

TRAINING AND MENTORING

Postbaccalaureate terminal degree and career choices of students who performed undergraduate research

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Abstract

This study analyzed terminal degree and career choices of students who performed undergraduate research. In one analysis, the study compared terminal degree and career choices between a course-based undergraduate research experience (CURE) and traditional non-course-based undergraduate research experiences at one primarily undergraduate institution (PUI). Students who pursued postbaccalaureate programs chose terminal degrees at levels exceeding 75%, with no significant difference between a CURE experience and a traditional research experience. Analysis of terminal degree and career choices at four PUIs providing traditional research experiences showed a marked difference in the number of students pursuing terminal degrees. Two PUIs showed rates > 75%, whereas students at the other two PUIs pursued terminal degrees <50% of the time. The majority of students not pursuing terminal degrees chose M.S. degrees in education and healthcare. An analysis was also performed among students participating in traditional summer undergraduate research on a research-intensive university (RIU) campus with a medical school. Students were accepted from two programs, an NIH IDeA Network of Biomedical Research Excellence (INBRE) program recruiting students from the RIU and an NSF Research Experiences for Undergraduates (REU) program recruiting undergraduates from rural PUIs and minority-serving institutions, particularly tribal colleges. Analysis showed that >70% of the students who pursued postbaccalaureate programs chose terminal degrees. INBRE undergraduates displayed a marked preference for the M.D. degree (73.9% vs. 17.4%), whereas the REU students chose the Ph.D. degree (75.0% vs. 22.9%). American Indian students were also analyzed separately for career choice and showed an equal preference for the M.D. and Ph.D. degrees when pursuing postbaccalaureate education. Overall, the results provide evidence that undergraduate student research stimulates student careers in areas needed by the nation's citizen stakeholders.

career outcome; CURE; postbaccalaureate degree; research experience; undergraduate

INTRODUCTION

Course-based undergraduate research experiences (CUREs) in the science, technology, engineering, and mathematics (STEM) disciplines are gaining increased acceptance as one of the best ways to facilitate science learning in the college environment (1–4). Furthermore, CUREs have also been shown to increase graduation rates and completion of STEM degrees (5). A unique feature of CUREs is that they require the student to address a research question or problem using a course-specific approach, with an outcome unknown to the students and the instructor. Students in a CURE are expected to initiate and perform a complete set of investigations and report their findings in a relatively short period of time. It has been advanced that CUREs enable students to conceptualize “real-life” research questions and to design viable approaches to generate meaningful results. Several reports have indicated that authentic research experiences enhance undergraduate

students' interest in science and the pursuit of STEM careers (6–10). One measure of undergraduate research impact on student interest in the STEM disciplines is success in the attainment of the undergraduate degree itself, completion of postbaccalaureate degrees, and the students' ultimate career choices. Previous studies by the authors have provided evidence by tracking student career choices that an undergraduate biomedical research experience enhances student entry into the health and service professions (11, 12).

The previous studies analyzed the career outcomes of undergraduate student researchers at four primarily undergraduate institutions (PUIs) and one research-intensive university (RIU) in North Dakota (ND). Undergraduate research was supported by the ND IDeA Network of Biomedical Research Excellence (ND INBRE) (13) and a National Science Foundation (NSF) Research Experiences for Undergraduates (REU) program. ND INBRE comprises one primary lead RIU, The University of North Dakota (UND) School of Medicine &



Health Sciences, as well as four PUIs and five tribal colleges and universities (TCUs) located in ND. The undergraduate research supported by ND INBRE provides year-long research experiences at the PUIs and summer research experiences at the RIU. The REU program only supports summer research experiences based at the RIU. The tracking of student career choices extends from students involved in 2005 through 2019. Both the INBRE and REU programs at the RIU are ongoing. In this report, student tracking data are further analyzed to address several aspects of undergraduate research. The first was a comparison of a long-duration CURE experience with the traditional non-course-directed individual investigator laboratory research experience. The CURE was initiated in 2005 by one investigator at a PUI in an effort to improve research productivity and not as a planned CURE experience. This has allowed an analysis of student outcomes compared to other laboratories within the same institution and those from other PUIs. A second undertaking was a beginning analysis of environmental factors that may influence career outcomes of individual students. Previous studies analyzed the undergraduate researchers as comparable groups between the PUIs and the RIU. In the present study, an attempt is made to define more precise differences among student populations. This is important since, although both the INBRE and the REU programs encourage diversity, the REU program recruits students nationwide from rural PUIs and minority-serving institutions, particularly TCUs, to increase diversity in undergraduate research participation whereas the RIU INBRE program is much more ND- and UND-centric in its selection of undergraduate student researchers.

METHODS

Data Acquisition

Data pertaining to student participation in the ND INBRE and NSF REU programs are obtained from a number of sources. Surveys conducted in conjunction with the annual Summer Undergraduate Research Symposia and the ND INBRE Undergraduate Research Symposia are a major source of basic information, including name, date of birth, gender identity, ethnicity, first generation status, home address, and college name and address. The provision of information is voluntary and does not affect participation in research or the symposia. The National Student Clearinghouse is also used to determine student institution/degree enrollment and outcomes. Graduation data for student matriculation to the bachelor's or other degree(s) is also collected from the news releases and graduation programs publicly provided by the respective universities. Career paths of students after graduation are also collected from a variety of sources. Periodically, a short survey (SurveyMonkey) is sent to past students with both checkbox questions and space for the students to provide written feedback. In between surveys, a major resource for student career tracking is social media, such as LinkedIn, as many students maintain contact with faculty and program staff through a variety of platforms. In addition, many students maintain social media presence (e.g., Facebook) that is public and can be accessed by program staff. Faculty mentors also often are aware of the degree and career outcomes of their past students. If a student received a master's degree

and then a terminal degree, they were only counted as having a terminal degree and were not counted for both degrees. No student received two terminal degrees. The program does not collect social security numbers. All information is stored in a database on a secure server maintained by Information Technology at the UND School of Medicine and Health Sciences. All activities related to the gathering of information for undergraduate student participants in the programs are approved by the UND Institutional Review Board.

Data Analysis

Statistical analysis was performed with chi-square statistics with Yates correction.

Definitions

As used here, "frontier counties" are defined as counties having a population density of six or fewer people per square mile. This is a very simple definition that does not consider other important factors that may isolate a community, as described by the Rural Health Information Hub (14). Thirty-six of fifty-three counties in ND retain a federal designation as "frontier counties."

RESULTS

Terminal Degree and Career Outcomes of CURE and Traditional Undergraduate Research Experiences

The results in this section of the present study are derived from undergraduate research experiences (UREs) at four PUIs (I1, I2, I3, I4) and one RIU (R1). Undergraduate research at the PUIs was supported by the ND INBRE and was performed on site for both the academic year and summer months. UREs at the RIU were supported by both the ND INBRE (R1 INBRE) and an NSF REU (R1 REU) program and consisted of a 10-wk summer research experience (Table 1, Fig. 1). The majority of INBRE students were residents of ND, whereas the majority of REU students were nonresidents of ND. The majority of ND INBRE students were undergraduates attending the RIU (R1), whereas the majority of REU students were from PUIs and TCUs located in rural areas. The

Table1. PUI and RIU institutional characteristics

Institution	PUI/RIU	Enrollment	Investigators	Participation	Summer/Year-Round
I1	PUI	3,000	3–6	2005–2019	Year-round
I2	PUI	1,400	2	2005–2019	Year-round
I3	PUI	1,000	2–3	2005–2019	Year-round
I4	PUI	1,300	2	2005–2017	Year-round
R1	RIU	14,700	6–14	2008–2019	Summer (10 wk)

Institution refers to the following universities: Minot State University (I1); Dickinson State University (I2), Mayville State University (I3), Valley City State University (I4), and the University of North Dakota (R1). PUI/RIU denotes whether the institution is a primarily undergraduate institution (PUI) or a research-intensive university (RIU). Enrollment numbers are rounded to the nearest hundred and are based on the average total institutional undergraduate enrollment. Investigators (range) indicates the number of faculty mentors involved each year. Participation is the years in which faculty at those institutions mentored undergraduates. Summer/Year-Round signifies whether undergraduate research participation was only during a 10-wk summer period or was year-round.

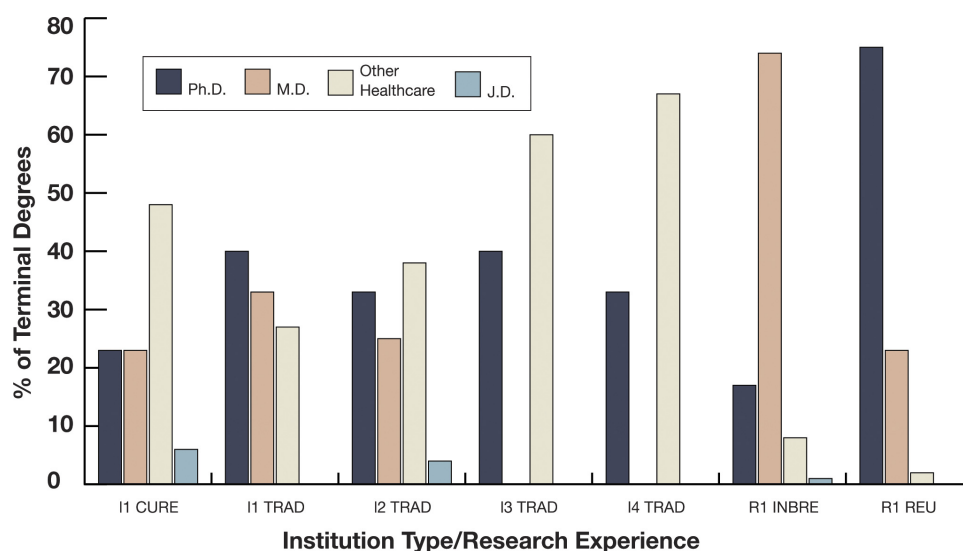


Figure 1. Distribution of terminal degrees at primarily undergraduate institutions (PUIs) and research-intensive university (RIU). Distribution of terminal degree outcomes of students who participated in the I1 Curriculum-based Undergraduate Research Experience at institution I1 (I1 CURE); I1 Traditional Research Experience (I1 TRAD); I2 TRAD, I3 TRAD, I4 TRAD, R1 INBRE Undergraduate Research Program (R1 INBRE), and R1 Research Experiences for Undergraduates Program (R1 REU). Both the R1 INBRE and R1 REU were well-defined summer programs that provided a 10-wk undergraduate research experience. Illustrated are the percentage of students and their terminal degrees categorized as follows: Ph.D. (doctor of philosophy), M.D. [doctor of medicine; also includes doctor of osteopathic medicine (D.O.)], Other Healthcare [which includes doctor of pharmacy (Pharm.D.); doctor of dental surgery (D.D.S.); doctor of veterinary medicine (D.V.M.); doctor of chiropractic (D.C.); doctor of optometry (O.D.); doctor of physical therapy (D.P.T.)], and J.D. (doctor of jurisprudence; the only non-healthcare or science terminal degree).

CURE was initiated in 2005 in an organic chemistry course at I1 and has been under the direction of the same faculty member since its initiation. The course was not developed with prior knowledge of the CURE concept but rather as a means to increase research productivity and to provide each student with sufficient research and data analysis to produce a poster and, for selected students, an oral presentation at the statewide meetings of the ND INBRE and the ND Academy of Science. To provide a research experience, the laboratory portion of the course was divided into individual units where each student was responsible for individual steps in the synthesis of unique organic compounds. At the end of the course, the new compounds were either complete or on the pathway to completion. As synthesis progressed, each student provided updates and summaries to all involved students at each laboratory session. Each student accomplished sufficient research to be included as an author on a research presentation. The institution further enhanced the undergraduate research culture by offering course credit for dedicated undergraduate research. This allowed an undergraduate to initiate organic chemistry research under a CURE format, elect to continue research for course credit, and elect to concentrate totally on research during the 10-wk summer session at the PUI through ND INBRE support. The ND INBRE administrative core examined the career choices of the students participating in the CURE program (Table 2, Fig. 1). This allowed the program to determine whether the students electing to pursue postbaccalaureate education pursued terminal (e.g., doctorate) or nonterminal degree programs with entry into the workforce with a master's degree or a similar program normally associated with a 2-yr time commitment (e.g., M.P.H., M.S.W.). The results showed that 94% (31/33) of students pursuing postgraduate education chose a

terminal degree program. The career paths chosen by the students in terminal degree programs were variable, but the doctor of philosophy (Ph.D.), doctor of medicine (M.D.), and doctor of pharmacy (Pharm.D.) programs were the most popular (Table 2). It is interesting that 4 of 31 students (13%) chose a career as a doctor of chiropractic (D.C.).

The other investigators at I1 provided traditional, non-CURE, research opportunities to undergraduate students. These experiences followed the traditional format of each student having an independent research question to pursue in the faculty member's laboratory, without any relationship to the course(s) being taught by the faculty member. Student-student and student-faculty interactions were outside the classroom in a casual and traditional laboratory meeting format. This allowed the ND INBRE to determine whether the distribution of students pursuing terminal degrees and their career choices were different between the CURE and more traditional (TRAD) UREs at I1 (Table 2, Fig. 1). The results showed that 76% (45/59) of students in traditional research experiences who pursued postgraduate education chose a terminal degree program. As seen with the CURE students, the Ph.D. and M.D. academic/career paths were the most popular choices. There were trends for differences in several of the individual career choices between the CURE and traditional undergraduate research students. The major trend percentage-wise was that the CURE students were more likely to pursue a Pharm.D. or other health professions degree than either the M.D. or Ph.D. degree. Although the trends between CURE and traditional undergraduate research are interesting, none of the differences attains statistical significance. The results may be affected by the fact that the CURE program was in organic chemistry and the others were a mixture of faculty in the research areas of

Table 2. Number of postbaccalaureate terminal degrees at PUIs and RIU

Institution	Ph.D.	M.D.	Pharm.D.	D.D.S.	D.V.M.	D.C.	O.D.	D.P.T.	J.D.	Total Term*	Master's**	Total***
I1 CURE	7	7	6	2	2	4	1	0	2	31	2	33
I1 TRAD	18	15	4	4	1	0	2	1	0	45	14	59
I2 TRAD	8	6	2	4	2	0	0	1	1	24	4	28
I3 TRAD	2	0	1	0	1	0	1	0	0	5	20	25
I4 TRAD	3	0	1	1	0	2	0	2	0	9	10	19
R1 INBRE	20	85	0	5	0	0	1	3	1	115	44	159
R1 REU	36	11	0	0	0	0	0	1	0	48	20	68

Institution refers to the institutions and respective course or program experience: I1 Curriculum-based Undergraduate Research Experience at institution I1 (I1 CURE); I1 traditional research experience (I1 TRAD); I2 TRAD, I3 TRAD, I4 TRAD, R1 INBRE summer undergraduate research program (R1 INBRE), and R1 Research Experiences for Undergraduates Program (R1 REU). Terminal degrees include doctor of philosophy (Ph.D.); doctor of medicine or doctor of osteopathic medicine (M.D./D.O.); doctor of pharmacy (Pharm.D.); doctor of dental surgery (D.D.S.); doctor of veterinary medicine (D.V.M.); doctor of chiropractic (D.C.); doctor of optometry (O.D.); doctor of physical therapy (D.P.T.); and doctor of jurisprudence (J.D.). *Total Term is the number of students completing the bachelor's degree who have completed or are enrolled in a terminal degree program. **Master's degrees are summarized in Table 3. ***Total number of students completing a postbaccalaureate degree, including both master's and terminal degrees.

biology or biochemistry. The traditional undergraduate research students were combined as a group for analysis, and the student numbers were too small for analysis among the individual non-CURE faculty members. Overall, the results do show that both mechanisms of undergraduate student research promoted a high level of student entry into postbaccalaureate terminal degree programs.

Terminal Degree and Career Outcomes at Three Other PUI Traditional Undergraduate Research Experiences

There are three additional PUIs in ND that are funded by the ND INBRE and provide traditional UREs to their students (Table 1). This allowed the ND INBRE to compare the students' pursuit of terminal degree programs at these three additional PUIs (I2, I3, I4), with the program at I1 providing both a CURE (I1 CURE) and traditional UREs (I1 TRAD) (Table 2). This analysis showed that results from one of the additional PUIs (I2) were very similar to the results from I1. The percentage of students at I2 entering terminal degree programs was comparable at 86% (24/28), and there were no notable significant differences in the professions the students elected to pursue. In contrast, results from the other two PUIs (I3 and I4) showed a significant precipitous reduction in the pursuit of terminal degree programs, with only 20% (5/25) of students at I3 and 47% (9/19) of students at I4 electing to pursue terminal degree programs ($P < 0.01$; I1, I2 vs. I3, I4). Furthermore, no student at I3 or I4 pursued an M.D. degree (Fig. 1). The low number of students pursuing terminal degrees did not allow an analysis for significance of program choice. Many characteristics of the four PUIs were examined to determine a possible reason for the difference in the students' pursuit of terminal degrees. The PUI's enrollment, tuition cost, physical plant, number of faculty, course offerings, degree programs, and undergraduate research support were very similar among the four PUIs. Historically, all four PUIs were teacher-training colleges or teachers' colleges. The only distinguishing feature that could be identified was the distance of a PUI from an RIU. Two PUIs, I1 and I2, are located between 210 and 270 mi and between 290 and 375 mi from the nearest RIUs, respectively. The other two PUIs, I3 and I4, are located between 40 and 60 mi and between 60 and 120 mi from the nearest RIUs, respectively. The I1 and I2 PUIs are also located within, or near, low-

population counties carrying the federal designation of "Frontier Counties." The I3 and I4 PUIs are also rural but located much closer (within daily driving distance) to the more populated areas where the RIUs are located. This study also examined the career choices of the M.S. degree students (Table 3). At two of the PUIs (I3, I4), M.S. degrees were chosen more frequently (68%; 30/44) than terminal degree programs (32%; 14/44) (Table 2). The results of this analysis further showed that students completing the baccalaureate degree at I3 and I4 chose master's degrees in educational disciplines far more than those at I1 and I2. In fact, 43% (13/30) of the M.S. degree students at I3 and I4 pursued a degree related to education, whereas only 20% (4/20) of the M.S. degree students from I1 and I2 made this career choice.

Terminal Degrees from the RIU Summer Research Program

The program has previously published the career outcomes from the 10-wk Summer Undergraduate Research program sponsored by the ND INBRE's home RIU, the UND School of Medicine & Health Sciences (12). However, the program has not independently examined the career choices of terminal degree students from the ND INBRE (R1 INBRE) program and that of the REU (R1 REU) program who were combined for career tracking of the students (see Table 2). The two programs are similar in the percentage of students attaining the baccalaureate degree, with 91% (234/256) and 88% (123/140) from the R1 INBRE and R1 REU programs, respectively (includes students lost to follow-up but not those still in school). For terminal degrees, the results showed that 72% (115/159) of R1 INBRE students and 71% (48/68) of R1 REU students pursuing postgraduate education chose a terminal degree program (Table 2, Fig. 1). These findings are similar to those reported by other undergraduate research programs in rural states. The Kansas INBRE and Oklahoma INBRE programs also found that ~70% of their undergraduate researchers pursued advanced/terminal degrees (15, 16). The analysis showed a marked significant difference, however, in individual career choice between the two programs. For the R1 INBRE program, 74% (85/115) of the terminal degrees were M.D. degrees, whereas only 23% (11/48) of students in the R1 REU program chose the M.D. degree. The percentages were virtually opposite for the Ph.D.

Table 3. Postbaccalaureate masters degrees/career fields at PUIs and RIU

Degree/Career Field	I1 CURE2/33 +	I1 TRAD14/59 +	I2 TRAD4/28 +	I3 TRAD20/25 +	I4 TRAD10/19 +	R1 INBRE44/159 +	R1 REU20/68 +
Lab/research/analyst/forensics	2	4	2	4	2	10	5
Education, K-12*		2		8	3	2	4
Education, postsecondary		2		2			1
Psych/counseling		2		1	1	2	
Env sci/wildlife		1		1	2		2
Allied health professions**		2	2	2	1	14	2
Business***		1			1	2	2
Public health				2		9	1
Social work/humanities						2	2
Engineering/comp sci/space studies						3	1

⁺ Number of master degrees/total number of postbaccalaureate degrees. *Education, K-12 includes teachers, counselors, and administrators. **Allied health professions includes physician assistant, nurse practitioner, occupational therapist, clinical lab scientist, and athletic training. ***Business includes administration, human resources, leadership, and communication.

degree, with 75% (36/48) of R1 REU students electing to pursue a Ph.D. degree and only 17% (20/115) of R1 INBRE students choosing that career path ($P < 0.001$, both comparisons). For either program, <10% of the students chose to pursue careers outside the M.D. or Ph.D. degree. The career choices of M.S. degree students were similar between the R1 INBRE and R1 REU students, with a trend for similarity to those of I1 and I2 (Table 3). The institutions with a high career choice of terminal degrees showed a trend to produce very few M.S. degrees devoted to teaching and education (Table 3).

The tendency for the NSF REU students to pursue the Ph.D. in much larger numbers than the M.D. degree was examined with regard to the location (state) of the students' home academic institution. The Association of American Medical Colleges (AAMC) 2019 annual report (17) was used to determine whether the difficulty associated with admission to medical school, that is, the number of medical students in each state, was related to career choice. The number of medical students in each state per 100,000 residents was used for this analysis. It was demonstrated that students choosing a career as an M.D. attended college in states that average 39 M.D. students per 100,000 residents, whereas those pursuing a Ph.D. were from states that average 42 M.D. students per 100,000 residents. This shows that the competition for medical school was not a factor in the career choice for the M.D. or Ph.D. degree. The number of students originating from PUIs in the R1 REU program who pursued the M.D. or Ph.D. degree was also examined. It was demonstrated that 73% (8/11) of students who chose the M.D. route as a career were from PUIs. Similarly, 69% (25/36) of students who pursued a Ph.D. degree were from PUIs. It was also noted that many of these PUIs were liberal arts colleges: 50% (4/8) for the M.D. and 60% (15/25) for the Ph.D. Of postsecondary institutions, liberal arts colleges historically graduate the highest percentage of students who eventually receive Ph.D. degrees.

American Indian Participation in the RIU Summer Undergraduate Research Programs

American Indian participation in the RIU Summer Undergraduate Research Programs has also been tracked for career choice by the ND INBRE administrative core. The ND INBRE does not track the undergraduates from INBRE-funded research programs that are held on campus at the

TCUs, respecting the privacy and sovereign status of the TCUs and reservations. However, the program does track the career outcomes of American Indian students who attend the Summer Undergraduate Research Programs at the RIU sponsored by the ND INBRE and the NSF REU. To date, 73 American Indian undergraduate students have participated in the RIU summer research programs at UND, 33% (24/73) and 67% (49/73) of whom were in the R1 INBRE and R1 REU programs, respectively. Of these 73 students, 2 students are still enrolled as undergraduates, 49 have received a bachelor's degree, 13 have joined the workforce with a terminal associate degree, and 9 have been lost to follow-up (Fig. 2). This represents an 88% (64/73) graduation/continuing enrollment success, with these students still enrolled or having completed at

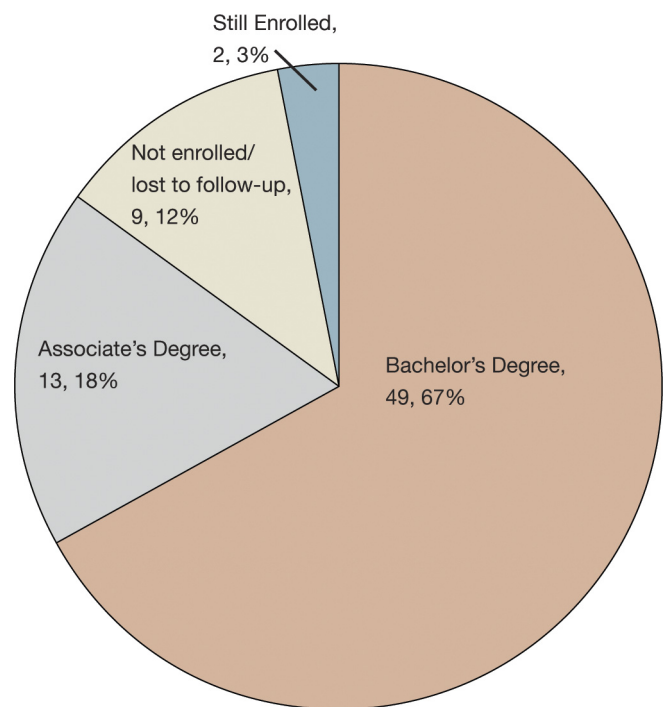


Figure 2. Degree outcomes of American Indians: degree outcomes of American Indians who participated in Summer Undergraduate Research Programs at the University of North Dakota. Illustrated in this pie chart are the number and percentage of American Indian students and their degree outcome.

a minimum an associate's degree. Forty-six of the forty-nine American Indian students completing the bachelor's degree identified their career choices (Fig. 3). Of these 46 students, 54% (25/46) chose careers related to the health professions, with 15% (7/46) enrolled in or having completed the M.D. degree, 2% (1/46) in a doctor of physical therapy (D.P.T.) program and 15% (7/46) enrolled in or having completed the Ph.D. degree.

DISCUSSION

There are several obvious advantages to using a CURE to introduce undergraduates to research (1). This course-centric approach allows more students to participate in undergraduate research compared to traditional experiences in individual laboratories with fewer students. Mentoring of many students in a CURE is through one faculty instructor, but there is also an increased opportunity for student-student peer mentoring. On the other hand, the traditional model may provide more faculty and student interaction but less student peer mentoring. The research experience occurs during class, which is advantageous for students who do not have time for research outside the classroom. Many undergraduate students maintain employment to defer the cost of education, and volunteering in a laboratory outside the classroom may not be possible. Thus, there appear to be advantages to both CURE and traditional experiences that likely vary with the individual student. What appears to not have been examined is the career outcomes of the CURE

students compared with those having a traditional research experience. Although unplanned, a CURE was developed in 2005 as part of the ND INBRE, a research infrastructure program sponsored by the NIH National Institute of General Medical Sciences. Concurrently, the ND INBRE also sponsored several other traditional research programs at the same institution. This has allowed the ND INBRE program to determine whether student career choices are influenced depending on whether a student was in a CURE or a traditional undergraduate research experience. This is one of the only studies to date to examine terminal degree outcomes by students experiencing either CURE or traditional research programs.

The INBRE is focused on biomedical research, with a major goal of promoting the development of the future generation of researchers and health professionals. A prime target of this effort is to support and foster year-round research at PUIs. In the present study, terminal degrees were chosen for analysis, since a previous study has shown that the overwhelming majority of students at PUIs complete the bachelor's degree with no difficulty and would not be expected to show differences between CURE and traditional research experiences (12). In addition, terminal degree programs are of long duration and INBRE support has continued unabated for >15 yr, allowing an analysis of terminal degrees. The results at this one institution (II) showed that a very high percentage of students who pursued postbaccalaureate education chose to pursue terminal degrees over M.S. programs or similar 2-yr experiences. Over 75% of the students from both groups chose to pursue terminal degree programs, and there was no significant difference between the two groups (93% CURE vs. 76% traditional). The M.D. and the Ph.D. were the most favored degrees for both groups of undergraduate researchers. There were several interesting trends between the career choices of the two groups, but none achieved statistical significance. There was a trend that the CURE students preferred a more varied mix of terminal degrees whereas the traditional student researchers preferred the M.D. and Ph.D. degrees. An important aspect of these findings is that both sets of students were in the same institution during the same time period, providing a control against institution-to-institution variation. In addition, monetary support of all the undergraduate research programs by the ND INBRE was similar. The few students from each group who chose a 2-yr postbaccalaureate degree program also chose a high percentage of health- and research-related careers. Overall, the results demonstrate that both types of undergraduate research stimulate students to attain terminal degrees in high numbers and stimulate student entry into the health and research professions. The study reinforces that undergraduate research, regardless of model, stimulates student achievement.

Three additional PUIs were supported by the INBRE program, and the terminal degree choices of their traditional research students were compared to those in the CURE and traditional programs at II. The results of this comparison were unexpected regarding terminal careers. One PUI, I2, showed results nearly identical to those of II, with 86% (24/28) of the students pursuing terminal degrees. However, the other two PUIs showed markedly different terminal degree outcomes. Students from these PUIs showed a marked

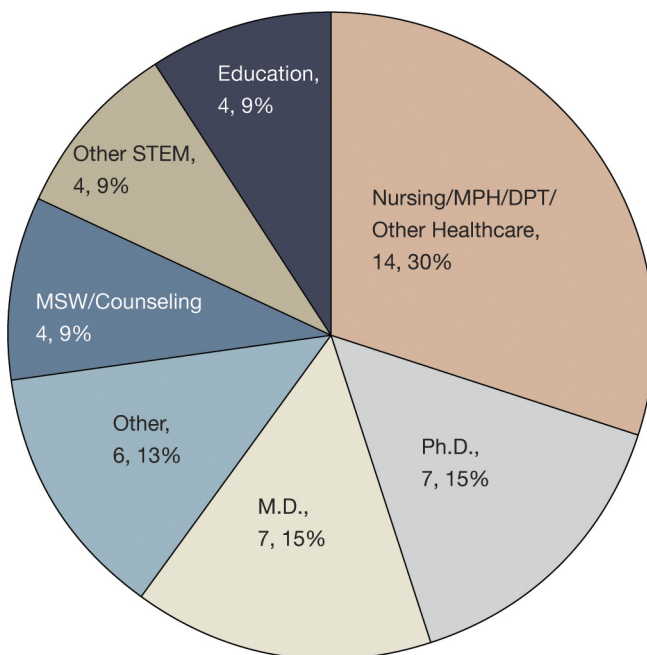


Figure 3. Career outcomes of American Indian bachelor's degree recipients: Career outcomes of American Indian bachelor's degree recipients who participated in Summer Undergraduate Research Programs at the University of North Dakota. Illustrated in this pie chart are the number and percentage of American Indian students entering each of these careers or career tracks. D.P.T., doctor of physical therapy; M.D., doctor of medicine; M.P.H., master of public health; M.S.W., master of social work; Ph.D., doctor of philosophy; STEM, science, technology, engineering, and mathematics.

significant reduction in the number of postbaccalaureate students choosing to pursue a terminal degree program. Only 20% (5/25) and 47% (9/19) of students from I3 and I4 chose terminal degrees, whereas students from I1 and I2 chose terminal degrees >75% of the time. The only difference that the authors could identify between I1 and I2 and I3 and I4 was the geographical location of the PUIs. The I1 and I2 PUIs are located in the most sparsely populated regions of ND and well away in distance from either of the state's RIUs. The other two PUIs are located close to the RIU institutions and, although rural, have a greater population, and none are located close to "frontier counties." One can speculate that the reason behind this difference is that highly motivated students of moderate to low financial means have no choice but to attend a closely located PUI. If such were shown to be true, the high performance level of these students would reinforce the value of PUIs that are located in the more remote rural regions of any state. According to teachers in these areas, comfort level may play a role, as students may not want to go away to the "big city." A review of the literature yielded no studies addressing these concepts.

The corollary to the above is that students living close to an RIU who are interested in a terminal degree program would tend to enroll in the RIU, rather than a closely located PUI. Similar to the above regarding distance and career choice, the authors could find no studies that examined career outcomes between RIUs and PUIs that are located in close proximity. However, these findings should not be interpreted in a negative way. The students from the closely located PUIs pursued M.S. degrees almost exclusively in education, healthcare, and technical support. In fact, 25% (11/44) of these students choose M.S. degrees in teaching within the K-12 system. This is important since there is a crucial need for teachers in the STEM disciplines in K-12 and, in addition, the M.S. degree and research experience puts these individuals in a leadership position to supervise Advanced Placement and college credit courses in the sciences. In contrast, only 2% (2/120) of the students from I1 and I2, far from the RIUs, pursued M.S. degrees in K-12 education. Thus, in the present study, PUIs located close to an RIU institution attracted students interested in advanced degrees in K-12 education.

The above findings motivated an examination of the terminal degree and careers of undergraduates performing research in the Summer Undergraduate Research Program offered by the RIU hosting the R1 INBRE and R1 REU programs. This examination was of interest because the R1 REU students are recruited from PUIs mainly outside of ND with an emphasis on disparities, whereas the R1 INBRE program serves mostly undergraduates from UND, the host RIU. The career outcomes from both programs have been presented in combined form in a previous publication but only using outcome data through 2017 (11). However, the career choices of the students for terminal degree programs has not been examined between these two summer research programs. The percentage of students pursuing terminal degrees was not significantly different between the two programs, with slightly more than 70% of the R1 INBRE- and R1 REU-sponsored students pursuing terminal degree programs. These percentages were similar and not significantly different from PUI institutions I1 and I2 but were significantly different from I3 and I4. Noticeably, the choice of terminal degrees

pursued by the R1 INBRE and R1 REU program students were significantly different between the two groups. For the R1 INBRE students, 82% (94/115) pursued health professional degrees (M.D., 74%, 85/115) while only 17% (20/115) pursued the Ph.D. degree. In contrast, for the R1 REU students the results were opposite, with 25.0% (12/48) pursuing terminal health professional degrees (M.D., 23%, 11/48; D.P.T. degree, 2%, 1/48) and 75% (36/48) pursuing a Ph.D. degree. Neither group displayed much interest in other terminal degree programs. The explanation for the difference between the two programs is not conclusively known, but a few explanations were ruled out. The simplest was that the REU students attended colleges in states where the number of medical school admissions per overall population were more limited than ND. However, when AAMC data detailing the number of medical students per 100,000 residents in each state were examined, there was no difference between the groups. Information regarding career possibilities also did not differ between the groups, as all summer undergraduate research students are given presentations on the admission process for medical and graduate school programs. A possibility that was not examined was the financial foundation of each student, which might correlate with the cost of a medical education in each state. Financial information about the students has not been collected by either program. In addition, the program has shown previously that first-generation students perform as well as others (11), which suggests that financial background is not a major factor. It is also possible that the REU program's nationwide recruitment net versus the INBRE's ND state focus may play a role. In short, the difference in the pursuit of the M.D. and the Ph.D. was significant between the two groups, but the explanation for the difference is currently unknown.

The location in the Northern Great Plains allows the programs to promote recruitment of American Indian undergraduate researchers into the summer undergraduate program. While these students are included in the above analysis of the summer program, their willingness to self-identify on the application allows the programs to track career success. The application for program participation does not require a photograph or any type of interview but does ask for two letters of recommendation. The programs only follow the career outcomes of American Indian students who participated in the summer undergraduate research programs at UND. As such, the career data only reflect those students participating in the R1 INBRE and R1 REU Summer Undergraduate Research Programs. The results for these students were comparable to the other students in the programs at the four PUIs. Completion of the baccalaureate degree was at 67% (49/73), with seven of these students pursuing an M.D. degree and seven a Ph.D. degree. These outcomes might have been even higher, but a number of students (18%, 13/73) did stop their studies with an associate's degree and a number were lost to follow-up (12%, 9/73). Nevertheless, most of the students choose careers in healthcare, potentially fulfilling a crucial need in the American Indian community. All the results of the present study suggest that students who choose to participate in undergraduate research programs have a high level of career achievement.

The career data presented here were only able to be obtained through support from the NIH INBRE and NSF

REU programs. Their support reinforces the need for sustainability in order to judge career success of the students. The INBRE program is larger and able to fund both the PUIs and part of the summer undergraduate research program. However, the NSF REU program, although smaller, added diversity with its recruitment of minority students from across the United States. The two programs working together were able to garner university support for childcare, a serious limitation for many students desiring a summer research experience. Suffice it to say that limited-duration undergraduate research programs lack the ability to judge the positive effect on student career outcomes. In general, one criticism of undergraduate research programs is that there does not exist a control group against which to measure their success. The career outcome results of the present study argue convincingly against this as a concern. These results, plus those of the authors' previous studies (11, 12), show that the overwhelming majority of students participating in undergraduate research pursue careers needed by citizen stakeholders. Health professionals, researchers, and K-12 science teachers are all in short supply, and students performing undergraduate research populate these career choices. The risk of questioning the results because of a lack of control group missing the opportunity for undergraduate research is far outweighed by the potential benefit of increased student participation in careers needed for the benefit of citizen stakeholders.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

D.A.S. and V.A.D. conceived and designed research; M.B., S.H.G., S.S., and V.A.D. performed experiments; D.A.S., K.L.C., and V.A.D. analyzed data; D.A.S., K.L.C., and V.A.D. interpreted results of experiments; K.L.C. prepared figures; D.A.S. drafted manuscript; D.A.S., K.L.C., M.A.S., and V.A.D. edited and revised manuscript;

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