IMPROVING SCIENTIFIC AND GRANT WRITING AMONG EARLY-CAREER SCIENTISTS INVOLVED IN HEALTH SCIENCE RESEARCH IN LOW- AND MIDDLE-INCOME COUNTRIES: A CASE OF STRENGTHENING INSTITUTIONAL CAPACITY FOR RESEARCH ADMINISTRATION IN UGANDA (SICRA)

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ABSTRACT

Background: Expertise in scientific and grant writing are essential in health science research and practice. Quality scientific and grant writing are uncommon in Uganda which is partly responsible for the low quality and quantity of research outputs. To address this, the Makerere University Walter Reed Project (MUWRP) implemented Strengthening Institutional Capacity for Research Administration in Uganda (SICRA).

Methods: SICRA conducted 3-day face-to-face and virtual training workshops in scientific and grant writing targeting early-career scientists (ECS) at institutions involved in health research and graduate training in Uganda. Mentorship and follow-up were by phone call, email and face-to-face meetings as required.

To determine the effect of SICRA interventions, we conducted a quasi-experimental impact assessment among trainees using a semi-structured questionnaire.

Results: 245 ECS attended SICRA workshops on grant writing (37.2%), scientific writing (33.3%), or both (28.2%). Seventy-eight trainees (32%) participated in the impact assessment. A majority of respondents (60.3%) had a master's degree; 83% were full-time employees at a research or academic institution and 97.4% were involved in health research. Before SICRA, only 34.6% of respondents had written a manuscript, 19.2% had submitted at least one manuscript for institutional internal review and 25.6% had been published. After SICRA, 66.7% had written a manuscript ($p<0.001$), 51.3% had submitted a manuscript for internal review ($p<0.001$) and 38.5% were published ($p=0.064$). Before SICRA, only 37.2% had submitted a grant proposal, 24.4% had won a grant and 43.6% had participated in grant writing teams. After SICRA, 64.1% had submitted a grant proposal ($p<0.001$), 42.3% had received funding ($p=0.011$), and 62.8% were participating in grant writing teams ($p=0.02$).

Conclusions: SICRA improved ECS scientific and grant writing which led to increased research output. The 3-day training approach is appropriate for Uganda and similar LMICs.

Keywords:

early-career scientists, scientific/grant writing, research administration

INTRODUCTION

Expertise in scientific communication including scholarly and grant writing are quintessential for a successful career in health science practice and research (Guyer et al., 2021; Behzadi & Gajdács, 2021; Council on Education for Public Health, 2021). The "modern" scientific paper can be traced back to the 17th century when form and style were first standardized with the publication of Le Journal des Scavans in France on 5 Jan 1665, and Philosophical Transactions in the United Kingdom on 6 March 1665 (Fyfe et al., 2015; Ghasemi et al., 2022). By the 19th century, experiments were being described in detail to allow reproducibility, referencing previous works; structuring scientific papers was evolving to ensure standardization. The current formal structure of scientific papers, i.e. introduction, methods, results and discussion (IMRaD) was adopted in the 1980s (Audisio et al, 2009). Currently, there are about 52,564 journals covering various topics in biomedical sciences (Ghasemi et al., 2022) and disseminating novel findings, knowledge and ideas through professional writing and publishing is critical for authors, the public and advancement of science (Azer et al., 2012).

Conducting rigorous research that is worthy of publication in impactful peer-reviewed journals requires sustainable funding, which is usually obtained through grant writing. Grant writing can be a daunting and tedious process for many scientists; depending on the application requirements, complexity of the idea/research and experience of the team, it may take six to twelve months to write, review and submit a winning grant proposal (Devine, 2009). Grant application success rates are low, for example, less than 15% of applications to the European Union's Horizon Research and Innovation Programme were funded in 2020, and less than 20% of applications were funded by the NIH (Weidmann et al., 2023). Practice and training can help in learning the basics of writing manuscripts and grants (Arrazola et al., 2020; Asokan & Shaji, 2016; Brumback, 2009; Bulage et al., 2021), however, good writing requires multiple procedures which are based on a framework/blueprint (Gemayel, 2016; Tullu, & Karande, 2017), mentoring by successful and seasoned authors and grant writers (Brumback, 2009), and robust supportive institutional structures including research and grant administration systems (Bavdekar & Tullu, 2016).

Many low- and middle-income countries (LMICs) including Uganda have low research output mainly because of structural barriers; e.g., inadequate funding and research infrastructure (Fosci et al., 2019; Chan & Costa, 2005; Franzen et al., 2017; Man et al., 2004), however Uganda has steadily improved (Fosci et al., 2019). In 2020, the Essence on Health Research ranked Uganda as having Upper Medium Research Capacity based on the number of clinical trials, international grants (World RePORT), publications (PubMED) and

training institutions offering Ph.D.s (Eigbike & Essence on Health Research, 2020). This is in part due to targeted capacity building programs funded by internationally renowned institutions including the National Institutes of Health (NIH), Fogarty International Center, Wellcome Trust, WHO's Tropical Disease Research (TDR), the Swedish International Development Agency (SIDA), Department for Research Cooperation (SAREC), the European Union and the Bill & Melinda Gates Foundation (Fosci et al., 2019; Whitworth et al., 2008). The NIH has played a leading role by providing grants for many individual and institutional training programs at Ugandan tertiary and research institutions, especially Makerere University, and many of the supported programs focus on research training in Malaria, HIV, TB, Trypanosomiasis, and a few noncommunicable conditions, e.g., cancers. International and local funding opportunities for Ugandan researchers and research institutions have also increased, especially after the COVID-19 pandemic. For instance, the government of Uganda and the U.S. Government have made significant multi-million-dollar investments in research funding and infrastructure development for health research and vaccine development in Uganda in recent years (Haberer et al., 2023; Kwizera et al, 2021). However, despite these efforts, the quantity and quality of research outputs including innovations and peer-reviewed publications remains relatively low in Uganda and many other LMICs particularly due to inadequate research support and administration (Fosci et al., 2019), and knowledge and skills gaps in scholarly writing. Uganda's secondary and tertiary education does not offer adequate training in scholarly writing (Nsambu, 2007, Kyakuwa, 2023) and the health workforce—especially early-career scientists (ECS)—have few opportunities or encouragement for continuing education, practice and mentorship to improve professional writing skills (Oluwasanu et al., 2019; Lescano et al., 2019; Obuku et al., 2018; Ssemata et al., 2017; Nakanjako et al., 2011).

To improve professional scientific and grant writing among ECS in Uganda, the Makerere University Walter Reed Project (MUWRP) implemented a NIH funded G11 program titled Strengthening Institutional Capacity for Research Administration in Uganda (SICRA) between 2015 and 2020. SICRA training targeted research and administrative staff at key partner institutions involved in health research and graduate-level training in Uganda, i.e. MUWRP, Uganda Cancer Institute (UCI), Makerere University College of Veterinary Medicine, and Animal Resource and Biosecurity (MakCOVAB). In July 2021, we conducted an impact assessment to determine the effect of SICRA interventions, and here we present the findings and recommendations from our work.

METHODS

Trainee and Mentor Selection

SICRA trainings were advertised by email, flyers/posters on notice boards at target institutions, and social media (WhatsApp). Prospective trainees were required to write an expression of interest including how the respective SICRA training workshops will impact their career. For grant writing workshops, trainees were expected to have evidence of employment with a research or academic program or to be a student at one of the recognized Universities. They were also required to have a proposal topic, a target funding opportunity for which they are eligible and a reference letter from their institutional head or immediate supervisor. For scientific writing workshops, trainees required a research dataset, a manuscript topic and at least an abstract. At the beginning of the training program, trainees were asked to enumerate their respective expectations from the training engagement at an individual and team level. Similarly, the training organizers enumerated the training goals and the responsibilities of the trainees. The expectations were reviewed daily between the trainees and the training organizers to assess how well they were being met, and together agreed on reasonable adjustments in the training approach so that expectations were met. The trainers and mentors for both the scientific/manuscript and the grant writing training workshops were selected based on their subject matter expertise, experience (including grant-winning history, publications in peer-reviewed journals, and adult learning), flexibility, commitment to the program and a demonstrable willingness to provide ongoing mentorship.

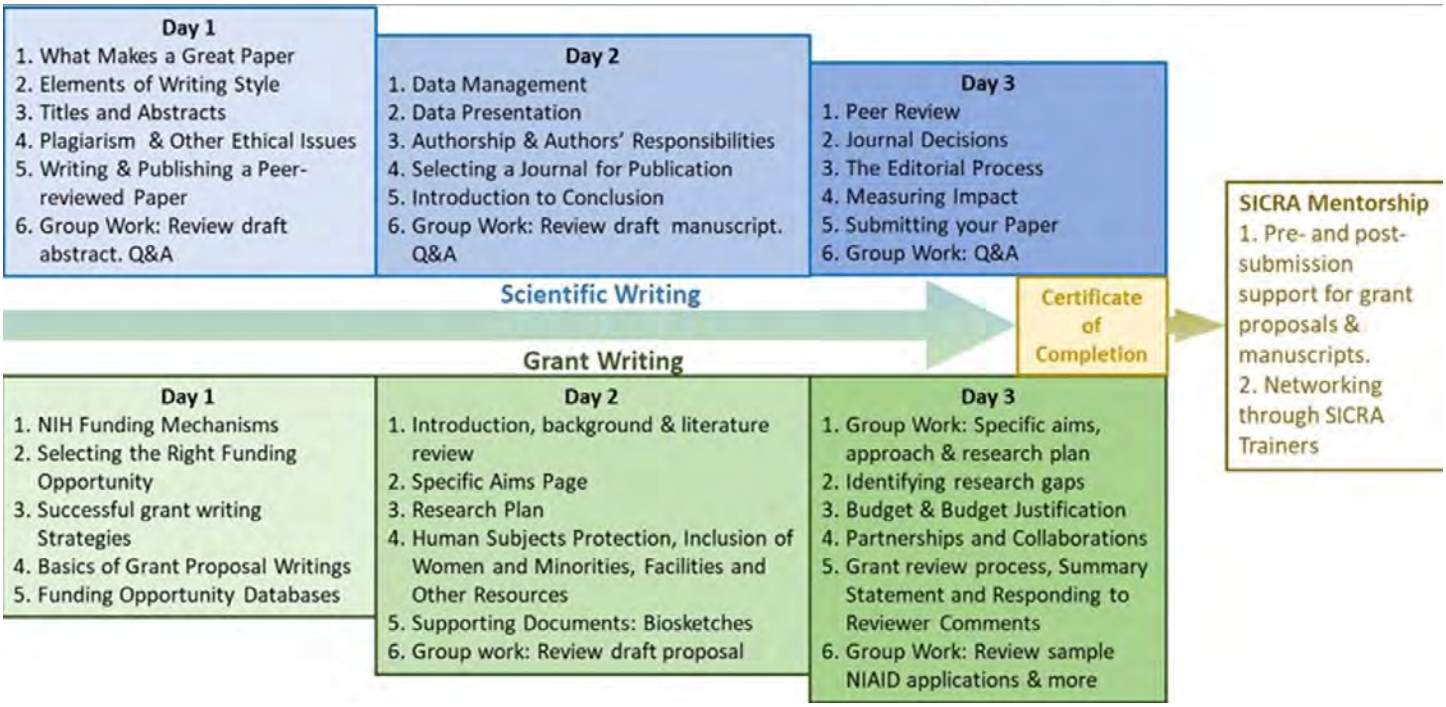
Training Approach

Figure 1 below summarizes the SICRA Training Approach. Between 2016 and 2020, SICRA conducted three workshops in scientific writing and six workshops in grantsmanship (including research administration) to train and mentor ECS at MUWRP, MakCOVAB, UCI, and other research and academic institutions in Uganda. Using an interactive approach that paid attention to specific individual and/or team training needs, trainees were supported to develop their draft grant proposals and/or manuscripts.

Training Curriculum and Trainers

The sample training curriculum is summarized below in Tables 1 and 2. Also refer to the Supplementary Materials for the sample training slides used as well as the abridged trainers' biography.

Figure 1
SICRA's 3-day Training Approach and Curriculum



The Training focused on (1) writing a good story from the editor's, reviewer's, or reader's perspective i.e. writing for the audience, (2) improving scholarly writing style for clear and concise writing, (3) manuscript structure (IMRaD) and NIH grant structure, (4) misconduct during writing and publication, (5) creating data management plans and best practices during data dissemination, (6) deciding who should be an author or principle investigator and how to share authorship and leadership on grant proposal, (7) criteria to consider when selecting target journals and funding mechanisms, (8) understanding the peer-review and grant review process and responding to reviewers' comments, (9) understanding research metrics, NIH scoring and contribution to science, and (10) preparing cover letters and navigating the submission process.

Table 1
Sample Agenda for the Manuscript Writing Workshops

DAY ONE			
Morning Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	What makes a great paper?	JT (Educationist and Journal Editor)	1 Hour
	Elements of writing Style	BA (Grants Management Specialist)	1 Hour
	Titles and Abstracts	MK (Educationist and Clinical Trialist)	1 Hour
Afternoon Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Plagiarism & other ethical issues	NS (Educationist, Clinical Trialist, Ethicist)	1 Hour
	Writing & publishing a peer-reviewed paper	NS (Educationist, Clinical Trialist, Ethicist)	1 Hour
	Group work: Review drafts Abstracts. Q&A	FK (Clinical Trialist, Clinician Educator)	3 Hours
DAY TWO			
Morning Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Data Management	MM (Epidemiologist and Public Health Researcher)	1 Hour
	Data Presentation	FM (Biostatistician and PH Researcher)	1 Hour
	Authorship & Author's responsibilities	FW (Educationist/Epidemiologist)	1 Hour
Afternoon	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Selecting a Journal for publication	FW (Educationist/Epidemiologist)	1 Hour
	Introduction to conclusion	ER (Educationist/PH Researcher)	1 Hour
	Group work: Review draft manuscript. Q&A	FK (Clinical Trialist, Clinician Educator)	3 Hours
DAY THREE			
Morning Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Peer-review Process	JT (Educationist and Journal Editor)	1 Hour
	Journal Decisions	JT (Educationist and Journal Editor)	1 Hour
	The Editorial Process	JT (Educationist and Journal Editor)	1 Hour
Afternoon Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Measuring impact	PN (Clinical Trialist)	1 Hour
	Submitting your paper	GN (Educationist, Clinical Researcher)	0.5 Hours
	Group work	FK (Clinical Trialist, Clinician Educator)	1 Hours
	Experiential sharing from a successful Journal Author, Q&A	Guest Speaker (Successful Peer/ Young/upcoming Investigator and author)	1 Hour
	Awarding Certificates	HK (Clinical Trialist, ED MUWRP)	0.5 Hours

Each SICRA workshop lasted 3 days and involved face-to-face and online didactic lectures, group practical sessions and question and answer sessions. After, trainees were awarded certificates of completion and offered ongoing mentorship and research/grant administrative support through email, text messages and phone calls.

Table 2
Sample Agenda for the Grant Writing Workshops

DAY ONE			
Morning Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Funding Opportunity Databases	SA (Senior Research Administrator)	1 Hour
	NIH Funding Mechanisms	HT (Senior Grants Specialist)	1 Hour
	Selecting the Right Funding Opportunity	SA (Senior Research Administrator)	1 Hour
Afternoon Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Successful grant writing strategies	BA (Grants Management Specialist)	1 Hour
	Basics of Grant Proposal Writing	MG (Social Scientist/Grants Management Specialist)	1 Hour
	Group work: Q&A	FK (Clinical Trialist, Clinician Educator)	3 Hours
DAY TWO			
Morning Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Literature Review: Finding research gaps	LN (Educationist/Clinical Researcher)	1 Hour
	Specific Aims Page	FK (Clinical Trialist, Clinician Educator)	1 Hour
	Research Plan: Significance, innovation, approach, Human Subjects protection; inclusion of women & minorities.	HT (Senior Grants Specialist)	1 Hour
Afternoon	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Facilities and other Resources	MG (Social Scientist, Grants Management Specialist)	1 Hour
	Supporting Documents: Biosketches, Letters of Support, etc.	SA (Senior Research Administrator)	1 Hour
	Group work: Review draft proposal. Q&A	FK (Clinical Trialist, Clinician Educator)	3 Hours

DAY THREE			
Morning Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Group work: Review specific aims, approach & research plan	FK (Clinical Trialist, Clinician Educator)	1 Hour
	Budget and Budget justification	AN (Finance and Administration Lead)	1 Hour
	Partnerships and Collaborations	FW (Educationist/Epidemiologist)	1 Hour
Afternoon Session	**Topic**	**Trainer Initials and Qualifications**	**Duration of the session**
	Grant review process: Summary statement and responding to reviewer comments	HT (Senior Grants Specialist)	1 Hour
	Group work: Review sample NIH applications.	HT (Senior Grants Specialist)	1.5 Hours
	Grants journey experiential sharing from a successful Young Investigator, Q&A	Guest Speaker (Successful Young/upcoming Investigator)	1 Hour
	Awarding Certificates	HK (Clinical Trialist, ED MUWRP)	0.5 Hours

Impact Assessment

In 2021, 245 former SICRA trainees were invited by email to participate in the impact assessment. We received confirmation of attendance from 70% of former trainees but 2 days before the workshop, COVID-19 containment measures were announced in Uganda which hindered travel and public gatherings including workshops. Despite this, 78 (32%) attended the half-day impact assessment workshop and participated in a quasi-experimental survey using a semi-structured questionnaire designed to collect data on: (1) demographics and (2) experience, knowledge, skills and attitude towards scientific and grant writing before and after SICRA. (Refer to Supplemental File 3). After the survey, attendees participated in open-ended discussions with the facilitators to ask questions and provide feedback about SICRA's training approach and impact.

Statistical Analysis

Demographic and descriptive data are presented as frequency counts and percentages. Data collected under a before and after SICRA design were analyzed using the two-sided exact McNemar's test for categorical variables and the Wilcoxon matched-pairs signed-ranks test for continuous variables. P-values (p) less than 0.05 were considered statistically significant.

Ethical Considerations

SICRA activities were approved by Makerere University School of Public Health Research Ethics Committee (MakSPH-HDREC) and the Uganda National Council of Science and Technology (UNCST). Since SICRA was a training program with a pre-planned impact assessment, MakSPH-HDREC granted a waiver of written informed consent. All individuals who participated in the impact assessment provided verbal informed consent. To ensure confidentiality, all questionnaires were coded and did not contain personal identifiers.

RESULTS

Demographics

245 ECS attended at least one SICRA workshop, i.e., grant writing (37.2%), scientific writing (33.3%), or both (28.2%). Although 70% of the trainees confirmed their intention to participate in the impact assessment, only seventy-eight trainees (32%) eventually participated

in the impact assessment mainly due to the COVID-19 containment measure announced by the Uganda Government restricting movements and gatherings. Of the 78 SICRA trainees who participated in the impact assessment, 43 (55%) were males, 29 (37.2%) attended the grantsmanship training only, 26 (33.3%) attended scientific writing training only, and 22 (28.2%) attended both. Forty-seven (60.3%) had a masters' degree, 65 (83.3%) were full-time employees at a research/ academic institution and 76 (97.4%) classified their work as involving research (Refer to Table 3).

Table 3
Demographics of SICRA Trainees who Participated in the Impact Assessment (n=78)

Participant Characteristics	n (%)
Gender	
Male	43(55.1)
Female	35(44.9)
Highest Level of Education	
Diploma	1(1.3)
Bachelors	20(25.6)
Post-graduate diploma	2(2.6)
Masters	47(60.3)
Ph.D.	7(1.3)
Post-Doc	1(1.3)
SICRA Workshop attended	
Grants writing	29(37.2)
Scientific writing	26(33.3)
Both	22(28.2)
No response/missing	1(1.3)
Employed at an academic/research institution	65(83.3)
No response/missing	2(2.6)
Job classification	
Research	54(69.2)
Academic	6(7.7)
Program implementation	9(11.5)
Administration	6(7.7)
Clinical	3(3.9)
Job involves research	76(97.4)
Expertise (multiple response question)	
Basic sciences research	27(34.6)
Clinical trials	39(50.0)
Public health/epidemiological research	39(50.0)
Implementation sciences/operational research	31(39.7)
Translational (basic sciences to clinical) research	15(19.2)
Bio-behavioral research	13(16.7)
Social Sciences research	18(23.1)

Scientific Writing

A majority of trainees who participated in the impact assessment reported that SICRA improved their knowledge, skills and competencies in scientific writing. Before SICRA, 42.3% said they lacked adequate writing skills/expertise, 17.9% mentioned they lacked confidence and 32% reported inadequate mentorship. All the aforementioned indicators reduced after SICRA: only 10.3% lacked adequate writing skills/expertise ($p<0.001$), 6.4% lacked confidence ($p=0.012$), and 11.5% noted inadequate mentorship ($p<0.001$). SICRA did not impact trainees' heavy workload, access to research data, data analysis skills and ability to identify research topics. Below are quotes from select SICRA trainees about the impact of SICRA on their scientific writing:

> *"My participation in SICRA training generally influenced my confidence in writing and helped me gain a more positive attitude towards scientific writing. Additionally, SICRA provided extra resources to help in guiding e.g., websites."* ***(K_01)***

> *"I had confidence in the abstract I was going to present because I was sure that it was well-written, and the research was well-done following mentorship and writing skills I received from SICRA."* ***(K_12)***

> *"After attending scientific writing training, I re-wrote my dissertation, I felt confident about my work and decided to share it with a bigger group."* ***(K_07)***

> *"It [SICRA] empowered me and gave me more knowledge on writing."* ***(K_39)***

SICRA also improved manuscript output and publications in peer-reviewed journals: before SICRA, only 34.6% had written a manuscript, 19.2% had submitted at least one manuscript for internal review, and 25.6% had published in a peer-reviewed journal. After SICRA, each of the aforementioned indicators increased: 66.7% had written a manuscript ($p<0.001$), 51.3% had submitted manuscript(s) for internal review ($p<0.001$), and 38.5% ($p=0.064$) had been published (Refer to Table 4).

Table 4
Trainees' Experience in Scientific Writing Before and After SICRA

Trainee skills	Before, n(%)	After, n(%)	p-value
Inadequate writing skills/expertise	33(42.3)	8(10.3)	<0.001
Lack of confidence	14(17.9)	5(6.4)	0.012
Inadequate data analysis skills/expertise	14(17.9)	7(9.0)	0.119
Inadequate mentorship	25(32.0)	9(11.5)	<0.001
Access to Data	8(10.3)	5(6.4)	0.4531
Lacked a topic	5(6.4)	2(2.6)	0.250
Heavy workload	20(25.6)	14(17.9)	0.146
Wrote a manuscript (as lead or one of the authors)	27(34.6)	52(66.7)	<0.001
Number of manuscripts written: median (IQR)	0(0-1)	1(0-2)	0.268
Submitted a manuscript for internal review	15(19.2)	40(51.3)	<0.001
Published in a peer-reviewed journal	20(25.6)	30(38.5)	0.064
Number of published manuscripts: median (IQR)	0(0-0)	0(0-1)	0.132
Number of published manuscripts: mean (SD)	0.7(1.9)	1.0(2.5)	0.370
Presented at a conference/symposium	37(47.4)	32(41.0)	0.442
Number of conferences/symposia: mean (SD)	1.7(3.5)	0.9(2.3)	0.003

Grant Writing

SICRA increased grant proposal output and participation in grant writing teams: before SICRA, 43.6% of respondents had participated in grant writing teams (including roles where they were not the lead) which increased significantly to 62.8% after SICRA (p=0.02). Similarly, there was a statistically significant increase in the proportion of respondents who submitted a grant proposal after SICRA, i.e. from 37.2% to 64.1% (p<0.001). The number of grant awardees also increased from 24.4% to 42.3% after SICRA (p=0.011). Below are quotes from select SICRA trainees about the impact of SICRA on their grant writing:

*"After attending SICRA I had the confidence and self-belief that I would participate in a successful grant writing and submission. SICRA gave me the skills and additional knowledge on how to perform grants writing." **(K_22)***

*"Participation in SICRA helped me learn how to draft a grant and even a concept, so I felt more confident to participate." **(K_60)***

*"The skills gained in critical appraisal, understanding FOA guidelines influenced my decision." **(K_58)***

SICRA also increased the number of trainees who joined grant writing teams and assumed various supportive roles. We observed significant improvements in the number of trainees who: 1) conducted literature reviews i.e. 17.9% to 35.9% (p<0.001); 2) developed statistical plans i.e. 3.8% to 12.8% (p=0.039); 3) developed budgets i.e.15.4% to 28.2% (p=0.021); 4) handled referencing/ citations i.e. 3.9% to 16.7% (p=0.006); and 5) formatted proposals i.e. 9.0% to 23.1% (p=0.012).

SICRA also significantly improved awareness about research and grant administration: before SICRA, 65.4% were aware of grant/research administration support systems at parent organization and 47.4% were aware of research policies/research strategic plans/Standard Operating Procedures at parent organization; both indicators significantly improved to 88.5% and 83.1% respectively.

Table 5
Trainee's Experiences in Grant Writing Before and After SICRA

Participant Milestones	Before, n (%)	After, n (%)	p-value
Submitted a grant proposal	29(37.2)	50(64.1)	<0.001
Number of proposals submitted: Median (IQR)	0(0-1)	1(0-3)	<0.001
Received funding for a grant proposal	19(24.4)	33(42.3)	0.011
Participated in grant writing not as the lead	34(43.6)	49(62.8)	0.020
Roles in grant writing Teams			
Drafting sections	16(20.5)	20(25.6)	0.524
Literature review	14(17.9)	28(35.9)	<0.001
Selecting collaborators	7(9.0)	14(17.9)	0.092
Participated in Concept Development	17(21.8)	27(34.6)	0.064
Study designing	15(19.2)	21(26.9)	0.238
Statistical plan development	3(3.8)	10(12.8)	0.039
Secretariat and administrative roles			
Yes	8(10.3)	10(12.8)	0.804
Budget development	12(15.4)	22(28.2)	0.021
Referencing	3(3.9)	13(16.7)	0.006
Proposal formatting	7(9.0)	18(23.1)	0.012
Aware of grant/research administration support system at parent organization	51(65.4)	69(88.5)	<0.001
Aware of research policy/research strategic plan/manual/SOP at parent organization	37(47.4)	64(83.1)	<0.001

Perception about SICRA Training Model

A majority of trainees who participated in the impact assessment considered the SICRA training approach as appropriate to address ECS training needs in professional scientific and grant writing: 75 (96.2%) indicated that they would strongly recommend SICRA to their colleagues; and 71 (91%) strongly agreed and/or agreed that SICRA provided adequate skills to write manuscripts/grants and/or identify appropriate funding opportunities. Only 24 (30.8%) reported that they required further training in scientific and grant writing after SICRA.

DISCUSSION

SICRA workshops and training modules were designed to target ECS at select institutions involved in research and graduate-level training in Uganda, as a majority of SICRA trainees were full-time employees holding a masters' degree, as is common for many ECS in Uganda.

Overall, our results demonstrate that SICRA significantly improved ECS's knowledge, skills, competence and confidence in scientific and grant writing including understanding the characteristics of good writing and review processes as evidenced by actual engagement in writing which culminated in publications in peer-reviewed journals and grant awards after SICRA. SICRA trainees therefore increased research output at MUWRP, UCI, MakCOVAB and other target institutions. Our findings corroborate previous scholars who showed that health research output and capacity building models that utilize seminars, workshops, and experienced scientists as trainers significantly improved research capacity (Arrazola et al., 2020; Varadaraj et al., 2019).

However, SICRA may not have significantly addressed some individual barriers in scientific and grant writing such as heavy workload, lack of access to data, inadequate data analysis skills and lack of a topic although there was a trend towards improvement. This could be because SICRA was designed to improve knowledge, skills and competencies in a narrow field

of professional scientific and grant writing, but not time management, data analysis (which varies greatly across scientific genre) and other individual skills required for successful careers in health research. Future SICRA trainings may need to be augmented with more activities and opportunities for ECS to learn from experienced mentors about how to navigate the early stages of a scientific career that usually require huge time investment, hard work and persistence (Shinkafi, 2020; Richards et al., 2021).

Sustaining health research capacity gains from SICRA and similar programs requires functional institutional systems including mentorship, research/grant administration systems (Brumback, 2009). SICRA significantly increased the number of ECS that were adequately mentored, aware and able to utilize grant administrative support staff and research policies at MUWRP, UC, MakCOVAB and other target institutions. The awareness about supportive institutional environments may have also contributed to the observed increase in research output at target institutions.

Finally, since more than 96% of respondents stated that they would recommend SICRA to their colleagues, the SICRA approach/model is appropriate for Uganda and similar settings to train and mentor ECS in professional scientific and grant writing. SICRA workshops and mentorship approaches are based on strategies implemented by others (Behzadi & Gajdács, 2021; Arrazola et al., 2020; Iskander et al., 2018; Sharma, 2010), but slightly adjusted to match the context-specific needs of ECS in Uganda and similar resource-limited settings. For instance, due to heavy workload, many ECS in Uganda rarely have time to spare outside their day-to-day jobs, therefore SICRA training content was condensed into a curriculum that could be taught in a short time (3 days) without significantly impacting working hours. The short-course approach enabled more ECS to attend SICRA workshops to completion, however, this approach may not impart all the knowledge, skills and competencies required to be a professional scientific and grant writer which could explain why some SICRA trainees attended multiple scientific and grant writing workshops.

Limitations

There was a low response rate (32%) in the impact assessment: only 78/245 SICRA trainees participated. We received confirmation of attendance from 70% of former trainees but 2 days before the workshop, COVID-19 containment measures were announced in Uganda which hindered travel and public gatherings. Therefore, it is possible that our data is biased by the low response rate. Second, we relied on the trainees' memory for the before and after SICRA analyses which could cause recall bias. To minimize this, we used each individual as their own control since a healthy ECS can clearly recall what they learned in 1-5 years. Third, the impact assessment did not collect data on other professional writing trainings that SICRA trainees may have attended between 2015 and 2020. However, the increasing popularity and interest in SICRA at various institutions alludes that as a model, SICRA was more appreciated than similar programs at the time. Lastly, SICRA impact assessment did not collect data or follow up on the quality but largely focused on quantity of publications by SICRA trainees.

CONCLUSION

SICRA had a positive impact on ECS's professional scientific and grant writing which lead to increased research output. The 3-day training approach is appropriate for LMICs where ECS may have little time to spare, however future trainings should be augmented with activities and mentorship opportunities that empower ECS to overcome personal barriers in health science career paths, e.g. time management, hard work and persistence. Therefore, future SICRA trainings and other programs considering similar health research capacity-building programs should incorporate training activities and modules that address SICRA's shortcomings and provide opportunities for ECS to sufficiently learn from experienced scientists and mentors. These lessons can inform best practices for future writing courses and resource allocation to support writing activities among ECSs.

AUTHORS' CONTRIBUTIONS

The authors contributed to the manuscript as follows: FK, SA, HK and HT participated in conceptualization and funding acquisition; FK, BA, SA, BM and HK participated in project administration and supervision. FK, BA and EM designed the methodology of the impact assessment; FK, BA, SA, EM, GN, LN, LAM and JK participated in data collection, curation and formal analysis; FK and BA participated in original draft preparation; all authors participated in final review and editing.

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Declarations

The authors declare that there is no conflict of interest.

Supporting Information

S1: SICRA Scientific Writing Workshop Agenda

S2: SICRA Grant Writing Workshop Agenda

S3: SICRA Impact Evaluation Questionnaire

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