UNDERGRADUATE STUDENT ATTITUDES AND PERSPECTIVES OF THE ACCESSIBILITY, SUPPORTIVENESS, AND APPRECIATION OF RESEARCH OPPORTUNITIES IN THE HEALTH SCIENCES

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Abstract

Undergraduate research is a "high-impact" educational practice that enriches student learning and facilitates student career advancement. This sequential explanatory mixed methods study, composed of a quantitative online questionnaire followed by qualitative focus group interviews, sought to explore undergraduate student attitudes on research and elicit perceived facilitators and barriers to undergraduate research engagement. The survey respondents (N = 377), all undergraduate health sciences students at McMaster University in Hamilton, Ontario, generally had positive attitudes toward undergraduate research, but had polarized perceptions of its accessibility, supportiveness, and appreciation. Follow-up focus group interviews with selected participants (N = 11) revealed four main themes: (1) the hidden curriculum of undergraduate research, (2) the paucity of meaningful research work for emerging student researchers, (3) the administrative barriers within the undergraduate research landscape, and (4) the inequitable access to undergraduate research opportunities. This study's findings suggest potential avenues to improve the undergraduate student research experience.

Keywords: undergraduate research, accessibility, mixed methods, student perspectives, post-secondary students, higher education

Résumé

La recherche au premier cycle enrichit l'apprentissage des étudiants et facilite l'avancement de leur carrière. Cette étude séquentielle explicative à méthodes mixtes, comprenant un questionnaire suivi de groupes de discussion, visait à explorer les attitudes des étudiants de premier cycle en sciences de la santé à l'égard de la recherche, ainsi que les facilitateurs et les obstacles perçus quant à leur engagement dans celle-ci. Les n = 377 répondants au questionnaire avaient généralement une attitude positive à l'égard de la recherche au premier cycle, mais avaient des perceptions polarisées quant à son accessibilité, au soutien reçu et à l'appréciation obtenue. Les groupes de discussion avec n = 11 participants ont révélé quatre thèmes principaux : 1) le « programme caché » de la recherche au premier cycle; 2) la rareté des travaux de recherche significatifs pour les étudiants chercheurs; 3) les barrières administratives; et 4) l'accès inéquitable aux possibilités de recherche. Les résultats de cette étude suggèrent des méthodes pour améliorer l'expérience de recherche des étudiants de premier cycle.

Mots-clés : recherche au premier cycle, accessibilité, méthodes mixtes, perspectives des étudiants, étudiants postsecondaires, enseignement supérieur

Introduction

Undergraduate research (UGR) is a "high-impact" educational practice (Kuh, 2008) that has been articulated as "an underlying principle" of undergraduate programs (Katkin, 2003). UGR is an invaluable means of enriching student learning, skill development, and self-actualization, and, in many disciplines, has become a prerequisite for student career advancement. The importance of early research exposure for undergraduate student learning is well-established in the literature. In addition to developing their research and critical appraisal skills (Ashcroft et al., 2020), UGR involvement also extends student learning by helping students conceptualize course content and appreciate the rationale underlying scientific inquiry, hypothesis testing, and knowledge generation (Madan & Teitge, 2013). As a result, across a diversity of student populations and disciplines of study, students have reported that UGR experiences have led to gains in skills and knowledge (Collins et al., 2017; Fini et al., 2018; Seymour et al., 2004).

Alongside improving student learning, UGR also cultivates personal development. UGR engagement develops collaboration skills (Madan & Teitge, 2013) due to the interdisciplinary, team-based nature of research, and knowledge translation skills through student participation in conference presentations and scholarly publications (Little, 2020). Furthermore, studies have documented that problem solving (Seifan et al., 2021), personal confidence (Little, 2020), intellectual independence, and comfort with self-directed learning (Imafuku et al., 2015) are also strengthened by UGR, thus preparing students for lifelong learning throughout higher education and in the workforce.

UGR is a known facilitator of career advancement and can help students finalize their career paths following graduation by exposing students to new career fields (Madan & Teitge, 2013). UGR opportunities have been shown to clarify student interest in research and encourage students who had not previously considered postgraduate studies to aspire for higher degree programs (Russell et al., 2007). Benefits have also been documented in UGR faculty supervisors, who report increased productivity in their scholarly work in terms of published papers, conference attendance, and receipt of grant funding relative to peers who did not mentor undergraduate student researchers (Baker et al., 2015).

The previous literature exploring the accessibility and barriers to UGR has emphasized the importance of fostering meaningful student mentorship and addressing curricular gaps in research training for undergraduate students (Assar et al., 2022; Kharraz et al., 2016). Some studies have also identified demographic factors such as race, socio-economic status, and gender serving as factors influencing student access to UGR opportunities (Aikens et al., 2017; Pierszalowski et al., 2021). However, there exists limited literature on how these factors influence the accessibility of UGR and student experiences with UGR specifically in the health sciences. Most undergraduate students in the health sciences pursue higher education through healthcare professional programs or graduate school, advanced degree programs that value research engagement for admission (Hecker & Violato, 2006; Yang et al., 2022). Previous work has identified that health sciences students engage in UGR to clarify career goals, gain knowledge and competencies that may be valuable in higher education, and increase their competitiveness for professional and graduate schools (Pacifici & Thomson, 2011).

Adding to the limited literature on the facilitators and barriers to UGR in the health sciences will improve the research experience of current and future students hoping to get involved in meaningful UGR opportunities. As such, we sought to answer the following explanatory research questions in this mixed methods study:

- What are the perceptions of undergraduate health sciences students regarding the accessibility, supportiveness, and appreciation of UGR?
- What associations exist between health sciences student demographics and educational characteristics and perceptions of UGR?
- What do undergraduate health sciences students perceive to be the facilitators and barriers to UGR?

Methods

Conceptual Framework and Study Design

Tinto's model (1975) is a validated framework for a student's transition to higher education spaces and their capacity to succeed in their program. Tinto's longitudinal, explanatory model defined the factors that underlie a student's decision-making process for persisting in or dropping out from higher education pursuits through a sequence of six successive steps: (1) pre-entry attributes, (2) objectives and initial commitments, (3) experience with the university system, (4) integration, (5) objectives and emerging

commitments, and (6) result. We selected Tinto's model as our conceptual framework as it allows us to examine the pre-entry demographic factors and the academic and social system influences on undergraduate student experiences and perceptions of UGR.

This descriptive study is exploratory in nature and employed a sequential explanatory mixed methods design (Creswell & Clark, 2017). Data was collected sequentially from undergraduate students in the Faculty of Health Sciences at McMaster University, in Hamilton, Ontario, through an online survey followed by semi-structured focus group interviews, with data analyzed separately but interpreted in concert in the discussion section. The qualitative arm of this study was approached through the lens of a qualitative description design. This design was selected to provide a rich description of a poorly understood phenomenon through the perspectives of the people involved in order to define evidence-informed interventions (Kim et al., 2017). The rationale for this sequential explanatory mixed methods approach is to enrich the quantitative data, which aims to establish general patterns of UGR involvement and student perceptions of UGR, with the qualitative data, which aims to elicit student-perceived barriers and facilitators to engaging in UGR. This study was approved by the Hamilton Integrated Research Ethics Board (Project #: 5522).

Study Setting

This sequential explanatory mixed methods study was conducted at McMaster University, in Hamilton, Ontario. McMaster University has been Canada's most research-intensive university for the past four years, from 2017–2020. McMaster faculty researchers receive on average $404,400 per year of research funding, almost double the national average of $265,000 of research dollars per faculty annually (Research InfoSource, 2020). McMaster University's Faculty of Health Sciences enrolled approximately 5,064 full-time students in 2019–2020 (McMaster University, 2021).

Participants

Students enrolled in undergraduate programs in the Faculty of Health Sciences at McMaster University were eligible to participate in this study. Participants in the quantitative arm were invited to complete a secure, open-source online survey shared through postings in university social media groups and faculty email lists. We collected 377 participants, each of whom provided their written consent to participate in the study and completed the online questionnaire. As part of the online survey, interested participants were invited to share their contact details with the research team to be contacted as interviewees for the qualitative focus-group interview arm of the study. Of the 56 participants who indicated an interest in being interviewed through the online survey, 45 did not respond and were lost to follow-up, and 11 participants were interviewed in the qualitative focus groups. Every participant who responded to the initial contact email sent by the research team was interviewed. The following list provides further contextual background information to identify each participant's enrolled undergraduate program and academic year, as well as their engagement with UGR at the time of their focus group interviews:

- Focus Group 1 Participant 1 (P1 FG1): Health Sciences, Year 4
- Focus Group 1 Participant 2 (P2 FG1): Health Sciences, Year 4
- Focus Group 1 Participant 3 (P3 FG1): Health Sciences, Year 3
- Focus Group 1 Participant 4 (P4 FG1): Health Sciences, Year 2
- Focus Group 2 Participant 1 (P1 FG2): Nursing, Year 4
- Focus Group 2 Participant 2 (P2 FG2): Health Sciences, Year 4
- Focus Group 2 Participant 3 (P3 FG2): Health Sciences, Year 2
- Focus Group 2 Participant 4 (P4 FG2): Health Sciences, Year 3
- Focus Group 3 Participant 1 (P1 FG3): Health Sciences, Year 3
- Focus Group 3 Participant 2 (P2 FG3): Integrated Biomedical Engineering and Health Sciences, Year 3
- Focus Group 3 Participant 3 (P3 FG3): Health Sciences, Year 1

All but one of the participants (P2 FG3) was involved in UGR.

Data Collection

Online Questionnaire

Data concerning undergraduate health sciences student research engagement and perceptions of UGR opportunity were collected through an online questionnaire. This online

questionnaire was developed to capture the pre-entry attributes and institutional experiences with UGR in keeping with Tinto's (1975) model through consensus by the study authors (ODL, SHL, SG, PS), who were all undergraduate students at the time, and was piloted on a small convenience sample of undergraduate students. The first part of the survey consisted of four multiple choice questions to collect information on the participants' demographic information, age, gender, program of study, and academic level (year 1–4). The primary outcomes of the questionnaire were explored in the second part of the survey, with four Likert scale questions measuring the extent to which participants agreed with a statement (1 = strongly disagree; 5 = strongly agree) to capture participant attitudes toward, as well as their perceptions of the accessibility, supportiveness, and appreciation of UGR. The terms of accessibility, supportiveness, and appreciation were not explicitly defined for participants. The third part of the survey explored participant research productivity through self-reports of their number of peer-reviewed scholarly publications, conference presentations, and undergraduate student research grants. The last question was optional and invited participants to write additional comments about their UGR experiences. Study data was collected and managed using LimeSurvey electronic data capture tools hosted at McMaster University. The online questionnaire was disseminated to undergraduate students in the Faculty of Health Sciences through social media. Eligibility was controlled by checking the demographic characteristics of the participants to ensure they were indeed a member of the Faculty of Health Sciences at McMaster University. The survey was made available from February of 2020 to December of 2020.

Semi-Structured Focus Group Interviews

Further exploration of the participants' attitudes and experiences with UGR, including the barriers and facilitators they may have experienced, were investigated through semi-structured focus group interviews. In keeping with the sequential explanatory mixed methods design, the interview questions were developed after the collection of the quantitative online questionnaire data. Due to the heterogeneity of perspectives of participants from different academic years and programs, probing questions about coursework, longitudinal changes in UGR experiences, and student suggestions to improve their UGR experience were included in the interview guide. Please see Table 1 for our semi-structured focus group interview guide.

Focus group interviews of 11 participants in groups of three to four were facilitated by two members of the research team (SG and PS, students enrolled in the undergraduate Bachelor of Health Sciences program at McMaster University during data collection, who are peers or near-peers to the participants) and conducted virtually via the Zoom videoconferencing platform. Each focus group was between 40–60 minutes in duration. Field notes were taken to capture non-verbal communicative signs from participants and researcher thoughts and observations during the focus groups. Discussions were audio-recorded and transcribed verbatim. No repeat focus groups were conducted.

Table 1

Semi-Structured Focus Group Interview Guide

	Focus group questions
1.	How do you find research opportunities? What are current resources you use, and do you find them to be effective?
2.	What resources for research do you think are missing from the McMaster community?
3.	Do you believe current coursework does an effective job at preparing you for research opportunities?
4.	What do you think about current upper year research courses?
5.	Do you believe there are non-academic barriers to accessing meaningful research opportunities?
6.	Has the research you have done in the past been fulfilling? What skills were you able to gain, and how could it have been improved?
7.	How has your research experience changed from first year as you moved further in your undergraduate studies?

Data Analysis

Analysis of the General Patterns of UGR Involvement and Student Perceptions of UGR from Questionnaires

Quantitative survey data was analyzed with analyses of variance on multivariable linear models with age, gender, program, year, and research engagement as explanatory variables for each primary outcome of our quantitative survey data (participant attitudes toward, as well as their perceptions of the accessibility, supportiveness, and appreciation of UGR). Explanatory variables significantly associated with the primary questionnaire outcomes (program and research engagement) were explored further with Mann Whitney U tests or one-way ANOVAs, followed by post hoc group comparisons with Tukey's correction for multiple comparisons. Statistical analyses were conducted in RStudio and GraphPad Prism 8.0 for Macintosh. All quantitative data are presented as mean +/- standard deviation. Statistical significance was set at $p < 0.05$.

Analysis of the Barriers and Facilitators to UGR from Interviews

A conventional content analysis approach was employed to analyze the interview data in order to describe a phenomenon with limited existing evidence by staying true to the collected data (Hsieh & Shannon, 2005). After the focus group interviews, the research team discussed overall impressions from the interviews, the field notes that were taken, and general ideas for potential codes. Four members of the research team (SG, PS, SHL, and ODL) subsequently reviewed the interview transcripts to independently develop codes for the data. The research team then consolidated the codes and arranged them into themes through induction, with conflicts resolved through team discussion to reach consensus. Member checking was performed to mitigate investigator bias and to provide study participants an opportunity to provide feedback on the themes derived from their semi-structured focus group interviews. The preliminary themes generated by the study authors were emailed to all focus group participants and participants were given two weeks to provide feedback and propose changes. All focus group participants approved the themes; one participant did not respond to the member checking email despite multiple follow-ups.

Results

Online Questionnaire

Quantitative survey data were collected from 377 undergraduate students enrolled in the Faculty of Health Sciences at McMaster University, with an estimated survey response rate of 7.4% given that there were 5,064 full-time undergraduate students in the Faculty of Health Sciences in 2019–2020 (McMaster University, 2021). Survey participants were predominantly female (75.9%), from the Bachelor of Health Sciences program (75.0%), and in their first three academic years (only 11.4% of participants were academic year 4 or higher) (Table 2). Almost half (181, or 48.0%) of study participants reported being involved in curricular or extracurricular research at McMaster University in some capacity. Undergraduate student participants reported $\bar{x} = 0.1 \pm 0.36$ published research papers as first author and $\bar{x} = 0.18 \pm 0.52$ as a non-primary author, and $\bar{x} = 0.27 \pm 0.78$ conference oral and poster presentations as first author and $\bar{x} = 0.18 \pm 0.59$ as a non-primary author. Participants reported a wide range of receipt of UGR grants ($\bar{x} = \$627 \pm \$2{,}119$).

Students' experience and self-reported satisfaction with their UGR experience ranged quite broadly (Table 3). Most students (64%) reported having a positive attitude toward UGR in the health sciences. However, student responses were more polarized in regard to their perceptions of the accessibility, supportiveness, and appreciation of UGR experiences—38% of students felt that UGR in the health sciences was accessible to health sciences students, while 29% of students disagreed or strongly disagreed that undergraduate health sciences research was accessible. While 35% of students felt that they were granted sufficient resources to conduct their research activities, on the other hand, 33% felt that they were not granted sufficient resources. Though 30% of students agreed or strongly agreed with the sentiment that their contribution to research in the health sciences is appreciated by faculty, the university, or the greater academic community, 24% of respondents did not feel that their UGR contributions were appreciated.

ANOVAs of multivariable linear models with age, gender, program, year, and research engagement as predictor variables for each primary survey outcome found significant global associations between student research engagement and program with student attitudes and perceptions of UGR (data not shown). Mann Whitney U testing showed that stu-

Table 2

Demographic Characteristics

Demographic Characteristic	*n*	%
Gender		
Female	286	76
Male	88	23
Other	3	1
Program of Study		
Bachelor of Health Sciences	283	75
Bachelor of Integrated Biomedical Engineering and Health Sciences	38	10
Bachelor of Science in Nursing	28	7
Bachelor of Health Sciences in Biomedical Discovery and Commercialization	26	7
Bachelor of Midwifery	1	0.5
Other	1	0.5
Academic Year		
1	137	36
2	105	28
3	92	25
4 or higher	43	11
Engaged in curricular or extracurricular research at McMaster University		
Yes	181	48
No	129	34
Did not disclose	67	18
Research Productivity	$\bar{x}$	*SD*
Published research papers in peer-reviewed academic journals		
As first-author	0.1	0.36
As non-primary author	0.18	0.52
Oral or poster presentations delivered at scholarly conferences		
As first-author	0.27	0.78
As non-primary author	0.18	0.59
Sum of research grants received ($CAD)	627	2119

Note: N = 377. Participants were on average 19.3 years old (*SD* = 1.46)

Table 3

Student Attitudes toward Undergraduate Research (UGR) and Perceptions of the Accessibility, Supportiveness, and Appreciation of UGR in the Health Sciences

Survey questionnaire	*n*	%
Overall, I have a very positive attitude towards undergraduate research in the health sciences		
Strongly disagree	4	1
Disagree	30	8
Neither agree nor disagree	102	27
Agree	158	42
Strong agree	83	22
Overall, I feel undergraduate research in the health sciences is accessible at McMaster University		
Strongly disagree	26	7
Disagree	83	22
Neither agree nor disagree	124	33
Agree	106	28
Strong agree	38	10
Overall, I feel that I am granted sufficient resources that support my research activities in the health sciences at McMaster University		
Strongly disagree	30	8
Disagree	94	25
Neither agree nor disagree	121	32
Agree	98	26
Strong agree	34	9
Overall, I feel that my contribution to research in the health sciences is appreciated by faculty, the university or the greater academic community		
Strongly disagree	26	7
Disagree	64	17
Neither agree nor disagree	174	46
Agree	83	22
Strong agree	30	8

Note: 377 participants completed the survey questionnaire.

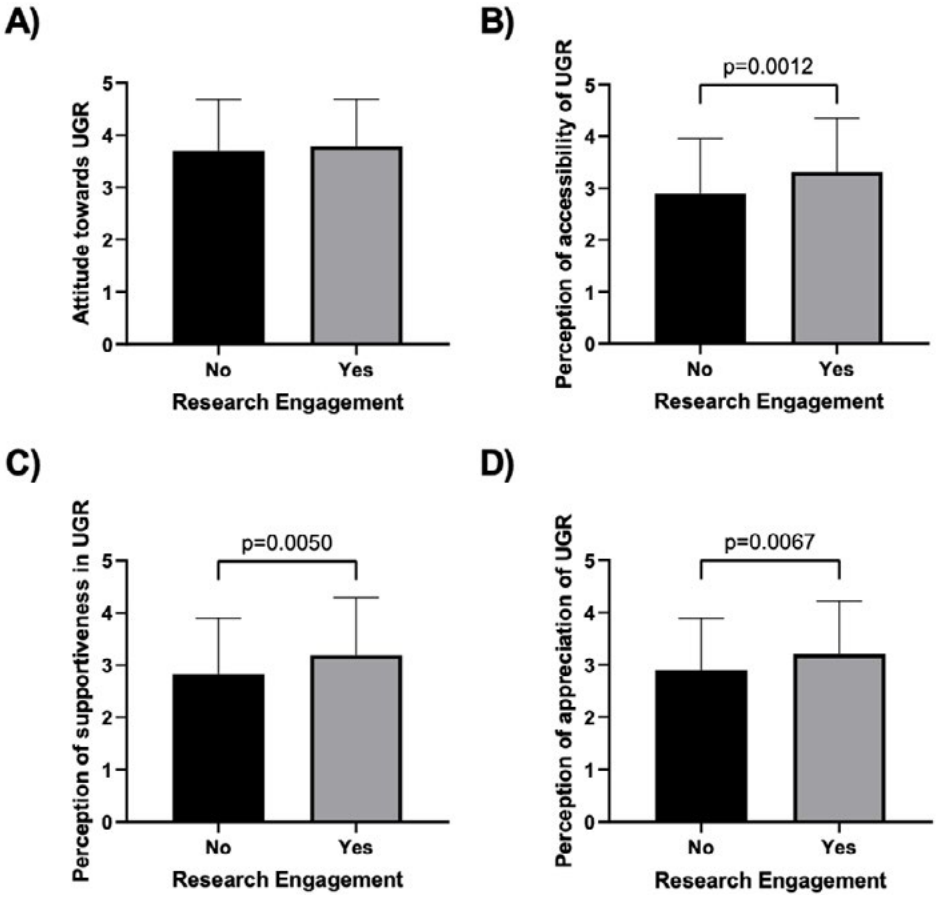
dents engaging in UGR have a more favourable perception of the accessibility (p = 0.0012; Fig 1B), supportiveness (p = 0.0050; Fig 1C), and appreciation (p = 0.0067; Fig 1D) of UGR relative to students that did not engage in research. In addition, one-way ANOVAs showed main effects of program on student perception of the accessibility (F (3,333) = 4.43, p = 0.0045) and supportiveness of UGR (F (3,333) = 4.40, p = 0.0076). Post hoc group comparisons with Tukey's correction showed that Biomedical Discovery and Commercialization (BDC) students indicated more positive perceptions of the accessibility and supportiveness of UGR relative to Bachelor of Health Sciences (BHSc) and Integrated Biomedical Engineering & Health Sciences (iBioMed) students (p < 0.05; Fig 2B & C).

Semi-Structured Focus Group Interviews

Three focus group interviews were conducted with 11 students enrolled in the Faculty of Health Sciences at McMaster University. Results from the focus groups were synthesized by study authors into four main themes: (1) the hidden curriculum of UGR, (2) the paucity of meaningful research

Figure 1

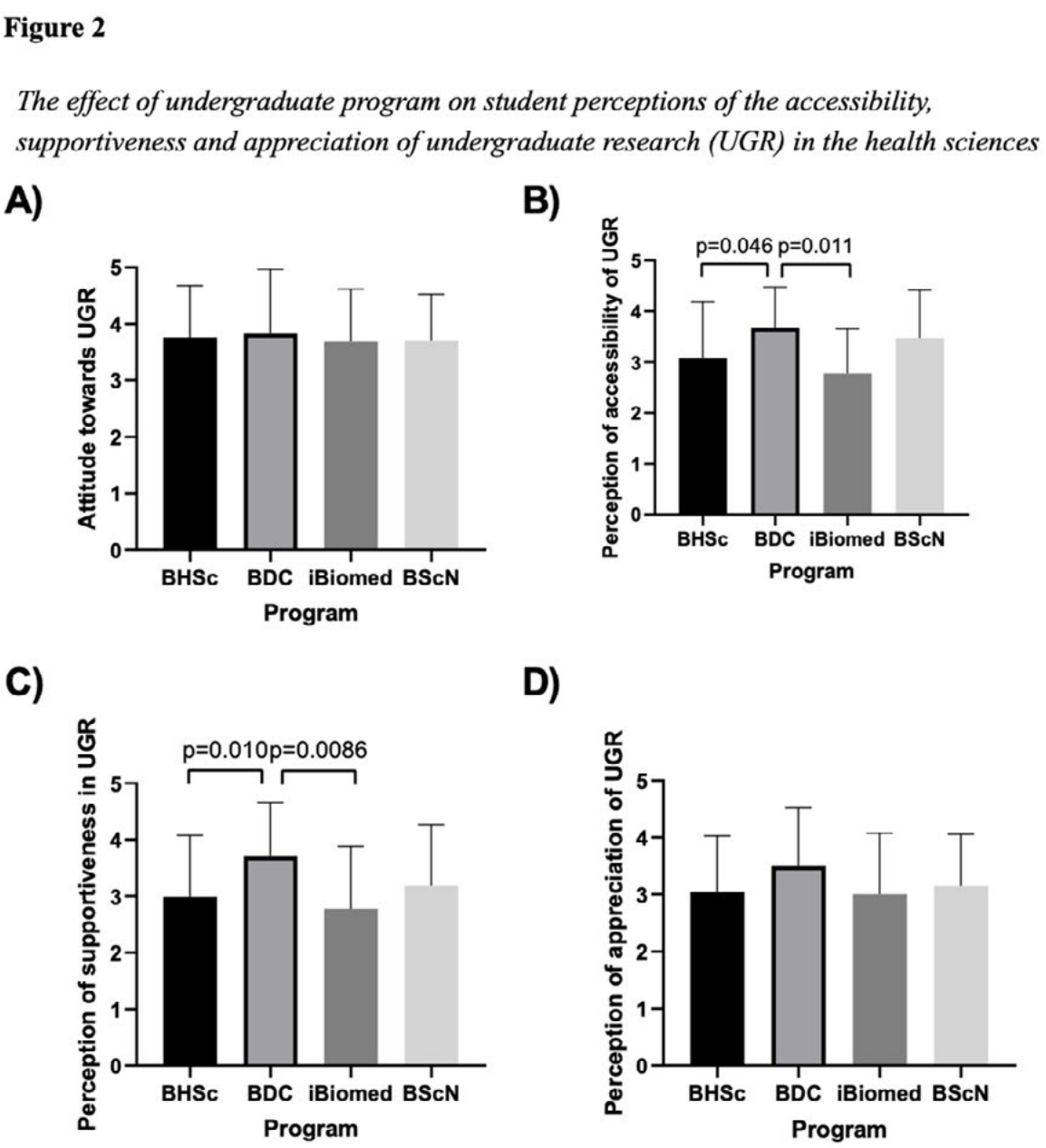
The Effect of Research Engagement on Student Perceptions of the Accessibility, Supportiveness, and Appreciation of Undergraduate Research (UGR) in the Health Sciences



Note: Students who have engaged in UGR were compared to those who have not engaged in UGR in regard to their self-reported attitude towards (A), and perceptions of the accessibility (B), supportiveness (C) and appreciation (D) of UGR. Data shown are mean +/- standard deviation of Likert scale questionnaire responses ranging from 1 = strongly disagree to 5 = strongly agree. Statistically significant differences are indicated with their respective p-values.

Figure 2

The Effect of Undergraduate Program on Student Perceptions of the Accessibility, Supportiveness, and Appreciation of Undergraduate Research (UGR) in the Health Sciences



Note: Students enrolled in the Bachelor of Health Sciences (BHSc), Biomedical Discovery and Commercialization (BDC), Integrated Biomedical Engineering & Health Sciences (iBioMed), Bachelor of Science in Nursing (BScN) undergraduate programs were compared in regard to their self-reported attitude towards (A), and perceptions of the accessibility (B), supportiveness (C) and appreciation (D) of UGR. Data shown are mean +/- standard deviation of Likert scale questionnaire responses ranging from 1 = strongly disagree to 5 = strongly agree. Statistically significant differences are indicated with their respective p-values.

work for emerging student researchers, (3) administrative barriers within the UGR landscape, and (4) the inequitable access to UGR opportunities.

The Hidden Curriculum of UGR

The theme of the "hidden curriculum" emerged when exploring student attitudes and perceptions toward UGR. Koutsouris and colleagues (2021) define the "hidden curriculum" as the culmination of "the unintended messages, underpinning norms, values, and assumptions that are often so unquestioned that they have become invisible."

Students emphasized a pervasive pressure to be involved in research as a result of peer comparisons and its perceived value for career advancement. Students noted that "it's implicit pressure that all students are doing research somehow" (P1 FG1), saying "I had this image that [research] was something I was supposed to do to get to another stage of life" (P4 FG2) and "You're always looking over your shoulder to see what other students are doing and whether you are doing the same amount" (P1 FG1).

This intrinsic pressure to contribute to research manifested in a trend of student engagement in projects that were not necessarily inspiring to them, with students saying, "In first year…I had to cold email every single prof, [and] ended up with a research position that I don't really care about" (P1 FG3), and "[Now], I can kind of focus my research on topics that I want to do, whereas mainly in first year, I was trying to do whatever I can to get that experience" (P3 FG2).

Participants also expressed that there seemed to be extrinsic pressure for students to engage specifically in medical research. This pressure was reinforced by the underrepresentation of non-medical research on popular advertising hubs for UGR opportunities and in health sciences program curricula:

> If they [undergraduate students in the health sciences] want to pursue something outside of medicine, they should have the liberty and opportunity to do so.... The opportunities given to them inside of medicine should be equal to the opportunities given outside of medicine. (P2 FG3)

The Paucity of Meaningful Research Work for Emerging Student Researchers

Despite the underscored benefits of UGR and the global pressure felt by students to participate, interviewees reported a paucity of meaningful research opportunities for students at this early stage of their education.

Across focus groups, this shortfall was largely attributed to a culture of assigning unglamorous "grunt work" to the most junior members of the research team, which include time-consuming rote and tedious tasks:

> I used to volunteer at a psychology lab, and they just had me transcribe interviews, and they were 1-hour long interviews, and I had to just transcribe everything including the "uhs" and the "uhms," stutters, everything. It was just pure grunt work. (P1 FG1)

Although many students felt that they were given graduated responsibilities over time, this often involved switching labs or supervisors, which detracted from longitudinal learning and the development of meaningful faculty–student mentorship relationships:

> I wish there were some sort of promotion within research positions, because for me, if I know I have done the same task for a few months and I want to learn something new, it would involve me finding a new research position with different tasks. (P3 FG2)

Within the curricular context, students noted that poorly designed research courses can not only fail to engage students in research, but actively detract from their interest in it.

> We were given hypothetical research questions and designs and [were told] to collect data from our peers, basically pretending like we are doing research but for the purposes of the course.... I think some of these research courses diminish the students' interest in research if the courses require students to do something that they are not really interested in. (P1 FG2)

Administrative Barriers within the UGR Landscape

Across all focus groups, a common grievance highlighted by almost all student participants was the disorganized nature of the UGR landscape. As a result of the ad hoc nature of securing UGR, many students resort to scouring faculty directories and cold emailing professors for opportunities, which is a discouraging, time-consuming, and variably successful process.

> When I was first getting into research, at least 100 emails were sent out to just random professors…[a] barrier of

> entry is all the emails and throwing out a big net and hoping the fish gets in. (P2 FG1)

Others seek opportunities on their program's Facebook group, but access to research positions in this way is highly dependent on the student's program and its associated research culture. The university also hosts research fairs, which some students find helpful. However, this patchwork of resources was found to be overwhelming and challenging to navigate by many students: "I think, at McMaster, there are a lot of student services and as a student, it is sometimes confusing who to go to when" (P4 FG2).

Student participants proposed that a central database from which students can search for research opportunities would improve their UGR experience:

> A barrier to all research is trying to find a professor in the first place. If they had a database where you know professors are looking for students and you know what type of research projects they are doing...that would be very helpful. (P1 FG1)

The Inequitable Access to UGR Opportunities

Further complicating the limited accessibility to meaningful research opportunities are structural barriers, which make securing research opportunities more difficult for particular groups of undergraduate students.

Resource constraints contributing to inequitable access to research were primarily financial and geographical in nature. Numerous students remarked upon the fact that most UGR opportunities are unpaid positions, which may exclude students who are less financially privileged.

> I think there is a big expectation on undergrads [that] you are [going to] work for free for profs and I feel like that's a huge barrier for a lot of people. I know a lot of people aim to work to pay their tuition or rent, so oftentimes they have the time to go work but then they won't have the time to go volunteer at someone's lab. (P4 FG1)

Access to paid research positions is similarly elusive due to the prerequisite research experiences often expected for these opportunities.

> For paid research, they advertise it as no experience required, but from what I have seen, they usually take the most experienced people, so...people who need a position to get an income from will stray away from that, but they also don't have the background then to get a paid position. (P3 FG2)

In terms of geographical inequity, participants noted that UGR opportunities are often clustered in urban academic centres. This may place undue financial burdens on students from rural communities, who must incur extraneous expenses to pursue summer research projects outside their home communities. One student stated "I always wonder about people from smaller communities which may not have these types of research opportunities. Over the summer, they usually end up staying at Hamilton, which eats up rent" (P2 FG1).

Discussion

The quantitative arm of this study found that students had generally positive attitudes toward UGR; however, there was heterogeneity in student-reported perceptions of the accessibility, supportiveness, and appreciation of UGR. In addition, survey findings indicate that students involved in UGR have better perceptions of research compared to those who are not, which is consistent with previous work highlighting positive student-reported outcomes from UGR involvement (Bowman & Holmes, 2018; Sears et al., 2017). Interestingly, program of study was found to influence student perceptions of UGR, with students from the BDC program reporting more favourable perceptions than their counterparts in the BHSc and the iBioMed programs. This may be related to the BDC program's design as an integrated Bachelor–Master program, which provides more curricular research opportunities to facilitate student progression through the program (McMaster BDC Program, 2021). Indeed, inadequate knowledge of research methodology and inadequate statistical skills are common student-reported barriers to participating in UGR (Kumar et al., 2019; Mugabo et al., 2021). Curricular research exposure that develops student competencies in performing fundamental research skills would thereby address this student-reported barrier, and prepare all undergraduate students to meaningfully participate in research projects. This is consistent with Tinto's (1975) model and its emphasis on integration between curricular and extracurricular commitments, which is critical to developing meaningful student engagement in UGR. Overall, this finding underscores that knowledge sharing between higher education programs and institutions will be valuable to identify effective case studies of educational and research program designs, and rapidly scale up these

innovative infrastructures to broadly promote UGR.

Students outlined that the "hidden curriculum" of peer comparisons and the perceived necessity of research experience for career advancement detracted from their UGR experience. These perceptions align with existing literature demonstrating that research participation in undergraduate education facilitates career advancement (Nikkar-Esfahani et al., 2012; Pacifici & Thomson, 2011). This "hidden curriculum" incentivizes "resume-padding" activities as students engage with research to fulfill perceived selection criteria and increase their competitiveness for professional and graduate programs rather than to pursue intrinsic research interests. In addition, "hidden curriculum" may result in premature student attrition in UGR projects and incentivize students to pursue many quick, low-impact research projects to inflate their scholarly productivity. This may undermine the well-documented student benefits of UGR, as longer UGR experiences have been identified as a strong predictive factor for positive student outcomes (Adedokun et al., 2014; Thiry et al., 2012). Addressing this "hidden curriculum" by reviewing admissions criteria for professional and graduate degree programs in the health sciences and creating space for students to discuss these topics with peers, faculty, and counselling staff may improve student retention in research during their undergraduate studies and beyond.

Student focus group participants also perceived the lack of meaningful research responsibilities for undergraduate students as a barrier to their participation. Previous work has identified that these feelings of frustration with tedious and monotonous tasks are associated with an increased likelihood of students leaving their UGR experience (Cooper et al., 2019) or even realigning their career and educational paths away from research (Thiry et al., 2012). Existing literature suggests that the assignment of menial research tasks in UGR is likely secondary to the limited provision of technical training which would allow students to serve more meaningful functions on the research team (Dolan & Johnson, 2009; Limeri et al., 2019). This finding is reflected in the fifth step of Tinto's (1975) model, where the juxtaposition of the learning objectives of the student and the fulfillment of attaining their educational goals influences their experiences with UGR. These findings underscore the need for institutional curricular development to teach students the prerequisite technical skills to allow for more meaningful research involvement. Through the implementation of research-based coursework, prior studies identified improvements in self-perceived competency and satisfaction with regards to the research skills of undergraduate students (Davidson & Palermo, 2015; Shanle et al., 2016; Si, 2020), and may also alleviate student-reported challenges in balancing research responsibilities with other undergraduate course work (Cooper et al., 2019).

Students also identified significant administrative barriers to UGR accessibility posed by the ad-hoc nature of UGR recruitment, in which students are expected to cold-email professors from staff directories in order to secure research opportunities. This method was found by participants to be tedious and frustrating, emphasizing the need for more streamlined methods to connect students with research supervisors. Tinto's (1975) model emphasizes the importance of positive meaningful interactions with faculty to facilitate an engaging academic experience, which is undermined by the difficulty students face in finding a faculty supervisor interested in working with undergraduate students. To address this administrative challenge, students in our focus groups proposed the development of a centralized platform on which research opportunities can be shared and searched. Previous work has found positive outcomes on a centralized research portal that matched 164 of 211 students with faculty supervisors for UGR opportunities (Dagher et al., 2016).

Study participants also highlighted inequalities in the accessibility of UGR. While financial support for students is a well-recognized facilitator of research participation (Fakayode et al., 2014; Partridge & Sandover, 2010), our quantitative results showed that undergraduate students generally received limited funding for their research activities. This was reinforced by focus group participants who highlighted the financial inequities in student access to UGR. Indeed, for undergraduate students who are financially unstable, have limited social capital, or have to juggle various responsibilities including employment, caregiving, and domestic work, the unpaid nature of many UGR opportunities can be a deterrent to engaging in them. This finding reinforces the important influences of pre-entry attributes on UGR experiences in the health sciences as outlined in Tinto's (1975) model. This undermines the capacity of higher education institutions to provide equal educational experiences for all students, and ultimately reduces the diversity of voices and perspectives in academia. Distributing UGR awards and bursaries with a greater emphasis on financial need would reduce financial inequities and permit a greater number of students to participate in UGR (Harde & Haave, 2012).

This study's findings support the applicability of Tinto's (1975) model to understanding the forces underlying UGR experiences in the health sciences and emphasizes the importance of informal interactions with peers and faculty that

may reinforce "hidden curricula" in UGR. Future studies are required to further explore the "hidden curriculum" in order to inform evidence-based interventions to address its negative impact on UGR in the health sciences.

Recommendations for Effective and Inclusive UGR Programs in the Health Sciences

The barriers identified by the undergraduate health sciences student participants in this mixed methods study revealed opportunities to improve UGR programs in higher education institutions, which are summarized as follows. First, UGR programs need to prepare all students with the competencies to participate in and contribute to research projects by expanding the representation of research skills teaching in curricula and making these research courses available earlier in undergraduate programs. Second, UGR programs in the health sciences should create opportunities for students to explicitly explore the "hidden curriculum" and critically assess the impact of this "hidden curriculum" on their academic and career trajectory. Third, higher education institutions should develop infrastructure that catalogues the faculty, laboratories, and research groups offering UGR opportunities. Lastly, institutions should revise the selection and eligibility criteria of UGR awards and bursaries to emphasize financial need to address financial barriers to accessing UGR experiences.

Limitations and Future Directions

This study has many strengths, as it draws from a large sample size of undergraduate students enrolled in health sciences programs with a robust sequential explanatory mixed methods methodology. Nonetheless, the study has some notable limitations. This study was conducted at a single institution, McMaster University, and thus its findings may not be generalizable to other academic centres. Despite the large sample size, the study's online survey had a low 7.4% response rate that could be explained by the inherent limitations of a convenience sampling method with social media and email list recruitment. Furthermore, the study was conducted at the height of the initial waves of the COVID-19 pandemic, which may have influenced participants' opinions on research opportunities given the restrictions on in-person research and campus closures. Regarding the survey instrument, the terms of "accessibility," "supportiveness," and "appreciation" included in the survey items were not explicitly defined for participants. These terms can invoke a spectrum of possible interpretations, and may have contributed to the heterogeneity of the study's findings. Further investigations are required to assess the validity and reliability of these survey items to help derive more specific and reliable conclusions in quantitative analyses of student experiences with UGR.

Conclusion

This sequential explanatory mixed methods study found that health sciences students generally have positive attitudes of UGR but had polarized perceptions of the accessibility, supportiveness and appreciation of UGR. Health sciences students highlight the hidden curriculum, paucity of meaningful research work for emerging student researchers, administrative barriers and financial and geographical inequities as key barriers to the accessibility of UGR and their UGR experience. An implication of this research is that it is imperative for educators, faculties, and institutions to review institutional policies and curricula to improve the accessibility, meaningfulness, and impact of research experiences to undergraduate students in the health sciences.

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