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## **Assessment of the impact of the Kansas IDeA Network of Biomedical Research Excellence program on undergraduate participation in research**

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1 Assessment of the Impact of the Kansas IDeA Network of Biomedical Research Excellence Program on  
2 Undergraduate Participation in Research

3

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20 Running Title: Survey of student outcomes

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22 CONFLICT OF INTEREST NOTIFICATION PAGE.

23

24 The authors declare no conflicts of interest.

25 **ABSTRACT**

26

27           The Kansas IDeA Network of Biomedical Research Excellence (K-INBRE) was established in 2001 and is  
28 a network of 10 higher education institutions in Kansas and northern Oklahoma. The program is funded by the  
29 Institutional Development Award (IDeA) program of the National Institutes of Health (NIH). As part of the  
30 program's goal to enhance the research infrastructure in Kansas, a training program was developed to encourage  
31 undergraduates to participate in biomedical research. From September of 2002 to May 2012, the K-INBRE  
32 supported 731 students at 10 institutions. Although 16% of student participants in the program are still  
33 undergraduates, 323 of our students have gone into biomedical graduate school or medical school programs. Thirty-  
34 seven percent of all the completed students have matriculated into graduate programs and 19% of our completed  
35 students went to medical school. Moreover, 12% have gone into other health-related professions. One percent of  
36 our students that went into medical school programs are in highly prestigious M.D./Ph.D. programs. In the fall of  
37 2011, we surveyed participants from the last 10 years about career choices and the impact of the K-INBRE program  
38 on those students. Two-hundred twenty-four former and current students responded to the survey with a consensus  
39 of high impact of the K-INBRE program on student training, career choices, and perceptions about research.

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41 Key words: Undergraduate research, program assessment

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53 **INTRODUCTION**

54           The Kansas IDeA Network of Biomedical Research Excellence (K-INBRE, originally designated the  
55 Kansas-Biomedical Research Infrastructure Network) program is a National Institutes of Health (NIH)-funded  
56 program to develop biomedical infrastructure and research in the state of Kansas (<http://www.kumc.edu/kinbre/>).  
57 The aim of the K-INBRE undergraduate program is to enhance the undergraduate educational experience by  
58 providing funding to undergraduate students, the next generation of biomedical scientists, to do research at the 10  
59 participating institutions in the States of Kansas and Oklahoma. The K-INBRE schools have wide-ranging missions.  
60 The lead university is the University of Kansas Medical Center (KU-MC), which has a comprehensive medical  
61 school and offers many doctoral programs leading to the Ph.D. K-INBRE also has two comprehensive  
62 undergraduate and graduate Ph.D.-granting institutions: the University of Kansas -Lawrence (KU-L) and Kansas  
63 State University (KSU). The program also has five predominantly undergraduate institutions (PUIs) that award  
64 Masters level degrees: Emporia State University (ESU), Fort Hays State University (FHSU), Pittsburg State  
65 University (PSU), Washburn University (WU), and Wichita State University (WSU). K-INBRE also includes two  
66 predominantly undergraduate institutions that serve mainly minority students (Haskell Indian Nations University  
67 (HINU) and Langston University (LU). The breadth of missions among the K-INBRE campuses requires that the  
68 K-INBRE have a flexible vision for how each institution achieves its mission as it fulfills the goals of the K-INBRE.  
69 Therefore, the execution and design of activities on each campus are unique to each site because it is recognized that  
70 programs that are appropriate at one institution may not be appropriate at another. Nevertheless, the major focus for  
71 each institution's program is to introduce undergraduate students to biomedical research.

72           The K-INBRE has continuously monitored student's initial placement after graduation for the last 10 years.  
73 However, we wanted additional feedback about program perceptions and career choices and outcomes beyond the  
74 initial tracking after graduation. Many times programs such as this lose touch with their participants after the  
75 student's initial after graduation placement. Therefore, the survey was intended to provide us additional feedback  
76 about student perceptions of the program and subsequent career outcomes and help us test the hypothesis that  
77 student enrollment in post-baccalaureate programs will be better if they participate in high-quality undergraduate  
78 research experiences compared to other undergraduates. This paper presents outcomes of K-INBRE participants  
79 since 2002 and the results of a survey sent to participants of the program through November 2011.

80

81 **METHODS**

82 **K-INBRE Overview.** The goal of the K-INBRE undergraduate program is to introduce undergraduate students to  
83 biomedical research. Each campus is provided funding (\$28,000) to enrich undergraduate participation in research.  
84 Activities considered for the program include: research scholarships for undergraduates, research mini-grants for  
85 faculty working with students, summer research programs for high school students, support for gatherings of K-  
86 INBRE participants to share information and experiences, and support to create informational/recruitment brochures  
87 to increase participation and awareness of the K-INBRE program. Other appropriate activities include: student  
88 travel support, sponsorship of symposia for student oral/poster presentations, support for the implementation of  
89 formal course credit for the research experience, funding for programs for undergraduate access to primary research  
90 literature on line, support for programs to incorporate new technologies into existing classes to better prepare  
91 students for graduate research, funding for invited speaker travel, and mini-grants to help update equipment for  
92 undergraduate student research. The programs that had K-INBRE support, and participation at each campus, are  
93 summarized in Table 1. For this program, students are selected on each campus by the on-campus faculty (Table 1).  
94 In general, at our K-INBRE institutions, faculty have very close interactions with the students and criteria such as  
95 motivation, class standing (e.g. Fr. vs. Sr.), and a faculty member's experience with a student are often used.  
96 Grades, previous research experience, letters of recommendation, enrollment in a research class, minigrants  
97 outlining the project, and post-graduate interests are used for selection in various combinations (Table 1).

98 In addition to individual campus programs, the K-INBRE also funds approximately 30 Summer/Semester  
99 scholarships each year (\$4000/student), which are independent of the campus funding  
100 ([http://www.kumc.edu/kinbre/summer\\_scholar\\_recipients.html](http://www.kumc.edu/kinbre/summer_scholar_recipients.html)). These applications are reviewed for the quality of  
101 the project and qualifications of the student by the K-INBRE Incentives and Awards Committee. This committee is  
102 comprised of faculty from several K-INBRE campuses. The students supply transcripts, letters of recommendation,  
103 a biosketch, and 1 page research project outline. The mentor is also required to supply an NIH biosketch. The  
104 committee uses all of this information to select high-quality students and mentors into the program. The funding  
105 allows students to participate in research either during the summer, during the academic year, or both.

106 The K-INBRE also instituted the Star Trainee program in 2003. This program selects outstanding junior  
107 students that have already shown strong research potential to receive a \$7,500 stipend their senior year  
108 ([http://www.kumc.edu/kinbre/star\\_trainee\\_recipients.html](http://www.kumc.edu/kinbre/star_trainee_recipients.html)), and the faculty mentor's lab receives \$2,500 for

109 supplies. Star Trainees also have \$10,000 applied to their graduate stipend if they enroll in a graduate program in  
110 the State of Kansas. These applications are also reviewed for the quality of the project and qualifications of the  
111 student by the K-INBRE Incentives and Awards Committee using the same information that is used for  
112 summer/semester scholars.

113 From 2010-2012, the K-INBRE received additional scholarship money from the American Recovery and  
114 Restoration Act (ARRA). This program allowed students to receive funding for 1 year at a level of \$5,000 per  
115 student. The same selection requirements used for the summer/semester scholars were used for the ARRA scholars  
116 and accounted for a 5% increase in the number of students that were funded by the K-INBRE (Table 2).

117 In addition to laboratory research, all K-INBRE students are asked to participate in at least six intra-campus  
118 K-INBRE scholar meetings per year to share student progress and learn from mentor experiences as part of the  
119 program. Campuses are provided with \$200 per year for refreshments for these meetings from the K-INBRE  
120 Undergraduate Office. The K-INBRE also holds an annual, program-wide symposium to allow students to present  
121 research posters, with some of the students asked to present orally along with national and regional faculty speakers.  
122 The 1.5 day symposium has grown from an initial participation of 25 student abstracts with 75 faculty and student  
123 participants in January 2003, to 108 student abstracts and 255 faculty and student participants in January 2012  
124 ([http://www.kumc.edu/kinbre/symposium\\_schedule.html](http://www.kumc.edu/kinbre/symposium_schedule.html)). Students are also encouraged to participate in individual  
125 campus research forums and national professional meetings.

126 To assess student outcomes, each campus coordinator recorded the number of students falling into the  
127 following categories: funded as summer/semester scholars, funded by regular K-INBRE campus funding,  
128 matriculated into graduate school, matriculated into medical school, matriculated into an M.D./Ph.D. programs,  
129 pursued other medical professional programs, students with other outcomes, funded in the Star Trainee program,  
130 Star Trainee program participants that enter graduate school, and undergraduates currently in the program (Table 2).  
131 **K-INBRE student survey.** The survey was administered using Survey Monkey (<http://www.surveymonkey.com/>),  
132 and consisted of 20 questions inquiring about participation, research, outcomes, careers, program impact, social  
133 media, and the demographics of the students (Appendix 1). Most of the questions were multiple-choice with areas  
134 to add comments or expand on answers. Some of the questions were developed based on previous undergraduate  
135 assessments (11, 12) to allow for comparative analyses. At the time of the survey, 659 students had participated in  
136 the K-INBRE over the approximate 10-year period at our 10 participating campuses. Contact information was

137 available for 569 out of 659 current and former students as of October 2011. Surveys were sent out via Survey  
138 Monkey to the email addresses after two notifications indicating that the K-INBRE would be doing the assessment  
139 and the importance of the survey. The survey was open for approximately 2.5 months (October 17-December 31)  
140 with 11 follow-up email reminders, including one from the campus coordinator at the school that the students  
141 attended. In addition, as incentive for participation, we announced that respondents could elect to be eligible for a  
142 drawing for an iPod. Forty-one of the email addresses to which the survey was sent bounced back, leaving us with  
143 528 possible survey responders. Two of the students opted out of the survey and future communication from K-  
144 INBRE. Two hundred twenty-four students responded to the survey; a 42% response rate (Table 3). This  
145 assessment was reviewed and assigned “exempt” status by the Human Subjects Institutional Review Board at KU-  
146 MC.

147

## 148 **RESULTS AND DISCUSSION**

149 **The K-INBRE 2011 student survey.** There was a 42% response to the K-INBRE survey by students that had or  
150 were currently participating in the K-INBRE program based on successful email notifications. Survey respondents  
151 attended all but one (HINU) of our K-INBRE campuses and the distribution of respondents was not statistically  
152 different ( $P=0.15$ ,  $\chi^2$  test) from the distribution of student participants throughout the entire length of the program  
153 (Table 3). The absence of respondents from HINU reflects that HINU was the campus with the smallest number of  
154 students that participated in formal research (Table 3), and possibly the general hesitancy of Native Americans to  
155 participate in assessments (4).

156 The survey participants were fairly evenly distributed based on when they graduated (Baccalaureate  
157 degree) and when they started postgraduate studies (*i.e.* medical or graduate school; Table 4). The “experience” of  
158 the survey participants exceeded that of the general K-INBRE student population based on the number of semesters  
159 that a student was funded by the K-INBRE (Table 5). There was a higher percentage of students that had more than  
160 2 semesters of funding among the survey respondents (47%) compared to the overall statistics compiled by the K-  
161 INBRE from 2002-2012 (23%;  $P=0.03$ ,  $\chi^2$  test). Perhaps more experienced students felt a greater obligation to  
162 respond to our inquiry or they were more motivated because they had a good experience in the program.

163 Regardless, the number of students that participated for two semesters was the largest group for both our survey  
164 respondents and total K-INBRE participants from 2002-2012 (Table 5). The pattern was also true for students that



165 participated one semester (second highest), four semesters (third highest), three semesters (fourth highest), and five  
166 semesters (fifth highest). Therefore, the survey included students with the complete range of possible laboratory  
167 experiences.

168 The gender of the survey respondents closely paralleled the gender distribution of student participants  
169 throughout the entire program's life ( $P=0.54$ ,  $\chi^2$  test; Table 6). The higher percentage of female participants reflects  
170 the growing trend of more females receiving bachelor's degrees than males (5) and the gender distribution of  
171 participating students reported by other undergraduate research programs (8, 11). The racial distribution of the  
172 survey respondents was 71% white, 8% black, 9% Asian, and <1% American Indian, Native Hawaiian, or Pacific  
173 Islander (Table 7). Five percent of our survey respondents indicated that they were of Hispanic, Latino, or Spanish  
174 origin. This is consistent with the distribution of students in other undergraduate research surveys (8, 11) and  
175 approximates the general participation of students in our program from 2002-2012. However, because ethnic  
176 distribution was only informally tracked in our program until recently, we did not attempt to do a statistical analysis  
177 on this demographic.

178 To evaluate the K-INBRE impact, we asked a series of questions about working independently and  
179 formulating ideas, being motivated, learning, analyzing and interpreting data, understanding the scientific process,  
180 overcoming obstacles, and increasing in self-confidence (Table 8). Average scores for K-INBRE participants were  
181 high, ranging from 4.14-4.52 (Table 8). These scores equaled or exceeded the mean scores for similar assessments  
182 of non-K-INBRE-funded undergraduates doing research reported in 2004, 2007 (11, 12), and 2010 (8). For  
183 example, when asked if the K-INBRE "...improved my understanding of how knowledge is constructed and how  
184 scientists work on real problems," the average K-INBRE score was 4.52/5.00 (Table 8). In the analysis of Surveys  
185 of Undergraduate Research Experiences (SURE) (11, 12), which included students from many different kinds of  
186 colleges and universities across the United States, similar inquiries about how much growth in students funded by  
187 the Howard Hughes Medical Institute (HHMI) or by students "who changed to graduate education in science" (GES  
188 students) scored 4.10/5.00 and 4.20/5.00, respectively. When asked if the K-INBRE "...improved my ability to  
189 integrate theory and practice," the average K-INBRE score was 4.32/5.00. In the SURE assessment, a similar  
190 question scored 3.85/5.00 by HHMI-funded students, and 4.13/5.00 by GES students (11). When asked if the K-  
191 INBRE "...gave me tolerance for obstacles faced in the research process," the average K-INBRE score was  
192 4.46/5.00. In the SURE assessment, the same questions scored 4.10/5.00 by HHMI-funded students, and 4.18/5.00

193 by GES students. We also compared K-INBRE student “tolerance for obstacles” to students in the undergraduate  
194 research program at Emory University (8). The average K-INBRE scores exceeded the scores of the Emory  
195 University students (4.00/5.00) (8). Moreover, when K-INBRE students were asked if “It increased my self-  
196 confidence,” the response averaged 4.14/5.00 (Table 8). In the SURE assessment, a similar question scored  
197 3.59/5.00 by HHMI-funded students and 4.03/5.00 by GES student respondents (11). “Self confidence” scores for  
198 all students reported in both the 2004 and 2007 SURE analyses were 3.50/5.00 (11, 12) and 3.7 at Emory (8).  
199 Therefore, in all the assessments summarized in Table 8, the students scored the K-INBRE program equal to or  
200 higher than students participating in research experiences assessed in the SURE or at Emory University. The sample  
201 size of the K-INBRE assessment was smaller than the SURE assessment (224 vs. 1135) (11, 12) or the  
202 undergraduate assessment done at Emory University (822). However, since the K-INBRE survey respondents  
203 appeared to reflect the general experience, demography, and campus distribution of the total K-INBRE student  
204 participation pool, it is likely that similar data would be obtained if we had a larger sample size. However, it is  
205 possible that whatever motivated students to respond to the survey may have also affected their opinion, therefore,  
206 some caution must be made in making that extrapolation. It is important to note that the K-INBRE survey also  
207 included students that worked on research during the academic year, so the student populations may not always be  
208 directly comparable to the SURE survey (11) which only analyzed students in summer research programs.

209 One recurring theme among the student comments was how the K-INBRE program provided experience  
210 and confidence (Supplement 2). For example, one student indicated, “It gave me the confidence to pursue an  
211 independent graduate studies program, the Master's International Program through the Peace Corps...., without my  
212 KINBRE experience, I would not have had the confidence to participate in this program” (Supplement 1, comment  
213 14). Another student added, “K-INBRE gave me a chance to explore science and help me decide that I wanted to be  
214 a scientist” (Supplement 2, comment 26). One additional response was, “...it gave me confidence that I never had,  
215 it let me believe that ordinary people like me can make scientific discoveries. If it is not for this program, I would  
216 never believe I could give a talk in front of a hundred people” (Supplement 1, comment 70).

217 We assessed the types of scientific presentations made by K-INBRE survey respondents (Table 9). Over  
218 70% of K-INBRE students were able to present a poster presentation off campus or at a conference or professional  
219 meeting. Over 27% were authors on a manuscript intended for publication in a professional journal (Table 9).  
220 Lopatto reported that 27.9% of undergraduates participating in research presented posters at conferences or

221 professional meetings, and that 19.7% were authors on a manuscript intended for a professional journal (10).  
222 Twenty and nine-tenths percent of the K-INBRE students surveyed were able to give a talk off campus at a  
223 conference or professional meeting. Lopatto reported that 12.9% of the students surveyed in his assessments gave a  
224 talk or colloquium at a conference or professional meeting (10). Almost 68% of K-INBRE students surveyed were  
225 able to make a poster presentation on campus (Table 9). Therefore, K-INBRE students had excellent opportunities  
226 to develop communication skills and had opportunities to present their research at levels comparable to, or better  
227 than, those seen in other undergraduate research programs. We attribute part of this outstanding participation metric  
228 on the annual K-INBRE symposium. Indeed, some of our survey respondents even commented on the annual  
229 symposium. One said, "...Perhaps the most important impact is attending the general meeting each January and  
230 realizing that I am part of a very large and very intelligent community of people who are interested in the same  
231 things as I am and who are willing to collaborate and share ideas and information. Coming from a small institution,  
232 it is not always possible to look around and realize my peers are there. These meetings motivate me ...." (Appendix  
233 2, comment 125).

234 The K-INBRE survey inquired about students' impressions about their research experience (Table 10),  
235 whether they would recommend the program to future students (Table 11), and whether they thought the K-INBRE  
236 program should be continued (Table 12). Over 90% of the K-INBRE students indicated that they had a positive  
237 experience and that they learned a lot and would do it again, with over 27% of those students indicating that their  
238 research project was "fantastic" (Table 10). The overall student impression was 4.16/5.00, and over 98% of the  
239 students surveyed agreed with the statement, "The K-INBRE made a big impact on my life and I recommend that  
240 other students participate in the program" (Table 11). One hundred percent of the students agreed or strongly agreed  
241 that the "K-INBRE program is an important program for student development and should be continued in Kansas"  
242 (Table 12). The positive K-INBRE impact is consistent with the general positive influence undergraduate research  
243 has on student academic development (10), especially for students at PUIs (16). This is also consistent with the  
244 finding that over 90% of the K-INBRE survey respondents agreed or strongly agreed that the participation in the K-  
245 INBRE program helped in the student's career choice (Table 13). Even when students indicated that research was  
246 not a career outcome, they felt that the K-INBRE research program provided a positive learning experience. For  
247 example, one student commented, "I realized that a life in research didn't fit my personality or goals. I learned a

248 little more about science, how to contribute to science, how to interpret/read literature, how to formulate  
249 experiments, how to get frustrated, how to gain resilience...” (Appendix 2, comment 165).

250 We also assessed K-INBRE participant’s experience with the K-INBRE’s electronic presence. Only one-  
251 third of the survey respondents had visited the K-INBRE website in the last year and less than 20% were friends of  
252 K-INBRE on Facebook or had visited the K-INBRE Facebook page (Table 14).

253 **Assessment of K-INBRE Outcomes.** As part of the K-INBRE survey we assessed the career choices of the survey  
254 respondents (Table 15). Almost 40% of the former K-INBRE participants that graduated went on to attend graduate  
255 school. Twenty-seven and eight-tenths percent of the respondents attended medical school. Eight percent of the  
256 respondents attended M.D./Ph.D. programs, and another 11% entered other medical professional programs.  
257 Therefore, over 85% of our former participants that responded to the survey entered some type of post-graduate  
258 educational experience (Table 15). The K-INBRE supported 723 students at our 10 participating institutions from  
259 2002-2012, including our Star Trainees, ARRA scholars, and our Summer/Semester scholars (Table 2). Thirty-eight  
260 percent of our students entered into graduate programs (includes M.D./Ph.D. programs). Twenty percent of our  
261 students went to medical school (includes M.D./Ph.D. programs) and 12% went into other biomedical professions  
262 (Table 2). These numbers closely parallel the career choices of the survey respondents, although a higher  
263 percentage of M.D/Ph.D. students responded to the survey compared to our overall student population (8% vs. 1%;  
264 Tables 2 and 15). Our Star Trainee program is one that allows promising undergraduate students to get extensive  
265 science and laboratory training as undergraduates, and by helping support them their first year in graduate school we  
266 make them attractive graduate student candidates. Forty-three Star Trainees have participated in the program since  
267 its inception in 2003, and 81% of those that completed their undergraduate degrees went into graduate programs  
268 (Table 2).

269 According to the National Center for Education Statistics, who have published several long-term cohort  
270 studies of individuals who received their bachelor’s degrees, in the 1992-1993 cohort, 29.8% enrolled in graduate  
271 school by 1997 (13). Twenty-four percent of those students were enrolled in the life or physical sciences (13).  
272 Importantly, of the 29.8%, only about half (49% of the 29.8%=14.6%) were enrolled within 1 year of graduation  
273 (13), which is the temporal metric the K-INBRE has been using as an outcome. Therefore, the K-INBRE overall  
274 post graduate success of 69% entering some kind of graduate, medical, or professional program is 2 to 4 times

275 higher than the national average for the 1992 cohort, depending on which population is used as a comparison (total  
276 in 4 years that go on to post baccalaureate degrees or within 1 year after graduation, respectively) (Figure 1).

277 In similar types of analyses, in the summary of 1999-2000 Bachelor's Degree Recipients (3), 22% went to  
278 graduate school or professional school. Of those that graduated with degrees in life science, 38.1% went on to  
279 graduate or professional school. Of those with degrees in a health field, 24.2% went on to graduate or professional  
280 school. Similarly, in the 2008-09 Baccalaureate and Beyond Longitudinal Study (5), based on data on post  
281 baccalaureate enrollment ((5)Table 5), 42.4% of students receive master's degrees, doctoral degrees, or at least one  
282 professional degree (5). Therefore, the K-INBRE overall post graduate success of 69% entering some kind of post  
283 graduate, medical, or professional program ranges from 1.7 to 3.1 times higher than these national estimates  
284 depending on which cohort group is used as a comparison (Figure 1).

285 According to the National Science Foundation (NSF), the number of science bachelor's degrees awarded in  
286 2008 was 426,260 in the U.S.A. ((14) Appendix Table 2-18). There were 99,501 first-time, full-time graduate  
287 students in those same fields in 2009 ((14) Appendix Table 2-23). Therefore, based on the statistics of the NSF,  
288 approximately 23.3% of the graduates in Agricultural, Biological, and Physical sciences went to graduate school.  
289 According to the Council of Graduate Schools, 30.2% of the applications to biological and agricultural sciences  
290 were accepted in the U.S.A. (2). The 2009 College Senior Survey (CSS) indicates that 28.9% of 2009 college  
291 graduates will attend graduate-professional school (6). Therefore, the K-INBRE success in graduate school  
292 placement (3) exceeds these national statistics by over 2 times (Figure 1).

293 In assessing students in the K-INBRE that go on to medical school, according to the Association of  
294 American Medical Colleges, 19,230 people were accepted into medical school in the United States in 2011 (1).  
295 Therefore, the percentage of science baccalaureate recipients that went to medical school in 2011, based on NSF  
296 2009 science bachelor's degrees ((14) 434,835; Appendix Table 2-18), is just under 5%  
297  $(19,230/434,835=0.044)$ . According to the CSS, 6% of students go to medical or dental school (6). Non-science  
298 majors often go to medical school as well. Therefore, it is difficult to know which population of students should be  
299 used to calculate the percentage of bachelor's degree recipients that go on to medical school. If one uses just natural  
300 science graduates ((14) Appendix Table 2-18), that percentage goes to 11%  $(19,230/181,914=0.106)$ . Regardless of  
301 the population we use for comparisons, the percent of K-INBRE students going to medical school exceeds national  
302 estimates.

303           The K-INBRE student attitude and success in entering post graduate studies were mirrored by the results of  
304 a national survey conducted between 2003 and 2005 (15). The Russell report indicated that involving students in  
305 undergraduate research led to better student understanding of research, more self-confidence, and higher awareness  
306 of what to look for in graduate programs. Thirty percent of the Russell report respondents said that being involved  
307 in research increased their interest “a lot” in a career in a science, technology, engineering, or math field (15).  
308 Ninety percent of the K-INBRE survey respondents indicated that participation in the program helped them in their  
309 career choices. Moreover, just bringing undergraduates into laboratories isn’t the only thing that makes for a  
310 successful program. According to the Chronicle of Higher Education’s report on undergraduate research,  
311 “...undergraduates learn and grow significantly from their research experiences, but require a strong mentor  
312 relationship to do so” (7). A long-term study, done at Indiana University, indicates that undergraduates do better  
313 when their mentors make it clear how important the student projects are (9). The K-INBRE’s strong survey scores  
314 in helping students work independently (4.35/5.00), making them more active learners (4.32/5.00), improving  
315 student’s ability to integrate theory and practice (4.32/5.00), and increasing the student’s ability to work in a team  
316 (3.92/5.00) all indicate that there must be strong mentorship in the program and that they are active participants in  
317 the research process. Students gain more from a research experience if they are involved in assessment and  
318 literature review, and not just collecting data (9). Over 27% of our K-INBRE survey respondents indicated that they  
319 were co-authors on a manuscript intended for publication in a professional journal (Table 9), and a recurring theme  
320 among the student comments (Supplement 2) was about the available mentoring and how it influenced them.  
321 Comments ranged from, “I was able to work with a great instructor” (Supplement 2, comment 45), to “...I have also  
322 been give[n] the chance to engage with fellow research partners and learn from an influential mentor. Our  
323 interactions have inspired teamwork within the laboratory and a fresh enthusiasm for learning...” (Appendix 2,  
324 Comment 55), and also included “K-INBRE piqued my interest in biomedical research, which ultimately drove me  
325 to attend graduate school. I actually pursued graduate studies with my K-INBRE mentor, since I had such as  
326 fantastic research experience as an undergraduate” (Appendix 2, Comment 132). Indeed, bad mentoring did lead to a  
327 bad student experience in our program as well. One student was angry with their mentor because “...I was denied  
328 the opportunity to see the project through from conception through synthesis of the final [product]” (Appendix 2,  
329 Comment 152).

330 In conclusion, for participants in the K-INBRE program, the percentage of students that go on to post  
331 baccalaureate programs (*e.g.* Medical, graduate, or professional) equals (using some conservative estimates), or  
332 exceeds (using several different measures), national estimates (Figure 1). Perhaps the flexibility of our individual  
333 campus faculty to select some students on less objective measures (*i.e.* motivation, faculty student interactions)  
334 along with more traditional selection processes (*i.e.* summer/semester scholar selection) allows us to identify strong  
335 students that fit “traditional” norms as well as ones that do not. Based on the information collected from our survey,  
336 the K-INBRE program is a positive experience for most of the participants (Appendix 2). Additionally, most  
337 students continued to pursue careers in the biomedical field beyond their undergraduate education. Indeed, we  
338 discovered that 47% of the students that responded to the survey that initially took jobs eventually went to graduate  
339 or medical school. In total, these data suggest that the student undergraduate training program is meeting the goals  
340 and objectives of the Kansas INBRE. The survey was limited by the ability to contact all past participants and  
341 reinforced that we need to find ways to keep better contact with our students. We did not have contact information  
342 for everyone that had participated in the program because it has been difficult to keep information updated when  
343 people move and change jobs. We had hoped that our use of social media (*e.g.* Facebook) would help link us to  
344 former students. The data suggest that additional efforts will be needed by the K-INBRE program to improve this  
345 communication medium.

346

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362 **REFERENCES CITED**

- 363 1. **Association of American Medical Colleges**  
364 <https://www.aamc.org/download/153708/data/charts1982to2012.pdf> July 12, 2012 posting date. U.S.  
365 Medical School Applicants and Students 1982-1983 to 2011-2012. [Online.]
- 366 2. **Bell, N.** 2011. Graduate enrollment and degrees: 2000-2010, p. 1-104. Council of Graduate Schools,  
367 Washington, D.C.
- 368 3. **Bradburn, E. M., R. Berger, X. Li, K. Peter, K. Rooney, and J. Griffith.** 2003. A descriptive summary  
369 of 1999-2000 bachelor's degree recipients 1 year later, with an analysis of time to degree, p. 1-181. *In* N. C.  
370 f. E. S. U.S. Department of Education (ed.), U.S. Department of Education, Institute of Education Sciences  
371 NCES 2003-165. National Center For Education Statistics, Washington, D.C. .
- 372 4. **Buchwald, D., V. Mendoza-Jenkins, C. Croy, H. McGough, M. Bezdek, and P. Spicer.** 2006. Attitudes  
373 of urban American Indians and Alaska Natives regarding participation in research. *Journal of general*  
374 *internal medicine* **21**:648-651.
- 375 5. **Cataldi, E. F., C. Green, R. Henke, R. Lew, J. Woo, B. Shepherd, and P. Siegel.** 2011. Baccalaureate  
376 and beyond longitudinal study (B&B:08/09): First look (NCES 2011-236), p. <http://nces.ed.gov/pubsearch>.  
377 *In* U. S. D. o. Education (ed.). National Center for Educational Statistics, Washington, D.C.
- 378 6. **Franke, R., S. Ruiz, J. Sharkness, L. DeAngelo, and J. Pryor.** 2010. Findings from the 2009  
379 administration of the college senior survey (CSS): National Aggregates, p. 1-110. Higher Education  
380 Research Institute at the University of California Los Angeles, Los Angeles.
- 381 7. **Guterman, L.** 2007. What good is undergraduate research anyway?, p. 12-16. *The Chronicle of Higher*  
382 *Education*, vol. 53. Washington, D.C. .
- 383 8. **Junge, B., C. Quiñones, J. Kakietek, D. Teodorescu, and P. Marsteller.** 2010. Promoting Undergraduate  
384 Interest, Preparedness, and Professional Pursuit in the Sciences: An Outcomes Evaluation of the SURE  
385 Program at Emory University. *CBE-Life Sciences Education* **9**:119-132.



- 386 9. **Lipka, S.** 2007. Helicopter parents help students, survey finds, p. 1,32. *The Chronicle of Higher Education*,  
387 vol. 54. Washington, D.C. .
- 388 10. **Lopatto, D.** 2010. *Science in Solution: The Impact of Undergraduate Research on Student Learning*.  
389 Council on Undergraduate Research, Washington, D.C.
- 390 11. **Lopatto, D.** 2004. Survey of Undergraduate Research Experiences (SURE): first findings. *Cell biology*  
391 *education* **3**:270-277.
- 392 12. **Lopatto, D.** 2007. Undergraduate Research Experiences Support Science Career Decisions and Active  
393 Learning. *CBE-Life Sciences Education* **6**:297-306.
- 394 13. **McCormick, A. C., A. M. Nuñez, V. Shah, and S. P. Choy.** 1999. Life after college: A descriptive  
395 summary of 1992-1993 bachelor's degree recipients in 1997, with an essay on participation in graduate and  
396 first-professional education, p. 1-115. *In* N. C. F. E. S. U.S. Department of Education (ed.), U.S.  
397 Department of Education, Institute of Education Sciences NCES 1999-155. National Center for  
398 Educational Statistics, Washington, D.C.
- 399 14. **National Science Board.** 2012. *Science and Engineering Indicators 2012*,  
400 [www.nsf.gov/statistics/indicators](http://www.nsf.gov/statistics/indicators). *In* N. S. Foundation (ed.). National Science Foundation, Arlington, VA.
- 401 15. **Russell, S. H., M. P. Hancock, and J. McCullough.** 2007. THE PIPELINE: Benefits of Undergraduate  
402 Research Experiences. *Science* **316**:548-549.
- 403 16. **Withers, G., and Detweiler-Bedell.** 2010. Using transformative research to enrich science curricula and  
404 enhance experiential learning, p. 35-45. *In* K. K. Karukstis and N. Hensel (ed.), *Transformative Research at*  
405 *Predominantly Undergraduate Institutions*. The Council on Undergraduate Research, Washington, D.C.  
406  
407

**Table 1.** Activities supported by K-INBRE at participating institutions<sup>1</sup>

<b>Campus Activity</b>	<b>ESU</b>	<b>FHSU</b>	<b>HINU</b>	<b>KSU</b>	<b>KU-L</b>	<b>KU-MC</b>	<b>LU</b>	<b>PSU</b>	<b>WU</b>	<b>WSU</b>
Research scholarships for undergraduates	x	x	x	x	x		x	x	x	x
Research mini-grants for faculty working with students	x	x		x			x	x	x	x
Summer research program for high school students		x				x				
Gatherings of K-INBRE participants to share information and experiences	x	x	x	x	x	x	x	x	x	x
Create informational/recruitment brochures to increase participation and awareness of the K-INBRE program		x	x		x		x		x	x
Support student travel to make presentations	x	x	x		x	x		x	x	x
Symposium for oral/poster presentations of student participants	x	x	x	x	x	x	x	x	x	x
Implement a program to allow the undergraduate research experience to be a formal course and have a credit hour value attached to it	x	x	x	x	x		x	x	x	x
Implement a program that will increase undergraduate access to primary research literature on line		x					x		x	x
Develop programs to incorporate new technologies into existing classes to better prepare students for graduate research		x	x				x		x	
Invited speaker travel: An invited scientist can present a seminar and interact with students		x	x			x	x	x	x	x
Develop programs to develop interdepartmental projects to foster cooperation among faculty and develop interdepartmental projects involving undergraduates		x	x				x	x	x	x
Mini-grants to help update equipment for undergraduate student research	x	x	x			x	x	x	x	
Methods used for student selection: grades, 1; previous research experience, 2; Letters of recommendation, 3; enrollment in a research problems class, 4; grant/minigrant with mentor/not just an application; 5; Post-graduate plans, 6.	2,6	1,5	4	1,2,6	1,2,3,6	N/A <sup>2</sup>	1,4,6	5	1,5,6	1,3

409 <sup>1</sup>Emporia State Univ., ESU; Fort Hays State Univ., FSU; Haskill Indian Nations Univ. (HINU); Kansas State Univ. (KSU); Kansas University-  
410 Lawrence, KU-L; Kansas University-Medical Center, KU-MC; Langston Univ, (LU); Pittsburg State Univ., (PSU); Washburn Univ., (WU);  
411 Wichita State Univ., (WSU).

412 <sup>2</sup>KU-MC does not have undergraduate students during the academic year. Summer interns are summer/semester scholars.

414

415 **Table 2.** Distribution of K-INBRE students and outcomes 2002-2012

<b>Distribution of K-INBRE Student Participants 2002-2012</b>		
<b>Category<sup>1</sup></b>	<b>Number</b>	<b>Percent<sup>2</sup></b>
Campus scholars	369	50
Summer/semester scholars	286	39
ARRA scholars	33	5
Star Trainees	43	6
Totals	731	100
<b>Outcomes for non-Star Trainees<sup>3</sup></b>		
Entered graduate program	212	37
Entered medical school	111	19
Entered MD/PhD	8	1
Entered other medical professional program	66	12
Still undergraduates	117	N/A
Other outcomes	174	31
Totals	688	100
<b>Outcomes for Star Trainees<sup>3</sup></b>		
Entered graduate program	30	81
Still undergraduates	6	N/A
Other outcome following graduation	7	19
Totals	43	100

416 <sup>1</sup>Campus scholars funded by individual campus programs. Summer/semester scholars, ARRA  
 417 scholars and Star Trainees were reviewed and awarded state-wide by the K-INBRE incentives and  
 418 awards committee.

419 <sup>2</sup>Percent of students in each of the four K-INBRE undergraduate programs (May 2002-May 2012).

420 <sup>3</sup>Outcomes of students that have completed study at K-INBRE institutions.

421

422

423 **Table 3.** Response by institution

<b>Institution<sup>1</sup></b>	<b># Responding<sup>2</sup></b>	<b>%</b>	<b># in Program<sup>3</sup></b>	<b>%<sup>24</sup></b>
Emporia State	25	11	73	1025
Fort Hays State	5	2	56	8426
Haskell Indian Nations	0	0	23	3427
Kansas State	56	25	117	1628
Kansas-Lawrence	36	16	89	1229
Kansas-Med. Center	2	<1	47	6430
Langston	17	8	74	1031
Pittsburg State	29	13	73	1032
Washburn	23	10	84	1133
Wichita State	31	14	95	1334
Total	224		731	435
				436

437 <sup>1</sup>Institution that students attended during the academic year438 <sup>2</sup>224 students responded out of 528 students that were emailed requests to participate in surveys based on deliverable  
439 email addresses.440 <sup>3</sup>Students in program 2002-2012.

441

442 **Table 4.** Distribution of survey respondents

Year	Number of Respondants	
	Baccalaureate graduation <sup>1</sup>	Entered Postgraduate School <sup>2</sup>
2002	2	0
2003	5	6
2004	15	8
2005	13	10
2006	22	13
2007	12	9
2008	14	13
2009	25	24
2010	25	16
2011	24	24
2012	34	0
2013	23	0
2014	5	0

443 <sup>1</sup>Four respondents did not answer and one received a DVM without obtaining a Baccalaureate degree

444 <sup>2</sup> Year respondent entered medical or graduate school, 39 answered N/A and 62 skipped the question

445

446

447 **Table 5.** Number of semesters of K-INBRE student participation<sup>1</sup>

# Semesters	% of survey respondents	% of Participants 2002-2012
1	25 (2) <sup>2</sup>	34 (2) <sup>2</sup>
2	28 (1)	42 (1)
3	17 (4)	6 (4)
4	19 (3)	13 (3)
5	5 (5)	2 (5)
6	2 (7)	1 (6)
>6	4 (6)	1 (6)

448 <sup>1</sup>Number of semesters students were funded by K-INBRE to participate in research.

449 <sup>2</sup>Ranking of semesters of K-INBRE student participation highest to lowest.

450

451

452 **Table 6.** Gender distribution of survey respondents

	<b>% in program</b>	<b>% respondents</b>	453
Male	44	39	454
Female	56	59	455
			456

457 <sup>1</sup>2% answered I would rather not answer

458

459

460

**Table 7. Race of Respondents**

<b>Ethnic Designation<sup>1</sup></b>	<b>% of Respondents</b>	
White	71	461
Black	8	462
American Indian	<1	463
Asian	9	464
Native Hawaiian/Pacific Islander	0	465
Other	3	466
I would rather not answer	4	467
Skipped question	8	468
		469
		470

471

472

473

<sup>1</sup>5% of the respondents indicated they were of Hispanic, Latino or Spanish origin, regardless of race, 92% indicated they were not, 3% indicated that they would rather not answer.



474

475 **Table 8.** Student research experience:to what extent did your research experience change you

<b>Question<sup>1</sup></b>	<b>Response</b>
It helped me to better think and work independently and formulate my own ideas.	4.35
It helped me become more intrinsically motivated to learn.	4.22
It made me a more active learner	4.32
It helped improve my skills in the analysis of data and interpretation of results.	4.46
It gave me tolerance for obstacles faced in the research process.	4.46
It improved my understanding of how knowledge is constructed and how scientists work on real problems.	4.52
It improved my ability to integrate theory and practice.	4.32
It increased my self confidence.	4.14
It increased my ability to work in a team.	3.92
It increased my potential to be a teacher of science	3.93

476 <sup>1</sup>220 out of 224 students responded to this question.477 <sup>2</sup>Students could strongly agree (5), agree (4), be neutral (3), disagree (2) or strongly disagree (1). Answers were weighted as indicated.

478

479

480 **Table 9.** Types of scientific presentations made by survey respondents

<b>Presentation Type</b> <sup>1</sup>	<b>% Response</b>
An academic paper presented by your mentor or other senior member in the lab	32.7
A poster presentation on campus	67.7
A poster presentation off campus at a conference or professional meeting	70.5
A talk on campus	45.5
A talk off campus at a conference or professional meeting	20.9
A manuscript intended for publication in a professional journal (one or more)	27.3
A website or internet presentation	2.3
None of the above	3.6
Other	5.0

481 <sup>1</sup>220 out of 224 students responded to this question. More than one choice was allowed therefore, the numbers will not add up to  
482 100%.

483

484

485 **Table 10.** Student overall impression about their research experience

<b>When you reflect on your research project as a learning experience, you feel that<sup>1</sup>:</b>	<b>Number</b>	<b>Percent</b>
My research project was fantastic (5)	60	27.3
I had a good time, learned a lot, and would do it again (4)	140	63.6
I feel neutral about it-there were both good and bad things (3)	17	7.7
It was better than working somewhere else, but I don't think I learned a lot (2)	2	0.9
Time in the lab was a waste-I didn't learn much (1)	1	0.5
<b>Overall score<sup>2</sup></b>	<b>4.16/5.00</b>	

486 <sup>1</sup>220 out of 224 students responded to this question.

487 <sup>2</sup>Answers were weighted as indicated in parenthesis.

488

489

490 **Table 11.** Participant recommendations to future students

<b>The K-INBRE made a big impact on my life and I recommend that other students participate in the program<sup>1</sup></b>	<b>Number</b>	<b>Percent</b>
Strongly agree (4)	120	58.0
Agree (3)	83	40.1
Disagree (2)	3	1.4
Strongly disagree (1)	1	0.5
<b>Overall score<sup>2</sup></b>	<b>3.56/4.00</b>	

491 <sup>1</sup>207 out of 224 students responded to this question.

492 <sup>2</sup>Answers were weighted as indicated in parenthesis.

493

494

495 **Table 12.** Participant recommendations about program continuation

<b>The K-INBRE program is an important program for student development and should be continued in Kansas<sup>1</sup></b>	<b>Number</b>	<b>Percent</b>
Strongly agree (4)	170	82.1
Agree (3)	37	17.9
Disagree (2)	0	0
Strongly disagree (1)	0	0
<b>Overall score<sup>2</sup></b>	<b>3.82/4.00</b>	

496 <sup>1</sup>207 out of 224 students responded to this question.

497 <sup>2</sup>Answers were weighted as indicated in parenthesis.

498

499

500 **Table 13.** K-INBRE influence on career choice

<b>Participation in the K-INBRE program helped you in your career choice<sup>1</sup></b>	<b>Number</b>	<b>Percent</b>
Strongly agree (4)	95	43.6
Agree (3)	102	46.8
Disagree (2)	21	9.6
Strongly disagree (1)	0	0
<b>Overall score<sup>2</sup></b>	<b>3.34/4.00</b>	

501 <sup>1</sup>218 out of 224 students responded to this question.

502 <sup>2</sup>Answers were weighted as indicated in parenthesis.

503

504

505 **Table 14.** Survey respondent's experience with K-INBRE electronic presence.

Question <sup>1</sup>	% Response	
	Yes	No
Have you visited the K-INBRE website at <a href="http://www.kumc.edu/kinbre">www.kumc.edu/kinbre</a> in the last year?	33.0	67.0
Have you visited the K-INBRE Facebook page at <a href="http://www.facebook.com/KansasINBRE">www.facebook.com/KansasINBRE</a> in the last year?	16.5	83.5
Are you a friend of K-INBRE on Facebook?	19.9	80.1

506

<sup>1</sup>206 out of 224 students responded to these questions.

507

508

509 **Table 15.** Career choices by survey respondents

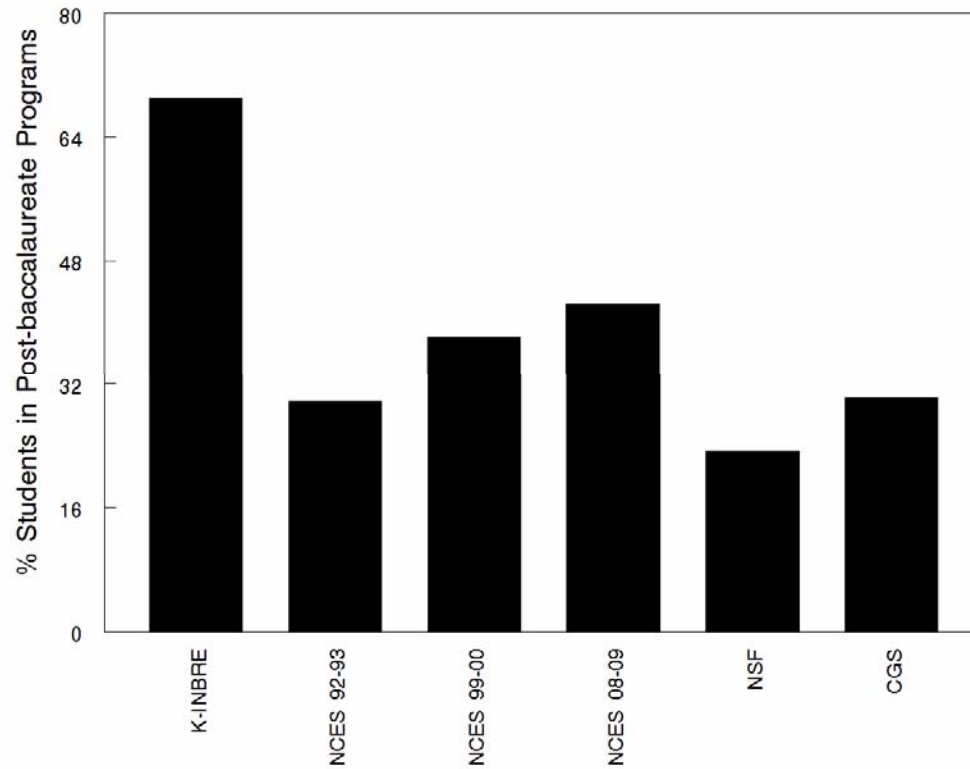
<b>Career Choice following graduation</b>	<b>% Response<sup>1</sup></b>	<b>% of graduates<sup>2</sup></b>	
Attended medical (MD/DO) school	21.6	27.8	510
Attended graduate school	30.7	39.6	511
Attended MD/PhD program	6.2	8	512
Attended other professional program	8.7	11.2	513
Took a job in a biomedical field	5.0	6.4	514
Took a job in a nonbiomedical science field	4.6	5.9	515
Took a job in a non science field	<1	1.1	516
Still an undergraduate in training	22.4	N/A	517
			518
			519

520 <sup>1</sup>218 out of 224 students responded to this question.521 <sup>2</sup>Distribution of career choices of graduates. N/A indicates not applicable.

522



523 **Figure 1. Comparison of K-INBRE student post-baccalaureate success to other national metrics.** Percent of K-INBRE students entering  
524 post baccalaureate programs compared to the National Center for Education Statistics (NCES) Bachelor's Degree Recipients 1 Year Later 1992-  
525 1993 cohort (13), the NCES 1999-2000 cohort (3), the NCES Baccalaureate and Beyond Longitudinal Study 2008-2009 cohort (5), National  
526 Science Foundation Statistics (14), the Council of Graduate Schools (CGS) survey 2000-2010 (2), and the 2009 College Senior survey (6). See  
527 text for details.  
528  
529



530