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DOI Number: <https://doi.org/10.26203/11sb-h738>

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To cite this article: Cotter, P. *et al.*, (2023). Engaging northern rural and Indigenous students: case studies using One Health and principles of educational resilience. *Education in the North*, 30(1) pp.69-91.



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Engaging northern rural and Indigenous students: case studies using One Health and principles of educational resilience

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Abstract

Indigenous and rural populations are underrepresented in many science-related educational fields, leading to underrepresentation in biomedical, science, and related professions. A contributing factor is the misalignment of Western education and engagement strategies and these cultures; this is especially true for northern subsistence cultures. We review the influence of a combined One Health/Quadripartite Model of Educational Resilience approach in promoting interest in, recruiting for, and retaining students in biomedical research and community health across three education levels. We suggest a One Health context resonates with Indigenous and rural populations and may be more culturally aligned than conventional education approaches. Implementing Quadripartite Model elements promotes educational accessibility and attractiveness to these populations across our programs. We suggest that 1) disciplines that may be perceived as remote and inaccessible to these populations can be culturally contextualized through a One Health lens and; 2) a more equitable sharing of responsibility for educational success may benefit students from underrepresented populations. Applying One Health/Quadripartite Model approaches may help increase representation of Indigenous and rural populations in a wide range of STEM, biomedical, and community health disciplines. We support continued efforts to modify conventional educational structures, institutions, and strategies to further engage these communities.

Keywords: one health, indigenous education, rural education, STEM engagement, educational resilience

Introduction

Several populations are considered underrepresented in science and the biomedical workforce by the United States' National Institutes of Health (NIH), including some racial and ethnic populations (e.g. African American/Black, American Indian/Alaska Native), people with disabilities, and individuals with low income or rural backgrounds (National Institutes of Health, 2019). As a result, workforce diversity in these fields is not reflective of the wider population (Valentine and Collins, 2015). Individuals underrepresented in the biomedical workforce often come from academically disadvantaged backgrounds, which can negatively impact college entrance rates and success, and career trajectories in science, biomedical research, and healthcare (Chang, Sharkness, Hurtado and Newman, 2014). Because public interest is best served when workforce demographics reflect community demographics and values (Cohen, Gabriel and Terrell, 2002), funding agencies have recognized these disparities and have sought to reverse these trends with initiatives focused on expanding opportunities for those from underrepresented populations (National Institutes of Health, 2019).

In this paper, we highlight 1) findings from a federally-funded One Health initiative focused on improving interest and persistence in, and trajectories toward, biomedical and health profession research careers in American Indian/Alaska Native (henceforth, "Indigenous"), rural, and non-rural Alaskan undergraduates and 2) observations from our experience expanding the One Health and Quadripartite Model of Educational Resilience models to engage rural and Indigenous students and professionals at different academic levels (high school, graduate school). We are unaware of other programs explicitly contextualizing their intended educational outcomes within One Health. We suggest our combined One Health and Quadripartite Model of Educational Resilience (henceforth, "Quadripartite Model") framework of our education initiatives aligns closely with the needs and interests of Indigenous and rural student cultures.

Background

Rural Alaska is characterized by low population density, expansive geography without road access, limited local educational and economic opportunities, and significant disparities in health and education infrastructure and health outcomes compared to urban areas. A built-in community resiliency, a result of intricate and multi-layered support structures for community members, is characteristic of rural Indigenous communities. The close tie to the environment – through traditional use of plants and animals for food, clothing, livelihood – strongly defines cultural identity in the region. Like other peoples of the circumpolar north, these populations live within a One Health context (Maatta, Hyvarinen, Aarela, and Uusiautti, 2020; Hueffer, Ehrlander, Etz, and Reynolds, 2019) – the inseparable linkage of human, animal, and environmental health. This well-established multidisciplinary approach to address complex human and community health issues at the human-animal-environment interface suggests the linkage between these three factors means that none can be optimally healthy without all being healthy (American Veterinary Medical Association, 2018). The One Health approach has always been part of, and consistent with, the Indigenous world view (Arquette et al., 2002; Cajete, 2000; Donatuto, Satterfield, and Gregory, 2015).

Education Challenges in Rural Alaska

Rural Alaska schools have less developed academic and career pathway support structures, and offer fewer course choices, than their non-rural counterparts (Defeo, Fallon, Hirshberg, and LeCompte, 2014). The educational aspirations/attainment gap for rural Alaska students (Indigenous and non-Indigenous) is wide – few of those interested in pursuing advanced education and career opportunities embark on, or persist in, education and career advancement. Rural Alaska students who pursue college opportunities are typically low income and first-generation college students; these students are at higher risk to not persist in their chosen educational and career trajectories (Doyle, Kleinfeld, and Reyes, 2009). Developing health scientists, medical and community health practitioners, and others engaged in community action from these rural, primarily Indigenous populations is key to 1) increase participation in biomedical, clinical, and behavioral health occupations; 2) build and maintain community resilience and empowerment; 3) improve health outcomes in these populations; and 4) promote tribal sovereignty (Cajete, 2020; Chapin, Knapp, Brinkman, Bronen, and Cochran, 2016; Henly, Struthers, Dahlen, Ide, Patchell, and Holtzclaw, 2006).

Contributing to the aspiration/attainment gap is the misalignment of educational cultures; Indigenous subsistence cultures embrace traditional Ways of Knowing that differ significantly from Western approaches to education (Grimberg and Gummer, 2013; Semken, 2003). These cultural dissimilarities are often partitioned within the daily lives of Indigenous and rural Alaskans as they experience “school” culture and “home” culture (Grimberg and Gummer, 2013). Too often, it is left to individual students to adapt to Western educational practices; failure to do so is often attributed to a deficiency of the individual instead of being the result of systemic social, educational, and institutional misalignments that maintain barriers to success (Willems, 2012; Masten, 1994). The Quadripartite Model offers a more holistic approach that includes instructors, institutions, communities, and students as responsible stakeholders in generating positive educational outcomes.

Meeting the educational needs of professional and non-professional adults in these communities is difficult. Lack of education resources in remote areas; expense of delivering education to few residents in remote areas; lack of commitment from governments and post-secondary education institutions to serve rural education needs; disparities in preparation for advanced studies between rural and non-rural populations; and the near universal requirement that individuals seeking education opportunities must adapt to the policies, procedures, and culture of the educational institution to be successful contribute to the challenge (Willems, 2012; Guillory, Wolverton, and Appleton, 2008; Guillory and Wolverton, 2008). Educators and institutions catering to those in the dominant culture often fail to accommodate those from non-dominant cultures; a failure that exacerbates the cultural gap (Guillory, 2009). Willems (2012) introduced the Quadripartite Model of Educational Resilience (henceforth, “Quadripartite Model”) – that the shared responsibility (and modifications of conventional approaches) of students, educators, institutions, and communities is necessary for successful Indigenous education initiatives, especially as it applies to distance-delivered courses and programs.

Self-governance

Similar to the notion that public interest is best served when workforce demographics reflect community demographics, community interest and self-reliance are best served when local residents identify problems and work toward solutions consistent with community ideals, priorities, and culture (Wallerstein and Duran, 2006; Wallerstein and Duran, 2003). This is especially important in rural and remote communities with demographic profiles that differ from the broader (or dominant) population - for example, remote Alaska villages with predominately Indigenous populations are located far away from state and federal seats of government. Individuals and communities are empowered and build resilience when local resources, expertise, and workforce contribute to problem identification and solutions (Maton, 2008; Hur, 2006). In remote areas, issues related to community health and wellness, resilience, infrastructure, and education are often poorly addressed. If they are addressed, it is often by centralized government entities or other outside forces that determine the nature and extent of problems and provide solutions - the strategies provided can conflict with local culture, disrespect the expertise and autonomy of community residents, and serve to widen the gap between rural, disadvantaged populations and the broader, dominant population (Cajete, 2020; Chapin et al., 2016). As a result, proposed and/or implemented solutions are often ineffective and not aligned with community interests, a scenario very common in rural Alaska communities on a wide range of issues (Gram-Hanssen, 2017; Lyons et al., 2016; Wilson and Stammler, 2016).

Barriers and Opportunities

Indigenous and rural Alaskans experience many of the same barriers to academic and career paths in science, biomedical research, and healthcare as other underrepresented groups (Toven-Lindsey, Levis-Fitzgerald, Barber, and Hasson, 2015), but they also face unique challenges. Their subsistence lifestyles provide critical perspectives and relevance to biomedical science, education, research, and community health. Given the education and health disparities, and other threats to self-determination in many rural communities, this perspective is crucial to address health care and unique community challenges in rural Alaska in culturally appropriate, relevant, and respectful ways (Lewis and Boyd, 2012; Henly et al., 2006; Wallerstein and Duran, 2006). We propose that combining One Health with redefined and culturally-relevant partnerships between students, educators, institutions, and communities (Quadripartite Model) into a holistic educational experience across education levels might better serve Indigenous and rural students and communities across multiple disciplines (Hueffer et al., 2019). Although widespread implementation may challenge long-held institutional norms, we anticipate this strategy will improve access to, and persistence in, undergraduate biomedical education opportunities and increase advanced degree relevance to rural and Indigenous students and communities.

This paper highlights observations of using One Health, within the context of a Quadripartite Model framework, as an engagement and persistence-enhancing strategy for underrepresented students in biomedical science and community engagement in three University of Alaska programs spanning high school, undergraduate, and graduate education levels. The Undergraduate Program (BLaST: Biomedical Learning and Student Training) is a NIH-funded collaboration between the University of

Alaska Fairbanks and a growing suite of university and college partners that engages Indigenous and rural undergraduate students in biomedical research within an overarching One Health and Quadripartite Model framework (Hueffer *et al.*, 2019; Taylor *et al.*, 2017). The program promotes mentored undergraduate research and other biomedical education support strategies specifically tailored to these student populations.

Since its inception, the Undergraduate Program has inspired the development of a High School One Health Program (RASOR: Rural Alaska Students in One Health Research) for rural high school students and the Graduate One Health Program (One Health Master's) for graduate students and professionals. Although the programs do not share administrative homes or funding sources and are under different leadership, the One Health theme and a commitment to modify typical academic culture to afford greater accessibility by rural and Indigenous students through Quadripartite Model elements is central to all three. In this paper, we discuss the value of adopting these frameworks in promoting engagement in these chronically underrepresented populations; we provide a synthesis of the collective experience gained from these distinct, yet related, programs.

Academic programs: development and overview

Undergraduate One Health Program

In the Undergraduate Program, our mentored One Health research experiences exists within a holistic mentoring framework including academic advising and psychosocial, emotional, research, and academic support structures focused on enhancing rural and Indigenous student experience. The program supports, through group activities and shared study/tutoring and social space, the development of a learning community, which is important in fostering student engagement and identity (Freeman, Alston, and Winborne, 2008; Ginty and Boland, 2016). Student engagement with the program varies from those participating in research and other program-supported academic and college life activities ("Scholars") to those whose sole programmatic involvement is research participation and financial support. Academic status ranges from first to last year of undergraduate studies. Program participants are STEM degree-seeking students gaining research experience, participating in research adjacent activities, and in the case of Scholars, includes 2 biomedical research courses in their academic study plan. Mentored research experiences are recognized as a high-impact education practice that increases science identity and self-efficacy (Kuh, 2008); increases interest in science, technology, engineering, and math careers among undergraduate students (Chang *et al.*, 2014; Eagan *et al.*, 2013); and impacts career trajectories (Yaffe, Bender, and Sechrest, 2014). A broader goal of our Undergraduate Program is to examine the efficacy of a holistic mentoring approach to student research experiences within a One Health context for Indigenous and rural students. With growing success of this program, we expanded student and professional opportunities by developing One Health-based high school and graduate level opportunities with robust remote delivery elements, consistent with the Quadripartite Model, to enhance accessibility to rural students.

High School One Health Program

In the High School Program, we use the One Health approach to engage high school students in place-based, culturally aligned research and education experiences. The program's primary innovation is the opportunity for high school students to participate in locally and culturally relevant mentored research in their own rural communities by modifying conventional education approaches to accommodate rural students. Student research projects are developed and mentored through a partnership with the Southeast Alaska Tribal Ocean Research (SEATOR) network; a confederation of regional tribal entities focused on monitoring harmful algal blooms and resulting toxins in shellfish populations throughout the region – shellfish have strong cultural significance and have been a traditional subsistence food source in Southeast Alaska for thousands of years (Butler and Campbell, 2004; Moss, 1993). This program includes place-based mentored research, attendance of a scientific conference, high contact distance delivered STEM curriculum, community-engagement projects, and presentation of research results. Students in the program can choose to receive both high school and college science credit through the “dual enrolment” program – the program curriculum meets high school and university standards for STEM credits.

Graduate One Health Program

In the newest One Health program, students customize their One Health graduate curriculum to support their professional aspirations and interests in and/or outside of biomedicine, including a variety of community and behavioural health fields (participants choose one of two concentrations; Community Advocacy or Biomedical). The student-driven, interdisciplinary program is designed to reflect a suite of social, community, cultural, and professional needs of Indigenous and rural students and their communities - students study within their home communities through distance delivered coursework and develop a locally relevant capstone project as part of their graduation requirements. This approach aligns with Indigenous perspectives on self-governance, self-reliance, and tribal sovereignty (Ongtooguk, 2003).

Methods

We explore the influence of three (Undergraduate, High School, and Graduate) programs utilizing the One Health concept within a Quadripartite Model framework on Indigenous and rural student academic, research, and professional interest and engagement. Because these programs differ in audience, scope, and focus, and have been implemented at different schedules and by different administrative bodies, we used program-specific instruments to solicit student feedback, evaluate program efficacy, and assess programmatic alignment with student needs. As these programs are related by their One Health and Quadripartite Model context, some instrument items were used across programs.

Student participants

We invited mentored undergraduate research students to voluntarily complete surveys during the last three weeks of their first program-supported research term; a subset of these students also participated in focus group sessions. High school students voluntarily completed surveys upon entering their program. Graduate students voluntarily completed surveys regarding their experience in, reasons for selecting, and expectations of, the Graduate Program. Student involvement in the work presented here,

including their participation in focus groups, completion of surveys, and recruitment strategies, was permitted by the University of Alaska Institutional Review Board.

Surveys

We developed the Undergraduate Research Participation Survey to capture participant demographics; self-reported impacts of mentored research experiences; science self-efficacy and identification; attitudes on One Health; and aspirations regarding biomedical research, education, and career pathways. Survey items included those mapped to “Hallmarks of Success”, a suite of priority metrics identified by the NIH Diversity Program Consortium (McCreath et al., 2017) and those specifically designed for our Undergraduate Program students. We administered surveys electronically to all students participating in program-supported mentored research experiences in each academic term (three terms/year) between September 2015 and December 2019. For our analysis of survey data reported in this study, we only included responses from first-term researchers – students newly introduced to the One Health concept. The high school student survey (2019-2021) was designed to capture student demographics, attitudes regarding One Health, aspirations, and interest regarding science and education/career trajectories prior to their engagement with the High School Program. The graduate student survey was administered once to students (September 2021) from all stages of degree requirement completion to illuminate elements of the program deemed most relevant to enrolled students. Surveys included Likert-style, retrospective pre-post, and open-ended questions where appropriate.

For all surveys, participants were informed by their respective program administrators they would be invited to participate in surveys administered by a third party (external evaluator, P. Cotter) and that their participation was voluntary. Survey introductions included a consent page outlining survey rationale, how data may be used (including in manuscripts for publication), and that university personnel had no access to raw data collected or have access to any information identifying survey participants or their responses. Advancing to the survey required participants to actively consent to the uses outlined in the introduction. Completing the survey, and any of the survey items, was voluntary; no survey items required a response, therefore there exists variation in sample sizes across items within each survey.

Focus groups

For a related project, we convened two focus groups with undergraduate students (first-term undergraduate researchers and multi-term undergraduate researchers) to gain narrative insight on survey data, personal experiences of students engaging in mentored research experiences, and the impact of program structure/staff on student interest, motivation, and experience. Discussions concentrated on student experience with, and impact of, program-trained staff members who are paired with each student to provide holistic mentoring. Focus group data supplemented survey data and provided a means to explain survey data from student perspectives, and to identify instances, and explanations, of cases that do not align with patterns observed in survey data (Rogers and Goodrick, 2012). Participant comments were captured and categorized thematically (e.g. One Health, self-efficacy) and are referenced in this paper to provide a narrative context of the student experience in the program.

Participation in focus groups was voluntary. Program administrators and external evaluator invited, via email, program participants to join focus group sessions. The invitation included rationale and topics for the focus group sessions, and that participation was voluntary. Sessions were conducted solely by the external evaluator; no one affiliated with the program was present. Prior to the start of each session, the evaluator obtained verbal consent from participants that data collected would be deidentified and possibly used in the preparation of a manuscript for publication. With consent from participants, we recorded focus group interviews for later transcription, reference, and to ensure accuracy. Program personnel had no access to the focus groups, recordings, or completed transcripts.

Data and analysis

All participant responses, including those collected through surveys and focus groups, were stored and maintained on multiple, password-protected drives which are only accessible by the external evaluator. Program administrators have access only to de-identified, aggregate data. Focus group recordings, once transcribed by the external evaluator, were destroyed.

We included all first-term undergraduate participant survey responses in our analysis to assess the impact of a single program-supported undergraduate research experience on student attitudes and aspirations. For within-undergraduate program comparisons, we stratified students by self-identified community type of origin – we collapsed survey community type into two categories; rural and non-rural, based on population, location, community access, and U.S. Department of Education criteria. These criteria are based on proximity to urban areas and population size (Geverdt and Duncan, 2015). We categorized small non-road accessible communities meeting U.S. Department of Education “Town-Remote” criteria as rural, due to their rural culture, distance from urban centers, limited access, and prevalence of subsistence lifestyles.

For Likert-style items, we compared groups using nonparametric methods – Kruskal-Wallis for rural/non-rural comparisons, and a paired-sample Wilcoxon for retrospective pre-post (“pre-current” for graduate student survey items) comparisons. To compare amplitude of retrospective pre-post change across rural and non-rural groups, we used a Kruskal-Wallis test on mean retrospective pre-post differences. Rural and non-rural responses to BLaST survey questions regarding One Health were compared using a chi-square test.

We compared high school, undergraduate, and graduate student responses on One Health items using a 2 x 3 chi-square test (Zar, 1974). When the overall chi-square was significant, we used a *post hoc* adjusted residual analysis to identify groups contributing to the observed significant differences (Sharpe, 2015).

Results

Undergraduate Students

Of the 112 unique respondents to the first semester of research survey, 89 (79%) and 23 (21%) included White and Indigenous as part of their heritage, respectively (Table 1). Among white students, 44 (49%) were from rural communities, and 14 (61%) of Indigenous students were from rural communities.

Table 1: Self-reported race/ethnicity* of undergraduate, high school, graduate student participants.

Program	Community Type	Indigenous	White	Other
Undergraduate (n=112)	Rural	14	44	5
	Non-Rural	9	45	16
High School (n=34)	Rural only	11	17	6
Graduate (n=11)	Rural	1	5	--
	Non-Rural	--	1	--

*Undergraduate Program participants were asked to identify race/ethnicities in their heritage resulting in a greater number of heritages identified than number of participants (112), whereas High School and Graduate Program participants were asked how they identify. Not all participants provided race/ethnicity data.

High school students

Because the High school program is focused on rural students, over 87% of survey respondents have spent most of their life in small, remote communities, villages, or unincorporated rural areas in Alaska - all inhabited small remote communities at the time of program participation. Those identifying as White (50%) or Indigenous (33%) made up the majority (83%) of respondents (Table 1).

Graduate Students

A total of 11 graduate students participated in the survey – the small sample size is due to the program being only in its second year. Nine of 10 (90%) respondents identifying where they reside lived in Alaska at the time of the survey. Only 1 of 8 (12.5%) responding to the question regarding type of community they lived in resided in an urban center; all others lived in small cities, towns, or lived outside of communities. Seven respondents identified their heritage; 6 were white, 1 Indigenous (Table 1). Six (55%) of respondents had completed less than 25% of program requirements; 2 (18%) had completed 25-75% of requirements; and 3 (27%) had completed more than 75% of program requirements. Ten respondents identified their current field of work; reflecting the diversity of the program, 9 unique fields were identified. Two individuals worked in government, 1 was unemployed. Other fields included healthcare, behavioral health, social work, veterinary medicine, adventure travel, environmental conservation, and Indigenous activism.

One Health: perceptions, interest, impacts

Across education levels, respondents indicated the relatedness of – and interest in connecting – human, animal, and environmental health (Figures 1 and 2). Generally, very few undergraduate and graduate students in our programs perceive human, animal, and environmental health as different disciplines, whereas nearly 21% of high school students indicated they perceive these as different disciplines (Figure 1). Making connections was strongest in graduate students; a self-selected population of those interested in One Health. Attitudes of One Health did not differ between Alaskan non-rural and rural undergraduate students (chi square ≥ 0.2 , all cases) suggesting that both rural and non-rural Alaska

students recognize or have a connection to their environment. The significance of One Health was summarized by one rural, Indigenous, undergraduate student:

“A big part of our health is subsistence in Alaska. Its so important for mental health. One Health, in general, having animal health, and then having people’s physical health, and then having people’s mental health. I feel like once I got here (Undergraduate One Health Program), I was like, ‘oh, OK, this totally ties in’.”

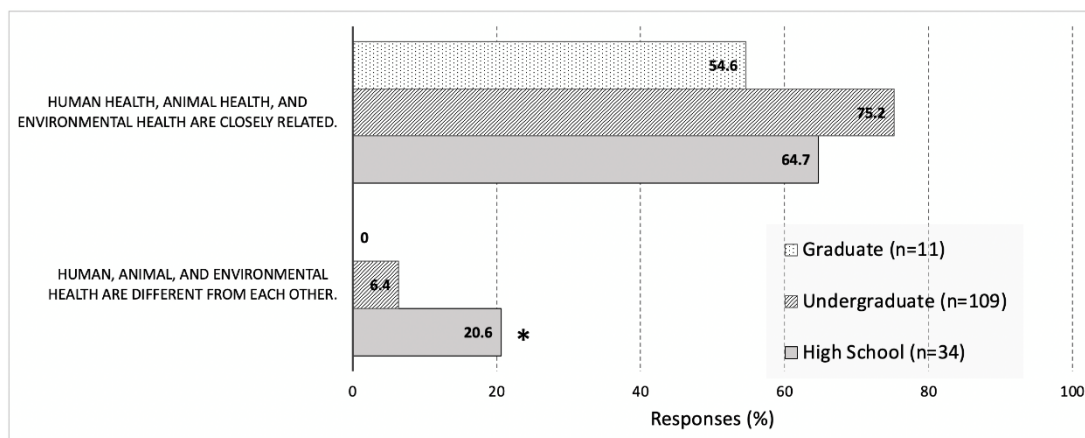


Figure 1: perceived relationship between human, animal, and environmental health disciplines among secondary, undergraduate, and graduate students participating in One Health programs (* $P < 0.05$).

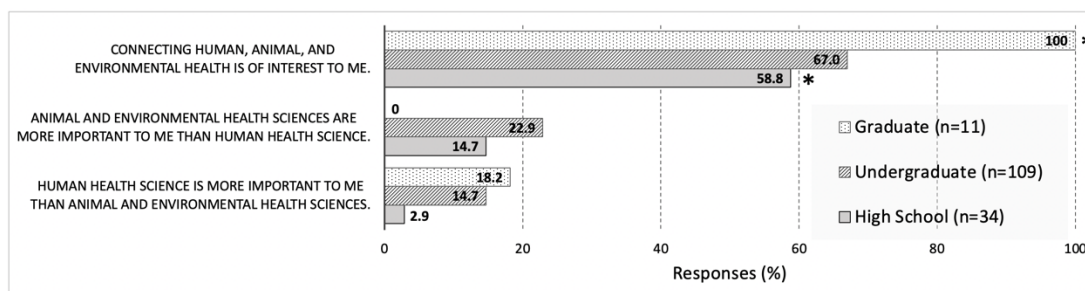


Figure 2: Relative interest in human, animal, and environmental health disciplines among secondary, undergraduate, and graduate students participating in One Health programs (* $P < 0.05$).

High school and graduate student responses showed opposite trends in the relative importance of human and animal/environmental health; no graduate students and nearly 15% of high school students indicated animal/environmental health to be more important than human health. We observed a different trend (18% and 3% graduate and high school students, respectively) in ranking human health as more important than animal/environmental health (Figure 2).

Undergraduate Students - One Health Research Experiences

First-term undergraduate students, both rural and non-rural, indicated increased interest in both animal/environmental health- and human health-related research following (versus before) their research experience ($P < 0.001$; Figure 3). Further, rural students’ interest in animal/environmental health-related research increased more than non-rural students ($P < 0.005$). Rural and non-rural students identified similar and significant self-assessed improvements in understanding of how science is done after a single term of undergraduate research - amplitude of increase was greater in rural

students (Figure 4). Both groups agreed or strongly agreed with statements regarding the impact of undergraduate research participation on indices of science identity (“makes me feel like a scientist”), career interest (“increases my interest in science as a career”), and science self-efficacy (“understanding of how science works”, “understanding of science principles and concepts”).

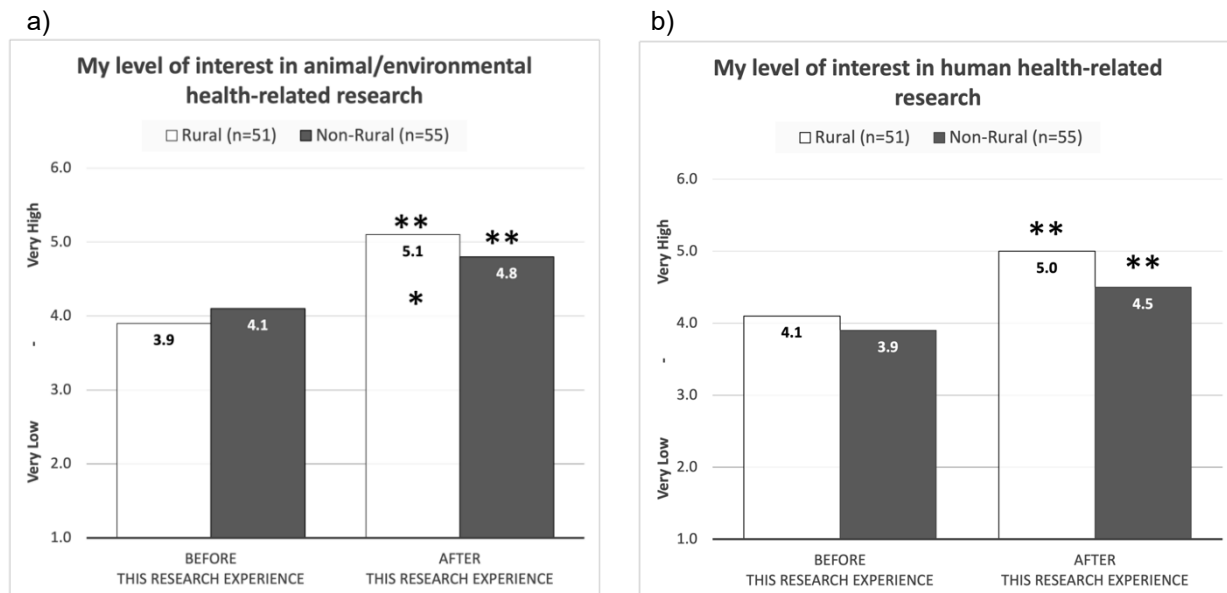


Figure 3: level of interest in a) animal/environmental health-related research and b) human health-related research before and after (retrospective pre-post) a single term of undergraduate research in rural and non-rural Alaska undergraduate students. Asterisks above the columns indicate significant before-after difference; asterisks within the column indicates a significant difference in differences between rural and non-rural respondents (** $P < 0.001$).

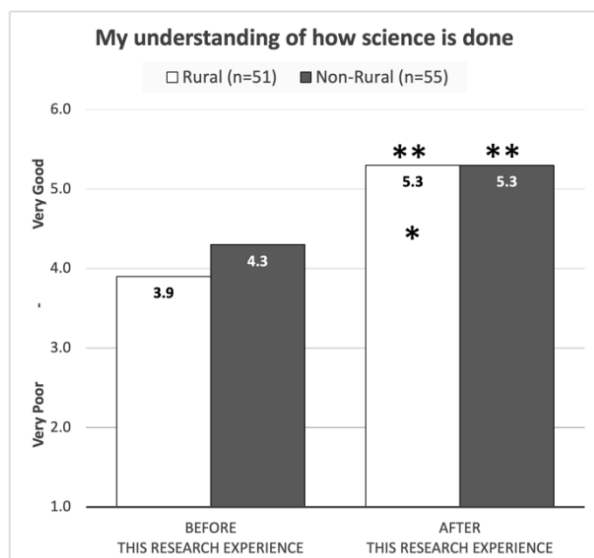


Figure 4: Self-assessed understanding of how science is done before and after (retrospective pre-post) a single term of undergraduate research in rural and non-rural Alaska undergraduate students. Asterisks above the columns indicate significant before-after difference; asterisks within the column indicates a significant difference in differences between rural and non-rural respondents (** $P < 0.001$).

Two undergraduates reflected on the impact of their research experiences with the following,

“I’m excited about my research and I didn’t even want to do it. At the beginning I was like, ‘I guess I will do research if it means I get a scholarship.’ If (The Undergraduate Program’s) goal is to get them excited about research and teach them how to do it, I think they have definitely succeeded.” (Second year Undergraduate Program Scholar).

“I come from a small village, where ‘research’, like only old people do that. Me doing it, is kinda weird. That makes me nervous. It makes me feel like I’m incapable, but because of (The Undergraduate Program) I’m capable.” (First year Scholar)

Graduate Students

By enrolling in the program, students in the Graduate Program are inherently interested in One Health. Survey respondents indicate a significantly increased ability to explain principles of One Health and to make One Health connections once being engaged in the programs ($P=0.01$, both cases). Similarly, despite self-selecting in a One Health program, respondents show increased interest in bringing a One Health perspective to their work lives ($P=0.02$), and an increased perceived value of addressing community issues from a One Health perspective ($P=0.03$; Figure 5). Graduate Program design and implementation measures including program structure (5.4), delivery method (5.2), relevance of content (5.3) and project options (5.0), and value of insight provided by instructors (5.3) were rated highly by students (1-6 scale; 1=strongly disagree; 6=strongly agree), reflecting the recognition of rural student needs by program administrators when designing the program. In response to an open-ended question to identify important factors in choosing the Graduate Program, 5 of the 9 respondents (56%) indicated that the One Health theme was particularly relevant to them. However, this high interest by students from rural areas suggests One Health is attractive and applicable to the goals, interests, and cultures of rural students and professionals, as summarized by one student:

“OHM (Graduate Program) is much more aligned to how my Inupiaq (Indigenous) culture solves problems. Everything is connected and many issues require a multi-disciplinary approach. I hope to help make a positive difference that benefits Alaska Native cultures.”

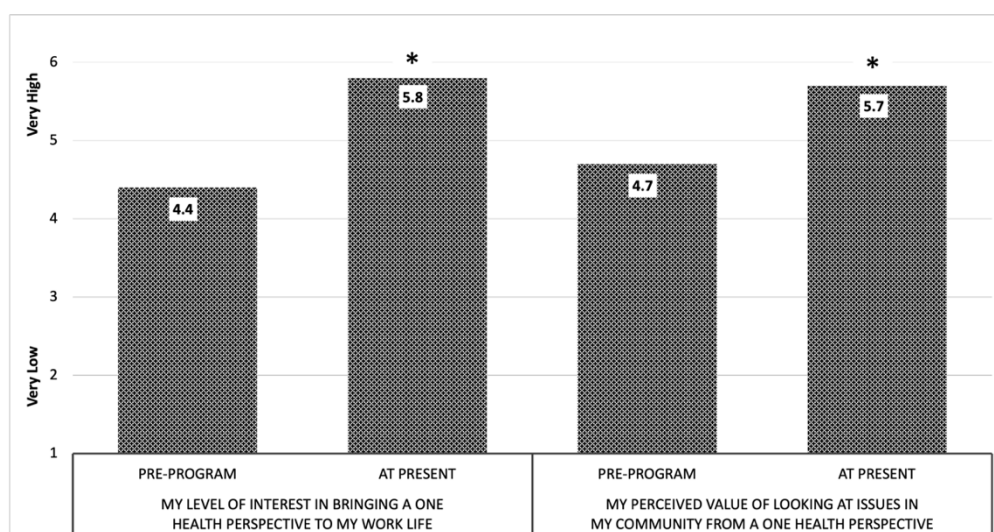


Figure 5: Level of interest in and perceived value of adopting a One Health lens into work and community life of One Health Master’s students ($n=11$). X-axis titles reflect survey questions as written (* $P<0.05$).

Discussion

In this paper, we present our observations using a combined One Health/Quadripartite Model approach to recruit and engage underrepresented students, primarily Alaska Indigenous and rural students, in biomedical science and community action career trajectories across three academic levels. One Health, the connection between human, animal, and environmental health, is historically an Indigenous concept and aligns with modern Indigenous and rural lifestyles and ways of knowing (Riley et al., 2021). The Quadripartite Model posits that there is a shared responsibility of students, instructors, institutions, and communities to improve educational outcomes for rural and Indigenous students (Willem, 2012). We assessed the alignment with, and applicability and effectiveness of, our combined One Health/Quadripartite Model approach on high school, undergraduate, and graduate students.

The approach stems from our observations, and extensive literature, regarding the disparities of access to education of rural and Indigenous students, and misalignment of western education and research practices and the culture, needs, and interests of these populations in Alaska and elsewhere (Minthorn, 2020; Rasmus, Rumbaugh Whitesell, Mousseau, and Allen, 2019; Grimberg and Gummer, 2013; Hollow et al., 2006; Henly et al., 2006). This misalignment contributes to the underrepresentation of rural and Indigenous students in many fields and may threaten efforts to capture and/or maintain critical self-governance (Chang, Wang, Mancini, McGrath-Mahrer, and Orama de Jesus, 2020; Ongtooguk, 2003). Although each of the three programs presented here focus on different educational levels and are administered separately, they share common themes – a One Health context and incorporation Quadripartite Model elements – to be more relevant and accessible to rural and Indigenous Alaska populations. Collectively, the programs represent a more comprehensive approach to education initiatives that more accurately and responsibly reflect and align community culture and value structures.

One Health

Students across our programs are highly interested in One Health and they view human, animal, and environmental health as being more closely linked than not (Figures 2 and 3). Undergraduate student interest in the linkage of animal, human, and environmental health was independent of background community type (rural versus non-rural Alaska), indicating that a One Health approach has a wide appeal and relevance in Alaska (Ruscio, Brubaker, Glasser, Hueston, and Hennessy, 2015). The widespread interest, even in non-rural areas, may be due to the connectedness of Alaskans to the environment through hunting, fishing, and gathering activities for subsistence, recreation, or livelihood, and the physical proximity of Alaskans to land, lakes, rivers, and ocean – a situation common to populations in the circumpolar north.

Among program students, the younger high school students did not demonstrate as strong an initial connection to the One Health concept as the older undergraduate and graduate students. High school program participants are adolescents, a group with little previous science exposure and limited life experience. There is little information regarding influences on academic and career identity in underrepresented populations (McMahon, Watson, and Lee, 2019), however in middle class, Western populations, adolescents are just beginning their academic and career exploration, commitment, and

reconsideration process of vocational identity (Porfeli and Lee, 2012). As such, programs like the High school program likely attract students across a spectrum of interest and commitment to a particular academic or career trajectory. While still well in the minority, that over 20% of high school student respondents (versus 6% undergraduates and 0% graduate students) indicated that human, animal, and environmental health are different from each other may be a function of cognitive development – adolescent brains are still developing the executive function of thinking in multiple dimensions, which includes integrating information and concepts (Keating, 2012; Steinberg, 2005) - recognizing connections between One Health components may not be as readily made as it is in older students. Further, a smaller majority than in the other age groups indicated that connecting the three One Health disciplines is important. This may be a function of age or maturation as described above, or due to disproportionate enrolment of high school students with environmental/ecological interests in response to advertised programmatic elements (e.g. outdoor field work).

The interest by all graduate student respondents in connecting human, animal, and environmental health likely reflects self-selection of these students; they chose the Graduate Program because of its focus on connecting One Health themes. The predominant interests of graduate students are in community and social health and action, not in environmental or ecological work; no respondents indicated animal/environmental health was more important than human health. Regardless, more than half of respondents recognize that human, animal, and environmental health are not separate domains, but closely related disciplines (Figure 1). Despite the maturity of, and deliberate selection of an advanced One Health-focused degree, graduate students indicated the program increased their One Health-efficacy and broadened their perspectives on One Health (Figure 6). The One-Health focus and the interdisciplinary nature of the Graduate Program are consistent with Indigenous Ways of Knowing and the need for broad-spectrum thinking when addressing problems in Indigenous and rural communities (Chapin et al., 2016; Kassam, 2009). Further, the rural focus of the Graduate Program is consistent with rural and Indigenous community self-governance and self-determination through student skill development, broadening student perspectives through interdisciplinary studies within the One Health context, and applying community knowledge and systems in generating locally and culturally relevant solutions (Ongtooguk, 2003).

One Health Research Experiences

The benefits of research participation to undergraduate students have been well documented, and include increased science self-identity and science self-efficacy, confidence, career choice clarification among others (McIntee et al., 2018; Madan and Teitge, 2013; Lopatto, 2010; Russell, Hancock, and McCullough, 2007). Our observations are consistent with these earlier studies. The increased interest in both animal/environmental health research and human health research suggests an overall positive impact of research experiences on research interest. Further, self-reported understanding of science was significantly increased during a single term of mentored undergraduate research. The more robust increase in these measures in rural students compared to non-rural students may reflect the documented academic opportunity gap between rural and non-rural schools (Defeo et al., 2014; Doyle, 2009). Therefore, research opportunities for rural undergraduate students may buffer their

disadvantaged academic and high school preparedness background. College programs promoting Indigenous and rural students may benefit from incorporating culturally relevant research experiences early in the college science curriculum (James, West, and Madrid, 2013; Hurtado et al., 2009; Villarejo, Barlow, Kogan, Veazey, and Sweeney, 2008).

Alaskan students, independent of community type, indicated that a mentored research experience increased their interest in both human and animal/environmental health-related research (Figure 3), suggesting these disciplines are not in conflict with each other in the view of surveyed students. This is consistent with our finding that 75% of undergraduate students identified these research areas as closely linked disciplines. Notably, rural students showed a significantly greater increase in animal/environmental health-related research interest than their non-rural counterparts after a single term of undergraduate research. Although many factors may contribute to this increase, it may suggest a differential impact of One Health education and research on rural and non-rural students and/or greater relevance of a One Health context to rural students.

Our results suggest One Health is an effective context for engaging Indigenous and rural Alaska students in biomedical research and other health-related career options. A One Health theme may be applicable to other underrepresented groups that share subsistence lifestyles and cultural features. The integration of human, animal, and environmental components within One Health accommodates the rich environmental- and place-based cultural identity common to subsistence and Indigenous communities, and provides relevant context for learning initiatives focused on biomedical career engagement and recruitment of indigenous and rural students. By embracing a world-view consistent with indigenous Ways of Knowing, One Health incorporates both place-based and culturally relevant components into the learning environment. These components are considered key features in both informal and formal education strategies in Indigenous communities (Mack et al., 2012; Semken, 2003; Sutherland and Swayze, 2012).

Quadripartite Model of Educational Resilience

The programs highlighted here each incorporate elements of the Quadripartite Model to better serve rural and Indigenous populations. Quadripartite Model posits that shared responsibilities of student, instructor, institution, and community are required to promote success, especially in distance-delivered Indigenous education initiatives (Willems, 2012). Because the programs were designed for different educational levels and with different outcome expectations, we did not apply a common intervention – as such there is differential use of Quadripartite Model elements across programs. However, all programs implemented modifications to conventional education delivery strategies to promote access and relevance to rural and Indigenous students. Modifications implemented include those in the original program designs, and those implemented based on formative stakeholder feedback to better serve program participants.

Undergraduate Program components were designed to be delivered on campus. As such, Undergraduate Program modifications to conventional education initiatives differed from those implemented in the distance-focused High School and Graduate programs. Institutional commitments

to promote positive education outcomes for rural and Indigenous students include holistic mentoring strategies designed to lower identified barriers for rural and Indigenous students (institution). Key to the Undergraduate Program strategy is the Research Advising and Mentoring Professional (RAMP); a professional position specifically designed to promote rural and Indigenous student success in biomedical research fields through research and academic advising, psychosocial support, navigating college life and work-life balance, and other challenges faced by Indigenous and rural students (Gildehaus et al., 2019). The development of the RAMP position is supported by the U.S. National Institutes of Health, has required a significant institutional investment, and challenges the assumption that a traditional post-secondary academic structure is the most effective means to promote success of Indigenous and rural students. It is currently being implemented at three additional institutions that serve Indigenous students.

Further, undergraduate student support is contingent on their active participation in novel scientific research in established laboratories. This student-level Quadripartite Model element requires students to be more engaged in the academic and research community than is the case for students not part of the Undergraduate One Health Program; student success is dependent on student engagement. Because this is a fundamental premise of the program, institution- and instructor-level elements have been integrated into program administration and support structures to promote student success.

The High School Program incorporates practices applicable to all Quadripartite Model elements. Program administration 1) coordinates with community mentors to work directly with students on locally and culturally relevant research opportunities (institution and community elements of the Quadripartite Model); 2) modifies coursework expectations to meet variations in individual student preparedness via a variable credit system (instructor and institution); 3) responds to student feedback by supplementing full class meetings with individual community cohort meetings with the instructor (instructor); 4) promotes community engagement through student presentations to their community and conducting locally-relevant research (student and community); 5) expects students to develop and maintain a research- and experience-focused working rapport with a research mentor (student); and 6) integrates with a tribal organization to better suit rural and Indigenous student needs (instructor, institution, and community). Although student research occurs in their communities with in-person mentors, the course content and course support is distance delivered (instructor and institution).

The Graduate Program uses an interdisciplinary, integrative, and constructionist approach to working with key stakeholders and community members to identify and address problems within a One Health context (institution). Developing the recognition of social, cultural, environmental, governmental, historical, and scientific implications of identified problems is central to the Graduate Program (Kassam, 2009). In addition to interdisciplinary course options, graduate students complete a capstone project – the project requires implementing a One Health approach to a real community issue by building a comprehensive management plan which includes a realistic pathway to addressing/solving the problem. Several programmatic elements are consistent with the Quadripartite Model: an emphasis on student self-direction in choosing an emphasis, course progression, and capstone project (student); capstone projects are a collaborative effort involving students working with a community through at least one

community liaison (student, community); the program relies on the coordination of several university departments, is delivered remotely through both synchronous and asynchronous means, and relies on the expertise and cooperation of guest speakers/instructors from multiple departments and sectors (instructor, institution); and was designed to meet the interests and access limitations of students across the Circumpolar North (institution).

Conclusions

Representation in many scientific, biomedical, and community/behavioural health fields by rural and Indigenous populations is low. Reversing this trajectory, and promoting rural community resilience, requires bold approaches to education and career training. We examine effects of implementing a Quadripartite Model of Education Resilience elements within a One Health context to increase access to, and promote success in, biomedical and community health careers for those from Indigenous and rural backgrounds. Our data and observations support the premise that shared responsibility of students, instructors, institutions, and communities; and contextualizing research and education models within a One Health framework, can resonate with rural and Indigenous populations at multiple education levels. We suggest this modifiable framework should be considered by institutions committed to increasing representation from these populations in the biomedical workforce and to further community resilience.

Acknowledgements and funding

This work was generously supported by the United States National Institutes of Health BUILD (Undergraduate Program, BLaST; Awards UL1GM118991, TL4GM118992, RL5GM118990) and SEPA (High School Program, RASOR; Award 5R25GM129838) initiatives. The University of Alaska Fairbanks (UAF) and Southeast (UAS - Sitka campus), and UAF College of Natural Science and Mathematics provided space, logistics, and administrative support. Without SEATOR and their network of rural scientists and mentors there would be no rural community high school student research.

Graduate Program (UAF One Health Master's) personnel, including Kelsey Nicholson, Hannah Robinson, and Laurie Meythaler- Mullins were instrumental in launching and maintaining UAF's One Health Master's Program. Akléi Helen Dangel, Leigh Engel, Kari Lanphier, Emma Park, Aurora Taylor, Chris Whitehead, and Meg Wright provided invaluable support for the High School Program (RASOR). The Undergraduate Program (BLaST) staff and Research Advising Mentoring Professionals have supported rural and Indigenous students for nearly a decade.

Without our dedicated and talented mentors at the university campuses and in rural communities across the state, these initiatives would not exist. And a special thanks to all the students (high school, undergraduate, and graduate) who have asked great questions, generated and explored new ideas, and contributed energy, excitement, passion, talents, and great hope for the future.

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