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Effects of the informed health choices secondary school intervention on the ability of students in Kenya to think critically about health choices: A cluster-randomized trial

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Abstract

Aim: There is an overabundance of claims about the advantages and disadvantages of health interventions. People need to be able to appraise the reliability of these claims. The aim of this two-arm cluster-randomized trial was to evaluate the Informed Health Choices secondary school intervention designed to teach students to assess claims about the effects of health actions and make informed decisions.

Methods: We conducted the trial among students from 80 secondary schools in five subcounties in Kenya. We used stratified randomization to allocate schools to the intervention or control arm. The intervention included a 2-day teacher training workshop and 10 lessons that addressed nine prioritized key concepts for assessing claims about treatment effects. We did not intervene in the control schools. The primary outcome was the proportion of students with a passing score (≥ 9/18 correct answers) on the Critical Thinking about Health test, which included two multiple-choice questions for each concept.

Results: Between May 11, 2022, and July 8, 2022, we recruited 3362 students and 80 teachers. We allocated 1863 students and 40 teachers to the intervention and 1499 students and 40 teachers to the control arm. In the intervention schools, 1149/1863 (61.7%) of students achieved a passing score compared to 511/1499 (34.1%) in the control schools (odds ratio 3.6 (95% CI 2.5–5.2), $p < 0.0001$).

Conclusions: The intervention had a large effect on students' ability to think critically about health interventions. It is possible to integrate the learning of critical thinking about health within Kenya secondary school curriculum.

KEYWORDS
adolescents, critical health literacy, critical thinking, health information, Kenya, secondary school curriculum, treatment claims

1 | INTRODUCTION

There is a very large amount of information about how to care for one's health and the health of others. The sources of this information include websites, peers, traditional information sources such as family members, magazines, radio, and television, and social media such as Facebook and WhatsApp. The basis for much of this information is unsubstantiated, untrustworthy or unreliable.[1] Many people are unable to assess the reliability of such information.[2,3] Believing and acting on unreliable health claims can contribute to overuse of ineffective or harmful health interventions and the underuse of helpful health interventions.[4,5] This includes preventive, therapeutic, rehabilitative, and palliative actions intended to maintain or improve the health or well-being of individuals or communities.

Schools can potentially modify behaviors not only by promoting specific health behaviors but by teaching adolescents how to appraise health claims they encounter in their daily lives, now and in the future.[6] A systematic review of the effects of school-based educational interventions to teach critical appraisal of health claims to adolescents found that most interventions had positive short-term effects, but the certainty of the evidence was low.[7]

There is a global focus on 21st-century competencies, including critical thinking in most school curricula.[8,9] These include critical thinking—reasonable reflective thinking focused on deciding what to believe or do.[10] In Kenya, the competency-based curriculum includes critical thinking as one of the seven core competencies.[11] However, it does not spell out clearly how learners can acquire these skills, and it is unclear how educators will measure these learning outcomes. Targeting adolescents in schools with critical thinking appraisal skills has the potential to improve their health decisions while taking advantage of the time in school, and they can carry this through to adulthood. A context analysis found that health is taught in across subjects but critical thinking about health was not being taught.[12]

Building on findings from a randomized trial of the Informed Health Choices (IHC) primary school intervention,[13] as well as context analyses in Kenya, Rwanda, and Uganda [12,14,15]we designed and piloted the IHC secondary educational intervention.[16] The intervention uses digital resources that can be accessed in secondary schools with computers or an Internet connection using a smartphone. The objective of this trial was to evaluate the effects of the intervention on the ability of secondary school students in Kenya to critically appraise claims about the effects of health intervention and make informed health choices.

2 | METHODS

2.1 | Design

This study was a two-arm cluster-randomized trial conducted in Kenya. We obtained ethics clearance from Masinde Muliro University of Science and Technology Institutional Ethics Review Committee and the Kenya National Commission of Science and Technology Institute (License number: NACOSTI/P/19/1986). The protocol for the study was registered April 5, 2022, in the Pan African Clinical Trial Registry (number PACTR202204883917313) and published online.[12,17]

2.2 | Setting and participants

We targeted 13-14-year-old students in one form-one class and one teacher in a random sample of secondary schools in five subcounties (districts) in Kisumu County, Kenya.

We obtained a list of all secondary schools in Kisumu County from the county director of education, who helped us identify schools that met the following eligibility criteria. Public and private schools that follow the standard national secondary school curriculum, have electricity, and consent to participate. We excluded schools that participated in the user testing or piloting of the resources, special needs schools, international schools, and schools located in districts prone to floods and insecurity. We stratified the schools by ownership (private/public) and geographical location (rural/urban) and randomly selected eligible schools from each subcounty and the four strata.

Together with the subcounty education directors, we invited principals of the selected schools to attend face-to-face recruitment meetings. The principal investigator (FC) introduced the study objectives and methods to them, and we obtained written consent from the principals to allow their schools and students to participate in the study.

The principals introduced the study to students, staff, and school management boards in their respective schools. The study and intervention content were endorsed by the Ministry of Education and by the board of management at each school, which consists of parent representatives. The school principals gave consent loco parentis on behalf of the students to participate in the study. In Kenya, school principals have a guardianship role in schools and make decisions on behalf of their students. We asked students to give their assent to complete the Critical Thinking about Health (CTH) test (Supplementary File 1), which

TABLE 1 Prioritized IHC key concepts used in the secondary school resources.

1.	Treatments can cause harms as well as benefits.
2.	Large, dramatic effects are rare.
3.	Personal experiences or anecdotes alone are an unreliable basis for most claims.
4.	Treatments that are new or technologically impressive may not be better than available alternatives.
5.	Widely used treatments or those that have been used for decades are not necessarily beneficial or safe.
6.	Identifying the effects of treatments depends on making comparisons.
7.	Small studies may be misleading.
8.	Comparison groups should be as similar as possible.
9.	Weigh the benefits and savings against the harms and costs of acting or not.

was used to measure outcomes. Each principal recruited one teacher that agreed to participate in the study prior to random allocation, and together with the selected teacher they randomly selected one form-one class. We invited the selected teachers to a meeting, introduced the study objectives to them, and obtained their written consent.

2.3 | Random allocation and masking

We stratified schools as outlined above. An independent statistician not involved in the recruitment of schools randomly allocated the schools to the intervention or control arm. The principal investigator (FC) assigned unique codes to the schools and provided the statistician with the codes to ensure that the allocation was concealed. The statistician then prepared the randomization list with the unique codes and corresponding allocation group for each participating school. He used block randomization with block sizes of four and eight and equal allocation ratios within each block to allocate the schools to the study arms. He used the Sealed Envelope computer platform.[18] The stratification in the sequence ensured a fair distribution of schools for the two variables. We did not change the final list of schools after random allocation by the statistician.

Because of the nature of the intervention, it was not possible to blind the research team, teachers, or students. We informed the teachers and students of the purpose of the CTH test used to measure outcomes in both arms of the trial but did not show them the test until the end of the school term when they were asked to complete it.

2.4 | Intervention

The intervention had two main components: digital resources called "Be smart about your health"[19] and a training workshop for teachers. In collaboration with teachers, students, and curriculum developers, we prioritized nine of 49 IHC key concepts[20] (Table 1) and used an iterative human-centered design approach to develop the resources.[15,16]

The digital resources included 10 lesson plans (Table 2). Each lesson was intended to last 40 min and the lessons were designed to be delivered in a single school term. The resources were designed so that they could be downloaded on a smartphone or computer, then used without an Internet connection. For each lesson, there was an overview, a lesson plan, and background information for teachers. There were two versions of each lesson plan: one for classrooms equipped with a projector and one for classrooms equipped only with a blackboard, whiteboard, or flipchart. The resources also included a teachers' guide, a glossary, teacher training materials, and optional printable files. The 2-day teacher training workshop was facilitated by four teachers who had participated in a pilot study.[16] We have described the intervention using the Guideline for Reporting Evidence-based practice Educational interventions and Teaching (GREET) checklist for describing educational interventions in Supplementary File 2.

2.5 | Procedure

We invited teachers allocated to the intervention arm to attend the training workshop a week before the start of the school term. At the end of the workshop, we gave the teachers the web link to access the resources and instructed them not to share it with anyone in the control schools. We invited teachers allocated to the control arm to a meeting where we introduced the study objectives. We informed them about the CTH test and told them we would offer them teacher training and access to the resources after a 1-year follow-up assessment.

School principals and teachers opted to deliver the lessons in place of life skills or physical education. Most schools had earmarked these lessons to complete the curriculum because of time lost during school closures due to the COVID-19 pandemic. Some teachers created extra time to teach outside the timetable (during early mornings, evenings, and weekends).

We monitored delivery of the intervention in accordance with guidelines from the Ministry of Education school supervisory schedule. We also followed up teachers by phone and through WhatsApp groups created separately for teachers in the intervention and control arms. We observed at least one lesson in all the intervention schools, and more than four lessons in eight schools selected for a process evaluation.[21] We did not provide any feedback or advice to the teachers during and after the lesson observations.

We trained research assistants that administered the CTH test to students and teachers in both arms of the trial. Students and teachers were assigned study codes that were written on the answer sheets. Students were instructed to write their age and gender on the answer sheet. We collected the sheets and scanned them using Zip Grade.[22]

2.6 | Outcomes

We assessed the outcomes at the end of the term when the intervention was delivered. We used the CTH test (Supplementary File 1) to measure students' and teachers' ability to think critically about health claims and choices. The test included 18 multiple-choice items

TABLE 2 Lesson plans.

Lesson	Goals By the end of the lesson, students should be able to
1. Health actions	- Identify health actions - Explain why it is important to think critically about health actions (why these lessons are important)
2. Health claims	- Identify claims about the effects of health actions
3. Unreliable claims	- Identify claims about the effects of health actions that are only based on personal experiences, how commonly used something is, or how new or expensive something is - Explain why most such claims are unreliable
4. Reliable claims	- Explain why knowledge about the effects of health actions depends on comparisons - Explain why we need researchers to make the comparisons
5. Using what we learned	- Remember what they learned in Lessons 1–4 - Use what they learned in these lessons in their daily lives - Recognize limits to what they have learned
6. Randomly created groups	- Explain why groups of people in comparison should be similar at the start
7. Large-enough groups	- Explain what it means for comparisons between health actions to be large enough
8. Personal choices	- Identify advantages and disadvantages of health actions, for individuals
9. Community choices	- Identify advantages and disadvantages of health actions, for communities
10. Using what we learned[2]	- Remember what they learned in Lessons 1–9 - Use what they learned in these lessons in their daily lives - Recognize limits to what they have learned

(MCQs)—two for each of the nine key concepts addressed in the IHC secondary school intervention. To develop the CTH test, we started with 27 MCQs (three for each of the nine key concepts) and conducted cognitive interviews with children, adults, and curriculum developers in Kenya, Rwanda, and Uganda. We made minor revisions to the questions and determined the reliability and validity of the test using Rasch analysis.[23] In addition to the MCQs, we included questions that measure intended behaviors and self-efficacy, using Likert response options.

We used a combination of Nedelsky's and Angoff's methods to determine the cut-off for passing and mastery scores.[24] The primary outcome was the proportion of students with a passing score (≥9 out of 18 MCQs answered correctly). Secondary outcomes included the proportion of teachers with a passing score, the proportion of students and teachers with a mastery score (≥14 out of 18 answered correctly), and measurements of students' intended behaviors and self-efficacy. We asked teachers assigned to the intervention arm to monitor for adverse events and report these to the principal investigator (FC) using an online questionnaire. We will measure retention of what was learned after 1 year, using the same test.

We are exploring use of what was learned in the students' daily lives, other potential benefits, and potential adverse effects in the process evaluation.[11,21]

2.7 | Statistical analysis

We estimated the sample size using the University of Aberdeen Health Services Research Unit's Cluster Sample Size Calculator[25] based on the assumptions in Table S1. We estimated that we needed a minimum of 74 schools to participate in the trial. We included 82 schools, to allow for a loss to follow-up of up to 10% as shown in Table S1.

We estimated odds ratios and differences in means for binomial and continuous outcomes, respectively. Odds ratios were estimated using mixed effects logistic regression or exact logistic regression if outcomes were completely determined.[26] Differences in means were estimated using mixed effects linear regression. For outcomes measured at the level of student, we accounted for the cluster-randomized 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 was necessary for outcomes measured on teachers. Except where noted below, all analyses were adjusted for the variables used in the stratified randomization (public vs. private schools and urban vs. rural schools). To aid interpretation, we reexpressed odds ratios as adjusted differences, accounting for uncertainty of control odds as well as the odds ratios. Missing test answers were counted as wrong answers. We included and analyzed data for all the students and teachers who completed the test in the arm to which they had been randomized. We report 95% confidence intervals and two-sided *p*-values, where appropriate, throughout. We performed all statistical analyses using Stata 16 (Stata Corp LLC, College Station, Texas, USA).

To put the effect of the intervention in the context of the effect sizes reported for other interventions to improve critical thinking or learning in schools, we estimated Hedges' g (a standardized mean difference) for the adjusted difference in students' mean scores. This was estimated as the ratio of the adjusted difference to within-cluster standard deviation.[27]

We estimated odds ratios comparing students' ability to correctly answer both multiple-choice questions for each of the nine concepts and present these results as a forest plot. For questions about intended behaviors and self-efficacy, we report numbers and percentages of students for each response option and estimates of odds ratios comparing dichotomized responses (e.g., "very unlikely" or "unlikely," vs. "very likely" or "likely"). We reexpressed the odds ratios as risk differences as before.

In the intervention schools, three additional questions were included in the CTH test. These used Likert response options to assess whether students "liked" or "disliked," "easy" or "difficult," and found them "helpful" or "unhelpful." We report numbers and percentages of students for each response option as well as for dichotomized responses (e.g., liked the lessons "a little" or "very much" vs. disliked the lessons "a little" or "a lot").

2.8 | Role of the funding source

This research was funded by the Research Council of Norway, project number 284683, grant no: 69006 awarded to ADO. The funder had no role in study design, decisions about publication, or preparation of the manuscript. The principal investigator (FC) was responsible for overseeing recruitment, data collection, data management, and reporting of the results. Trained research assistants were responsible for collecting consent forms and data from each school.

3 | RESULTS

3.1 | Baseline characteristics

We assessed 250 schools for eligibility between May 11, 2022, and July 8, 2022. After recruitment meetings, 81 schools consented and were randomly assigned to either the intervention ($n = 41$) or the control arm ($n = 40$). One school assigned in the intervention group dropped out after enrolling because the teacher had competing tasks. This left 80 schools that provided data and are included in the analysis. Altogether, we enrolled 3253 students in the selected classes at the start of the trial. More students completed the CTH test than were enrolled at the start of the trial (43 students more in the control schools and 66 more in the intervention schools). This was most likely because schools continued admitting students, and because students who were not enrolled at the start of the trial were enrolled when the test was administered. Figure 1 shows reasons for exclusion of schools and the flow of schools, teachers, and students through the study. Seventeen schools used the projector version and 23 used the blackboard version of the IHC lessons. The teachers used between 50 and 120 min to teach each lesson.

As shown in Table 3 most schools (90%) in both the intervention and control arms were publicly owned. All the teachers completed the CTH test at the end of the term. Most teachers in both the control and intervention arm (90.0% and 97.5%) held a bachelor's degree qualification. There was a higher proportion of male students in the intervention arm (55.3%) compared to the control arm (40.3%). This was due to having more boy schools randomized by chance to the intervention arm. The mean age of students was 15.6 years in the control arm and 15.5 years in the intervention arm. Most students in both arms had low scores (46.4% and 42.8%) or moderate scores (40.2% and 38.6%) on the end-of-term internal examination before the trial. These examinations assess students' understanding of topics taught in each subject during the term.

3.2 | Main results

In the intervention schools, 61.7% of the students had a passing score (≥9/18 correct answers) on the CTH test compared to 34.1% in the control schools. The odds ratio was 3.6 (2.5–5.2) and the adjusted difference was 27.3% (95% CI 19.6–34.9, $p < 0.0001$) (Table 3). In the intervention schools, 18.3% of students had a mastery score (≥14/18 correct answers) compared to 2.3% in the control schools with an adjusted difference of 14.7% (95% CI 11.0–18.4) (odd ratio 9.1, 95% CI 5.5–15.1, $p < 0.0001$). The average score for students in the intervention schools was 55.0% compared to 40.7% in the control schools (adjusted mean difference 14.1%, 95% CI 10.8 −17.3, $p < 0.0001$) (Table 4).

In the intervention schools, 97.5% of the teachers (all but one) had a passing score compared to 87.5% in the control group (odds ratio 5.3, 95% CI 0.6–264.3, $p = 0.2115$, adjusted difference 11.7%, 95% CI −2.6 to 26.0). Thirty-five of the 40 teachers in the intervention schools (87.5%) had scores indicating mastery, compared to 22.5% in the control schools (odds ratio 24.6, 95% CI 7.4–82.4, $p < 0.0001$, adjusted difference 68.4%, 95% CI 48.3–81.3). The mean score for the teachers in the intervention schools was 86.8% compared to 63.3% in the control schools/span > odds ratio 24.6 (7.4–82.4) adjusted difference 23.4%, 95% CI 17.9–28.9, $p < 0.0001$) (Table 4).

3.3 | Result for each concept

For each concept, the proportion of students who answered both multiple-choice questions correctly was greater in the intervention schools than in the control schools (Figure 2). The adjusted differences ranged from 6.5% for the concept "Do not assume that treatments have large, dramatic effects" to 22.8% for the concept "Consider whether the people being compared were similar."

3.4 | Intended behaviors

In the intervention schools, 54.3% of the students responded that they were "likely or very likely" to find out if a treatment claim was based on a research study compared to 42.5% in the control schools (odds ratio 1.6, 95% CI 1.4–1.8, adjusted difference 11.7%, 95% CI 18.3–15.1). Students in the intervention schools were only slightly more likely to find

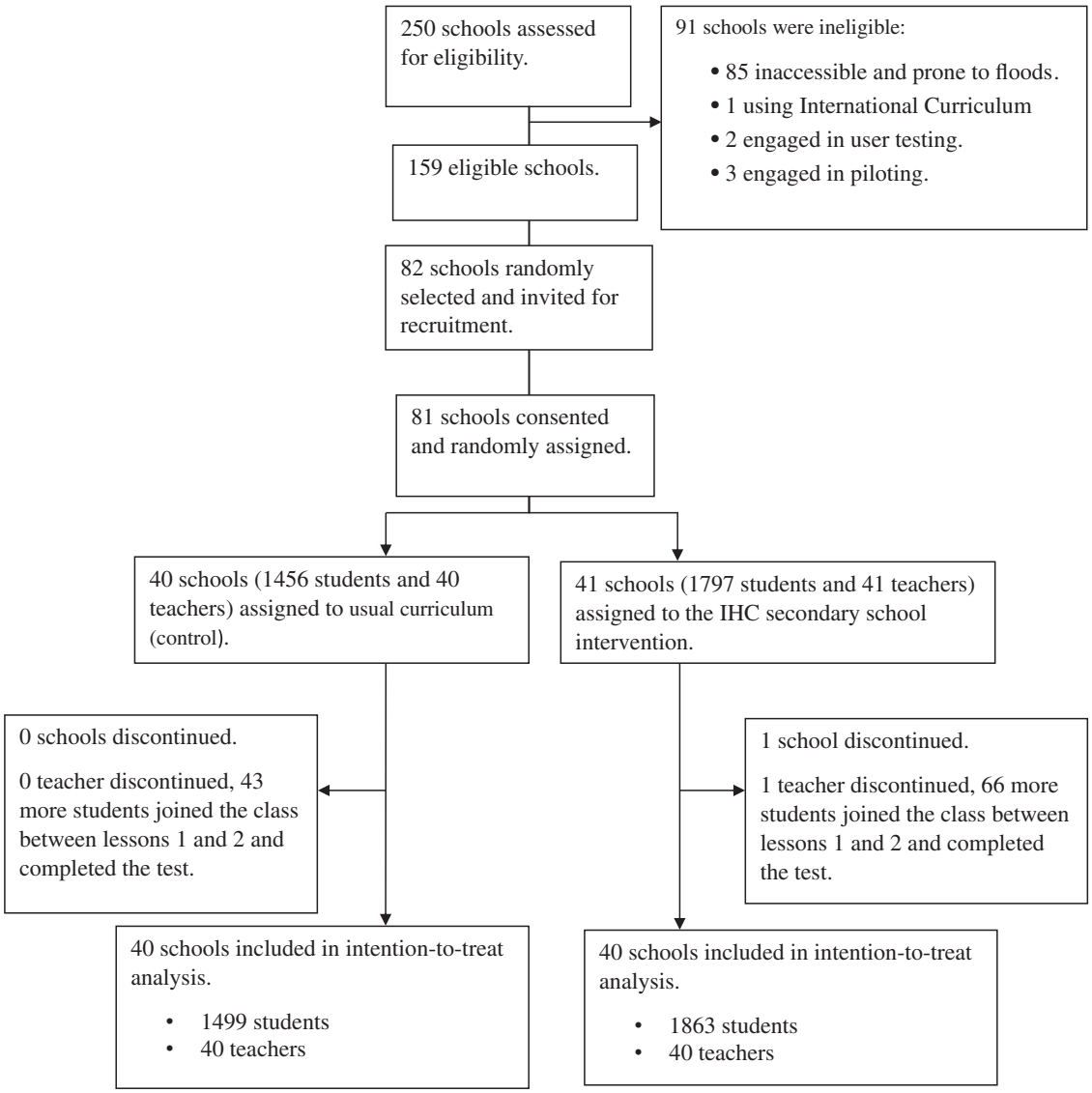

FIGURE 1 Flow diagram of study participants in the trial.

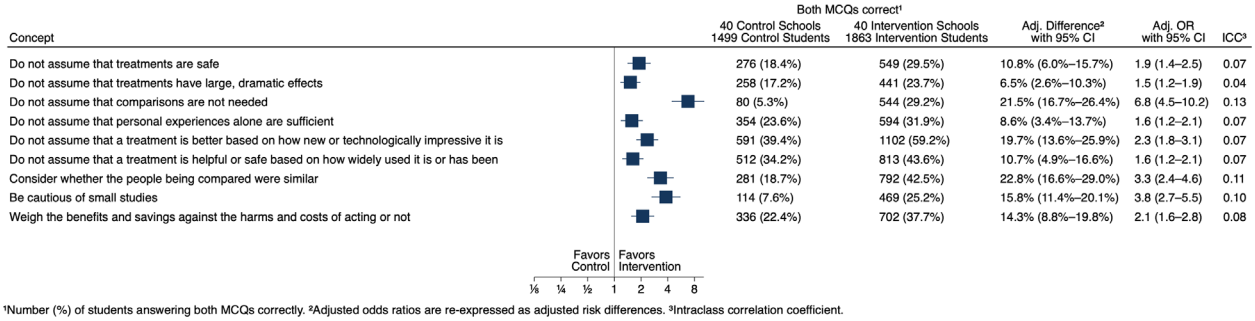

FIGURE 2 Results for each key concept covered in the trial. $p < 0.0001$ for all comparisons; number (%) of students answering both MCQs correctly; adjusted odds ratios are reexpressed as adjusted risk differences; intraclass correlation coefficient.

out what a claim was based on (odds ratio 1.2, 95% CI 1.1–1.5; adjusted difference 5.4%, 95% CI 1.3–9.5) or to say "yes" if asked to participate in a research study (odds ratio 1.1, 95% CI 1.0–1.4; adjusted difference 3.1%, 95% CI −0.8 to 7.0) (Table S2).

3.5 | Self-efficacy

In the intervention schools, 52.6% of the students found it "easy" or "very easy" for them to know if a claim about treatments is based on

TABLE 3 Baseline characteristics.

			Control schools *N* (%)	Intervention schools *N* (%)
Schools			40	40
	Subcounties	Kisumu Central	5 (12.5%)	3 (7.5%)
		Kisumu East	5 (12.5%)	5 (12.5%)
		Kisumu West	13 (32.5%)	7 (17.5%)
		Nyakach	11 (27.5%)	14 (35.0%)
		Seme	7 (17.5%)	11 (27.5%)
	Location	Rural	29 (72.5%)	29 (72.5%)
		Urban	11 (27.5%)	11(27.5%)
	Ownership	Public	36 (90.0%)	36 (90.0%)
		Private	4 (10.0%)	4 (10.0%)
Teachers			40	40
	Completed tests		40 (100.0%)	40 (100.0%)
	Education	Diploma	2 (5.0%)	0 (0.0%)
		Degree	36 (90.0%)	39 (97.5%)
		Masters	2 (5.0%)	1 (2.5%)
	Gender	Female	19 (47.5%)	18 (45.0%)
		Male	21 (52.5%)	22 (55.0%)
Students	Enrolled in school		1456	1797
	Completed tests		1499	1863
	Completed tests per class: median (IQR)		46 (38–55)	52 (45–62)
	Class size: median (IQR)		46 (38–55)	52 (45–62)
	Gender	Missing	0 (0.0%)	1 (0.1%)
		Female	894 (59.6%)	831 (44.6%)
		Male	604 (40.3%)	1031 (55.3%)
	Age: mean (SD)		15.6 (1.1)	15.5 (1.1)
	Internal exam performance	Missing	43 (2.9%)	67 (3.6%)
		Low	696 (46.4%)	798 (42.8%)
		Moderate	603 (40.2%)	719 (38.6%)
		High	157 (10.5%)	279 (15.0%)

a research study compared to 32.1% in the control schools (odd ratio 2.3, 95% CI 1.9–2.8; adjusted difference 19.7%, 95% CI 15.2–24.2). The adjusted differences for the other self-efficacy questions were small: 7.8% (95% CI 3.6–12.0) for finding information based on research, 4.2% (95% CI 0.4–8.0) for judging the trustworthiness of research results, and 6.8% (95% CI 2.5–11.2) for knowing if the results of a research study were relevant (Table S3).

3.6 | Students' perceptions of the lessons

Most of the students in the intervention schools (94.1%) said they liked the lessons "a little" or "very much," 78.5% said that the lessons were "easy" or "very easy" to understand, and 94.0% said what they learned from the lessons was "helpful" or "very helpful" (Table S4). The teachers in the intervention arm did not report any adverse events.

4 | DISCUSSION

The IHC secondary school intervention had a large effect on the ability of secondary school students in Kenya to think critically about health choices. More than a half (61.7%) of the students had a passing score on the CTH test compared to 34.1% of students in the control schools. Eighteen percent of students had a mastery score compared to just 2.3% in the control schools.

Similar effects were achieved in two concurrent randomized trials that were conducted in Uganda and Rwanda (unpublished work). The proportion of students in intervention schools with a passing score

TABLE 4 Main results.

	Control schools 1499 students 40 schools	Intervention schools 1863 students 40 schools	Adjusted difference	Odds ratio	*p* Value	ICC
Primary outcome[a]						
Students with a passing score (≥9/18)[b]	511 (34.1%)	1149 (61.7%)	27.3% (19.6%–34.9%)	3.6 (2.5–5.2)	<0.0001	0.15
Secondary outcomes[a]						
Students with a mastery score (≥14/18)[b]	35 (2.3%)	341 (18.3%)	14.7% (11.0%–18.4%)	9.1 (5.5–15.1)	<0.0001	0.14
Mean score for students[c]	40.7% (16.3%)	55.0% (20.2%)	14.1% (10.8%–17.3%)		<0.0001	0.13
Teachers[d]						
Teachers with a passing score (≥9/18)[e]	35 (87.5%)	39 (97.5%)	11.7% (−2.6%–26.0%)	5.3 (0.6–264.3)	0.2115	
Teachers with a mastery score (≥14/18)[b]	9 (22.5%)	35 (87.5%)	64.8% (48.3%–81.3%)	24.6 (7.4–82.4)	<0.0001	
Mean score for teachers[b]	63.3% (13.9%)	86.8% (11.4%)	23.4% (17.9%–28.9%)		<0.0001	

Note: Data are % (SD), % (95% CI), or *n* (%).
ICC = intraclass correlation coefficient.
[a]The cluster design was accounted for using random intercepts at the level of school.
[b]Logistic regression was used to estimate an adjusted odds ratio, which is reexpressed as an adjusted risk difference.
[c]Linear regression was used to estimate an adjusted difference in means.
[d]Teachers were treated as equivalent to the units of randomization (schools), so these models did not include random intercepts.
[e]Exact logistic regression was used to estimate an odds ratio, accounting for complete determination by school ownership. The stratification variables were modeled as fixed effects in all analyses. Wald-type confidence intervals and two-sided normal *p*-values were computed in all analyses except for the exact logistic regression, which uses conditional distributions of sufficient statistics.

was slightly higher in Kenya (61.7%) compared to Rwanda (58.2%) and Uganda (55.1%). However, the adjusted difference was less (27.3%, 37.2%, and 32.6%, respectively) due to a higher proportion of students in the control schools with a passing score (34.1%, 19.4%, and 24.7%) and, correspondingly, a smaller odds ratio (3.6, 10.6, and 4.8).

The effect of this intervention is also consistent with findings of a previous randomized trial of the IHC primary school intervention in Uganda.[13] Apart from that trial, there are no directly comparable evaluations of school-based interventions for teaching critical thinking about health in low-income settings. Other evaluations of school-based interventions for teaching critical thinking about health have used different outcome measures and were in high-income settings.[6]

In contrast to the primary school intervention, the IHC secondary school intervention did not include a textbook for the students or teachers. Only teachers had access to digital resources. The teacher training included in the secondary school intervention was likely a critical component of the intervention, given the lack of resources that students could access directly. The training may also have improved teachers' interpretation of the nine key concepts and critical thinking pedagogy, as reported in evaluation of other critical thinking interventions.[28] The teacher training also may have addressed two factors that were reported in the context analyses: the inability-order questions over higher-order questions, and lack of training in constructivist teaching approaches.[12,29,30]

Strengths of this trial include participation of a large number of schools and random sampling to ensure inclusion of a representative sample of schools and applicability to other schools in Kenya.

Limitations of this study include that we developed both the intervention and the outcome measure, and the outcome measure was aligned with the intervention (treatment-inherent). That is, it measured content taught in the intervention schools and not in the control schools. In education, treatment-inherent measures are associated with larger effect sizes than treatment-independent outcome measures.[31] However, the CTH test drew on questions from a databank of items that independent researchers judged to have face validity,[32] we validated the outcome measure using Rasch analysis,[23] and an independent group of judges determined the standards for passing and mastery.[24]

Other limitations of this study are that we did not measure long-term outcomes (retention of what was learned), use of what was learned in daily life, or adverse outcomes. Although we asked teachers in the intervention arm of the trial to monitor for adverse events and report these, we did not specify any specific potential harms, such as conflict due to students challenging teachers or others, or misunderstandings resulting in poor health choices. We are exploring other potential benefits and adverse effects in a process evaluation[21] and we will measure retention, far transfer, and adverse effects in a 1-year follow-up study[21] Additionally, the intervention we evaluated was

a one-time, stand-alone set of lessons. It included only 9 of 17 key concepts prioritized for lower secondary school students out of 49 potentially important concepts for assessing claims about health interventions and making informed choices.[20] It also did not include other relevant skills, such as finding health information that is reliable, and it did not address lack of access to reliable health information or to effective health care. It seems unlikely that the IHC secondary school intervention alone will have a measurable impact on health outcomes.

In summary, we have shown reliably that it is possible to teach adolescents in secondary school to evaluate information about treatments in low-income settings. Teaching critical thinking about health is possible within the current Kenyan lower secondary school curriculum, but learning resources will need to be adapted for inclusion in and across existing subjects. The IHC educational resources can help secondary school students develop skills that they need to make informed health decisions now and in the future.

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CONFLICT OF INTEREST STATEMENT

We both developed and evaluated the intervention.

DATA AVAILABILITY STATEMENT

The deidentified dataset and data dictionary will be available on Zenodo with publication of this report, together with the protocol, informed consent forms, and outcome evaluation tool.[16]

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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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