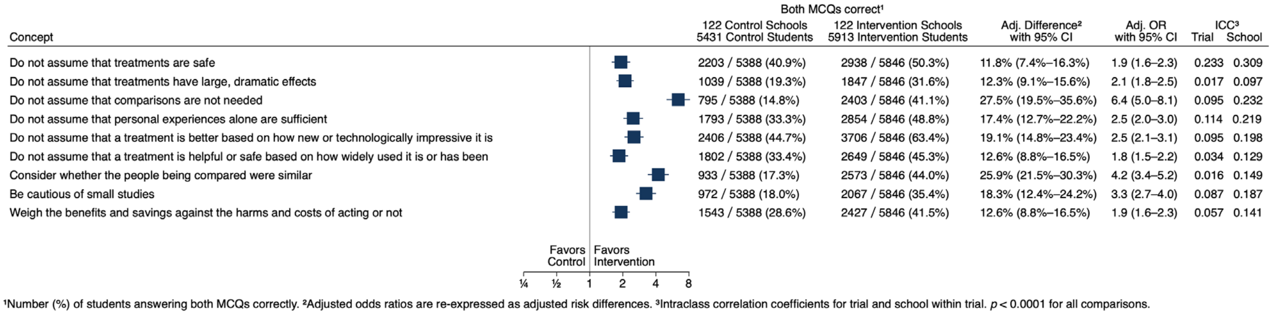

FIGURE 4 Students' results for each concept.

TABLE 2 Potential effect modifiers.

Factor (comparison)	Interaction between intervention and factor	*p* Value
Outcome	(95% confidence interval)	
Version (blackboard* vs. projector)		
Passing score (≥9 out of 18 correct answers)†	1.71 (1.02–2.86)	0.040
Mastery score (≥14 out of 18 correct answers)†	2.39 (1.00–5.70)	0.051
Test score (% correct)‡	26.3% (1.3%–51.2%)	0.039
Class size (continuous variable§)		
Passing score (≥9 out of 18 correct answers)†	0.99 (0.98–1.00)	0.102
Mastery score (≥14 out of 18 correct answers)†	1.00 (0.98–1.02)	0.993
Test score (% correct)‡	−0.2% (−0.8% to 0.4%)	0.487
Performance** (low* vs. moderate or high)		
Passing score (≥9 out of 18 correct answers)†	1.57 (1.15–2.16)	0.005
Mastery score (≥14 out of 18 correct answers)†	1.55 (0.74–3.23)	0.247
Test score (% correct)‡	42.3% (29.0%–55.6%)	<0.0001
Sex (female* vs. male)		
Passing score (≥9 out of 18 correct answers)†	1.49 (1.23–1.81)	<0.0001
Mastery score (≥14 out of 18 correct answers)†	1.87 (1.05–3.33)	0.034
Test score (% correct)‡	10.2% (2.8%–17.5%)	0.007

Note: Hierarchical random intercepts were used to model clustering of students within schools, and schools within country (trial).
*Reference group.
†Estimates of interactions are odds ratios adjusted for projector use, class size, performance, gender, and school ownership (public or government-funded vs. private), and the interaction terms. Odds ratios greater than one suggest the intervention (rather than the control) is associated with higher odds of passing or mastery in the comparison group compared to the reference group.
‡Estimates of interactions are differences in mean test scores, expressed as percentages, and adjusted in the same way as for the dichotomous outcomes. Differences greater than zero suggest the intervention (rather than the control) is associated with higher scores in the comparison group compared to the reference group.
§The unit of measurement for class size was student. The magnitude of the odds ratio is larger for a larger difference, for example, for an increase of 10 students, the OR is $0.99^{10} = 0.90$ (95% CI 0.80–1.02).
**Performance on exams at the end of the previous school term for individual students in the Kenyan trial and for schools in the Rwandan and Ugandan trials.

adjusted difference 12.4%, 95% CI 9.4–15.3) (Table S8). They also were more likely than control students to respond that they found it easy or very easy to judge the trustworthiness of the results of a controlled trial (OR 1.8, 95% CI 1.5–2.1; adjusted difference 12.0%, 95% CI 8.7–15.2). There were smaller differences in how easy they thought it is to find information about treatments that is based on controlled trials or to know if the results of a controlled trial are relevant to them.

Most of the students in the intervention schools liked the lessons (91.7%) and found them helpful (93.1%) (Table S9). The teachers did not report any adverse effects in the intervention schools.

Use of a projector was associated with an increase in the effectiveness of the intervention for the primary outcome (OR for the interaction 1.71; 95% CI 1.02–2.86) (Table 2). Performance on exams at the end of the previous term was available for individual students only for the Kenyan trial. In that trial the intervention was more effective in moderate or high performing students than in low-performing students (OR for the interaction 1.89; 95% CI 1.32–2.70) (Table S10a). Only school-level performance data were available in Rwanda and Uganda (Table 10b and c). Overall, a larger effect was associated with moderate or high performance on end-of-term exams compared to low performance (OR for the interaction 1.57; 95% CI 1.15–2.16). The intervention was more effective in boys (OR for the interaction 1.49; 95% CI 1.23–1.81). Larger class sizes may be associated with smaller effects for the primary outcome. For example, the odds ratio for an interaction for an increase in class size of 10 students would be $0.99^{10} = 0.90$ (95% CI 0.80–1.02).

Compared to students with advanced English reading proficiency, students who lacked proficiency or had basic proficiency were less likely to have a passing score on the CTH test (Table S11a–c).

3.1 | Risk of bias and certainty assessment

Two independent researchers assessed the three trials as having a low risk of bias for passing, mastery, and mean scores for both students and teachers (Table S12).

The main findings are summarized in Table 3. There is high certainty evidence of an important effect on passing (>20% more students with a passing score) and an effect on mastery, and the mean score for students. There is moderate certainty evidence (due to insufficient sample size) that the intervention probably increases passing, mastery, and the mean score for teachers. The extent to which these results are

TABLE 3 Summary of findings.

Outcomes*	Control schools†	Intervention schools‡ (95% CI)	Relative effect odds ratio (95% CI)	Number of participants (effective sample size)§	Certainty of the evidence (GRADE)**
Students					
Passing	34.1%	66.9% (59.5–74.2)	3.6 (2.5–5.2)	11,325 (1173)	⊕⊕⊕⊕ High certainty
Mastery	1.3%	19.7% (16.9–22.5)	25.9 (6.8–98.8)	11,325 (875)	⊕⊕⊕⊕ High certainty
Mean score	37.1%	54.2% (50.5–57.9)		11,325 (1126)	⊕⊕⊕⊕ High certainty
Harms††	–	–	–	–	⊕◯◯◯ Very low certainty
Teachers					
Passing	65.6%	97.5% (71.9–100)	13.7 (4.6–40.4)	244	⊕⊕⊕◯ Moderate certainty††
Mastery	9.8%	86.1% (67.7–100)	51.9 (17.4–154.4)	244	⊕⊕⊕◯ Moderate certainty††
Mean score	53.6%	85.1% (76.6–93.7)		244	⊕⊕⊕◯ Moderate certainty††
Harms‡‡	–	–	–	–	⊕◯◯◯ Very low certainty

*Passing: ≥9 of 18 correct answers. Mastery: ≥ 14 of 18 correct answers. Mean = average percent correct answers.
†Average of the proportions and means for the three trials.
‡Average for control schools + adjusted difference. 95% CI account for uncertainty of the control odds as well as the odds ratios for proportions, and the control mean as well as the mean difference for means. The values in this table differ slightly from values reported in the text, which are the observed proportions in the intervention schools.
§Three cluster-randomized trials and 244 schools were included for all six outcomes. The effective sample size, which accounts for clustering, is the original sample size divided by the "design effect" (Table S13).
Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group grades of evidence. ⊕◯◯◯ **Very low certainty: The research does not provide a reliable indication of the likely effect. The likelihood that the actual effect will be substantially different is very high. ⊕⊕◯◯ **Low certainty evidence**: The research provides some indication of the likely effect. However, the likelihood that the actual effect will be substantially different is high. ⊕⊕⊕◯ **Moderate certainty**: The research provides a good indication of the likely effect of a treatment. The likelihood that the actual effect of the treatment will not be substantially different is moderate. ⊕⊕⊕⊕ **High certainty**: The research provides a very good indication of the likely effect of a treatment. The likelihood that the actual effect will be substantially different from this is low.
††Downgraded due to insufficient sample size.
‡‡No adverse effects were reported by teachers. However, potential adverse effects are being explored in process evaluations and the 1-year follow-up study.

applicable to other settings outside of East Africa is uncertain. There is very low certainty about adverse effects and other outcomes that we did not measure.

Finally, using the projector version of the lessons may be more effective than using the blackboard version (low credibility), and the intervention probably is more effective for high or moderate performing students than for low-performing students, for smaller class sizes, and for boys (moderate credibility) (Table S14).

4 | DISCUSSION

In all three trials, the IHC secondary school intervention had a large effect on the ability of students and their teachers to think critically about health choices. The odds ratios for students were heterogeneous, with the largest relative effects in Rwanda and the smallest in Kenya. Students in the control schools in Rwanda had the lowest scores and students in control schools in Kenya had the highest scores, so the absolute effects were similar in the three countries.

Overall, 58.0% of the students in the intervention schools achieved a passing score. Many students (42%) did not achieve a passing score, indicating that they did not have a basic understanding of the prioritized key concepts and would need additional (or alternative) instruction.[29] Students who performed poorly on end-of-term exams, students in large classes, and girls probably are more likely to need additional (or alternative) instruction.

Systematic reviews and an updated search found only one other large, randomized trial of an educational intervention to improve critical thinking about health choices.[14–16] That trial of the IHC primary school intervention also found a large effect.[36] The primary school children retained what they learned for at least 1 year, some children used what they learned in their daily lives, and there was no qualitative evidence of adverse effects.[37,38]

A limitation of this meta-analysis was that the principal investigators of the included trials were the lead authors. To avoid bias in the assessments of the risk of bias and the certainty of the evidence, two researchers who were not involved in the trials made these assessments.

Critical thinking about health choices was the focus of the intervention and the outcome measure and was not taught in the standard curricula. Therefore, the results showed that explicitly teaching critical thinking about health choices compared to not teaching it was effective, at least for some students.

This was the first time that teachers in the three trials taught the lessons, and the lessons were an add-on to the standard curriculum. Also, the lessons were taught in the first or second term when schools reopened following closures due to the COVID-19 pandemic. This might have created additional stress for teachers and students. If the teachers had more experience, the lessons were not an add-on, but replaced something else, and there were normal circumstances, they could be more effective.

Nonetheless, it was likely that more than 7 h of classroom time were needed, as well as additional lessons to ensure that all or nearly all the students benefit, to reinforce what was learned in these lessons, and to teach other key concepts. At the start of the project, together with curriculum developers and teachers in the three countries, we prioritized 17 key concepts that should be taught to lower-secondary school students,[18] but it was not practical to teach all of those concepts in a single school term.

Inequities in the extent to which students benefit from the intervention might be reduced by translating the lessons for students lacking English reading proficiencies. Other strategies that might help include more use of formative assessments and feedback, smaller classes, and teacher training focused on strategies for supporting students who need additional help.[39] However, inequities in the outcomes of the IHC secondary school intervention likely reflect broader inequities in educational outcomes shaped by educational systems,[40] and interventions to reduce educational inequities may need to start early in children's lives.[41]

Another important challenge was improving access to health information that was reliable and understandable.[2,42] It was not easy to find evidence-based information, and there was a tremendous amount of misinformation.[1,2] In low-income countries where many people had limited if any access to the Internet and to health professionals, accessing reliable information was especially challenging.

In summary, adolescents in secondary schools in low-income countries can learn valuable skills needed to decide what to believe or do. This could help to reduce waste and unnecessary suffering and provide a foundation for critical thinking about health policies as well as personal choices, and about other types of interventions.[43]

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CONFLICT OF INTEREST STATEMENT

FC, MM, RS, AN, MK, NKS, MO, SER, JM, and ADO both developed and evaluated the intervention.

DATA AVAILABILITY STATEMENT

Data collected for this meta-analysis, including deidentified individual participant data and a data dictionary defining each field in the set, will be made freely available with publication on Zenodo, licensed under a Creative Commons Attribution 4.0 International license. The study protocol was published on Zenodo prior to recruiting participants: https://zenodo.org/record/6597493#.ZC-2xXZBzq4. The *Be Smart about Your Health* resources are licensed under a Creative Commons Attribution-Non-Commercial-Share-Alike 4.0 International license and are freely available: https://besmarthealth.org/.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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