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The Reliability, Validity, and Student Perceptions of an Undergraduate Research Program in Health Sciences (BHSc) as a Premedical Program: A Preliminary Study

The purpose of this study was to investigate the reliability and validity of the admission process for an undergraduate research program in health science and to assess the students' statement of purpose for entering the program. Admission data (high school marks, supplementary application information, and overall rater score) and first-year GPA were analyzed for the 2003-2004 inaugural class (n=55, mean age 17.9 [SD 1.0] years, 61.8% female and 38.2% male). Although the stated purpose of the program is to educate future health researchers, nearly half (43.6%) indicated that their reason for entering the program was to help them to gain admission to medical school. Final high school grades and overall rater scores were the best indicators for first-year performance (multiple R=.66; 42.9% of the variance).

Ce projet avait comme objectif, d'une part, d'étudier la fiabilité et la validité du processus d'admission à un programme du premier cycle de recherche en sciences de la santé et, d'autre part, d'évaluer les raisons évoquées par les étudiants pour s'inscrire au programme. Nous avons analysé les données d'admission (notes du secondaire, informations supplémentaires liées à la demande et la note globale de l'évaluateur) et la moyenne pondérée cumulative de la première année pour la première cohorte 2003-2004 (n=55, âge moyen 17,9 ans [écart type 1,0], 61,8% femmes et 38,2% hommes). Alors que l'objectif explicite du programme est d'instruire des étudiants qui deviendront chercheurs en santé, presque la moitié (43,6%) des étudiants ont déclaré qu'ils s'étaient inscrits au programme pour favoriser leurs chances d'être admis à une école de médecine. Les notes du secondaire et les notes globales des évaluateurs étaient les meilleurs indicateurs des performances en première année (multiple R=0,66; 42,9% de la variance).

Introduction

In the last few decades there has been an increased call for the integration of research into the undergraduate experience in Canada and the United States (Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century, 2003; Kenney, 1998). As outlined in this article,

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research is defined as an undergraduate student working on his or her own self-directed project under the supervision of a faculty member. The focus of the call for undergraduate research is mainly on curricular changes and research faculty participation. Undergraduate programs that are research intensive are costly both in terms of technology and the number (as well as quality) of faculty needed to deliver the program. Most undergraduate programs that emphasize research are restricted in terms of resources, and this limits the number of positions available for students. Notwithstanding the enthusiasm for research programs, there is little empirical evidence to support the idea that a research experience at the undergraduate level is of benefit to students. As Bauer and Bennett (2003) pointed out,

It would be helpful for faculty and administrators, as well as the general public, to know whether the considerable costs of undergraduate research programs, both in funds and in faculty time, can be justified in terms of value added to the education of the undergraduates who participated in these programs. (p. 212)

Moreover, most of the commentators on undergraduate research programs do not address the recruitment and selection of students whose educational goals and aspirations are in accordance with these types of learning environments. Indeed, preliminary reports suggest that undergraduate students interested in medical school are searching for undergraduate programs that are relevant to the health professions and not basic science degrees identified as premedical programs (Hall & Stocks, 1995; Lovecchio & Dundes, 2002). Although we do not propose to answer Bauer's and Bennett's (2003) imperative comprehensively in this study, we do provide empirical evidence bearing on a research-intensive undergraduate program.

The Bachelor of Health Sciences Program and Admissions Process

The Bachelor of Health Sciences program (BHSc) in the Faculty of Medicine at the University of Calgary was created with a focus on the student undergraduate research experience. It consists of three majors, Biomedical Sciences, Bioinformatics, and Health and Society. The enrollment is limited to 25 students per major entering directly from high school. The program is multidisciplinary, utilizing research faculty from across disciplines to deliver courses designed to introduce students to health research in their first year of studies. This is accomplished by (a) a series of inquiry courses, one per semester for the first three years, in which students from each of the majors are brought together to learn about all aspects of health and how to conduct health research; (b) a mentorship program where students interact with faculty to discuss and study health sciences research; and (c) provision of summer research opportunities for all students. All the components of the program are intended to prepare students for their final-year research project that is the culmination of the program. The primary educational goals are:

1. The student will be able to conduct empirical research in the health sciences;
2. The student will have an understanding of the conceptual basis of scientific reasoning;
3. The student will have an understanding of cultural literacy;
4. The student will have knowledge in the major field of study.

Typically, early admission into Canadian undergraduate programs is based on high-school marks from specific grade 12 courses or their equivalents. The cut-off mark for offer of early admission to a program is determined by applicants' marks (the higher the presented marks, the higher the cut-off percentage), and the number of positions available for that particular program for that particular year. Because of the small number of positions (25/major), the anticipated high demand, and high grade 12 marks of the applicants, it was decided to request additional application information to use in the selection of students for the BHSc program. The supplementary application information form (SAI) required students to make statements in support of their application and was used as a tool to identify applicants who were interested in the wider aspects of health research.

In this study we report the use of the SAIs for admission decisions for those applicants who were selected for final positions for the respective majors based on early admission marks. As this was the first year of the program and no other undergraduate programs used this form of supplementary application information, the University admissions committee and the administration of the BHSc decided to pilot the use of SAIs with only these applicants to determine their suitability for admission decisions.

Assessing Admissions Criteria

Admission criteria have been extensively studied for professional programs such as medicine, law, nursing, and social work. Although the Scholastic Aptitude Test (SAT) is widely used for general college admissions in the US, little research has been conducted on research-intensive undergraduate programs in Canadian and US universities. Using admission to medical school as an example, cognitive factors such as undergraduate marks and medical college admissions test (MCAT) results are heavily used for selection and screening of medical school applicants (Ferguson, James, & Madeley, 2002; Ferguson, James, O'Hehir, & Sander, 2003; Kulatunga-Moruzi & Norman, 2002; Salvatori, 2001). There is agreement that noncognitive factors are deemed valuable to the profession such as integrity, leadership ability, and communication skills (McGaghie, 1990), but there is considerable difficulty in the reliable and valid measurement of these attributes. A number of studies have been published that assess the content of the personal statements as a predictor for performance during medical school and residency training (Albanese, Snow, Skochelak, Huggett, & Farrell, 2003; Ferguson et al., 2003; Ferguson, Sanders, O'Hehir, & James, 2000; Lovecchio & Dundes, 2002; McManus, Smithers, Patridge, & Fleming, 2003). Results from these studies are inconclusive as to whether the statements candidates used in support of their application predict performance. This is primarily due to uncertainty in quantifying the information that is contained in the personal statements. The exploratory assessment used in the present study is modeled on the studies that have been performed in the United Kingdom (Ferguson et al., 2000; Ferguson et al., 2002; Ferguson et al., 2003).

The major purposes of the present study were (a) to investigate the reliability and validity of the admission process to a research-intensive undergraduate program, and (b) to investigate students' self-reported reasons for applying to a research-intensive undergraduate program in the health sciences.

Methods

Participants

The data were collected from the entire first-year cohort of the program, which consisted of 55 students (21 men [38.2%], 34 women [61.8%], mean age 17.9 [SD 1.0]). All the participants had graduated from Canadian high schools: Alberta, 47 (85.4%); British Columbia, 4 (7.3%); Ontario, 3 (5.5%); Saskatchewan, 1 (1.8%).

Context

The study was conducted in a major Canadian university (25,000 undergraduate students). The BHSc program adopted the following admission procedure. For the inaugural year of 2003-2004, all applicants were required to present early admission averages (calculated from the top two self-reported marks from senior-level academic courses) and complete the supplementary application information (SAI) that consisted of two short-answer questions (150 words each), an essay (250 words), and self-reported extracurricular activities. The short answer questions were "What characteristics do you have to offer the program? What are your strengths and where are your challenges?" and "What do you expect to gain from your experience in the BHSc?" The essay question was "In the next 4 years, what do you think will be the greatest health research related challenge and why?" Applicants were rank-ordered by their early admission percentage, and those who were tied for the final positions were then assessed using their supplementary application. The only major where this occurred was Biomedical Sciences. A combined mark of the early admission percentage and mean rater score was then used to rank-order this group of applicants. Figure 1 provides a breakdown of the number of applicants by major, the number of applicants reviewed using the SAIs, the number of offers of early admission, the number that accepted, and the total number of students at the end of the 2003-2004 academic year. (Applicants were allowed to choose a first- and second-choice major in the program. The number corresponding to major [Biomedical Sciences, Health and Society, and Bioinformatics] is the number of applicants who chose that major as their first choice. If candidates were not offered their first choice, the administration of the BHSc program offered applicants early admission in their second choice if they met the minimum mark requirement. The figures in parentheses represent the number of students for whom the major was a first choice or the number of students for whom it was a second choice. The final two rows in the schematic present the number of students who entered the program in September 2003 and who remained in the program at the end of the academic year, April 2004 ($n=55$)).

Of the 116 applicants, 84 were offered admission and 55 accepted. The present study examined the 21 applicants who were reviewed for the final positions in the Biomedical Sciences major. Fourteen accepted offers of early admission, three were offered early admission to Biomedical Sciences, and 18 were offered admission to their second choice; 11 accepted.

Measures and Assessment

The following measures and information were collected: (a) sex; (b) high school performance (early admission percentage) calculated on the top two presented marks from four specified academic senior-level high school courses; (c) high

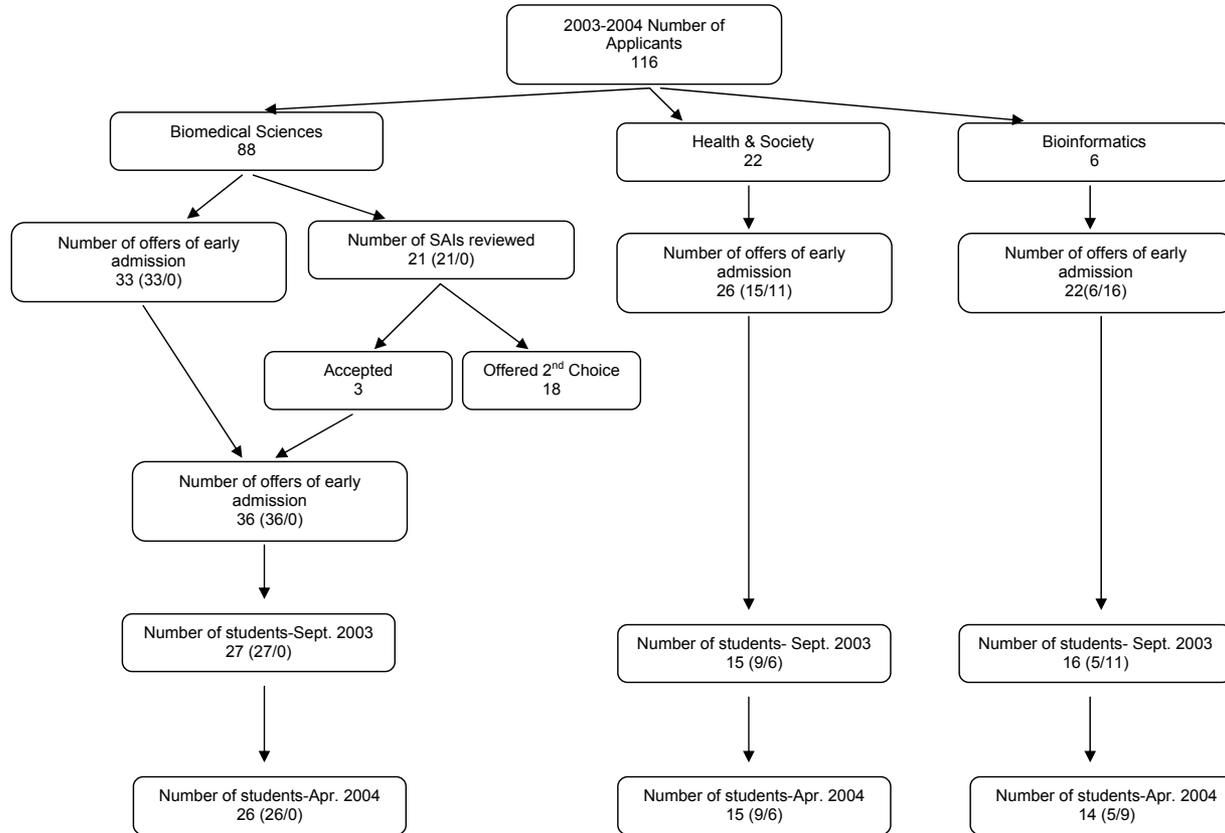


Figure 1. 2003-2004 applicant pool for the Bachelor of Health Sciences program.
SAIs: Supplementary application information.

school performance (final admission percentage) calculated on five specified academic senior level high school courses; (d) SAI (consisting of one essay, two short-answer questions, and a section for extracurricular activities); (e) rater score (SAIs were scored by four independent raters, three faculty members, and one university administrator. Raters were asked to assess applicants based on their understanding of the BHSc program, written communication skills, knowledge of the essay topic, and extracurricular activities); and (f) first-year cumulative grade point average (GPA).

Exploratory Content Analysis

Exploratory content analysis was used to identify the informational content and quantify the amount of information in the SAIs (Stemmler, 2001). A modified emergent coding strategy was used to classify key phrases and words (Krippendorff, 1980; Stemmler). One of the authors (KH) read the statements for the 21 applicants who were reviewed for the final positions in the Biomedical Sciences major, and a list of categories was created. The categories represent a condensed list of key words or phrases that reflect the achievements, abilities, motivations, and interests that were used by applicants to support their applications. KH then reread the statements of all 55 students and the applicant statements were coded (see Appendix).

Analyses

Descriptive, univariate (correlation, *t*-test, analysis of variance) and multivariate statistics (linear regression) were used. Ethical approval to collect and analyze these data was obtained.

Results

Descriptive Statistics

Table 1 contains a summary of the descriptive statistics for the 55 students accepted to the BHSc. The mean high school early admission percentage was 94.0% (*SD* 2.6), the mean high school final admission percentage was 92.1% (*SD* 2.8), and the mean cumulative first-year GPA was 3.69 (*SD* 0.24). There was a significant difference between the overall early admission percentage and the final admission percentage ($t=6.9, p<0.001$), and there were significant differences between the overall early admission average, overall final admission average, and the first-year GPA (GPA was converted to a percentage for this comparison using the institution's conversion policy, $t=8.6, p<0.001$, and $t=6.9, p<.001$ respectively). There were significant differences in the early and final admission averages and first-year GPA between majors ($F=19.5, p<0.001$; $F=10.8, p<0.001$, and $F=4.9, p<0.05$ respectively). Tukey's HSD post hoc tests revealed that the early and final admission percentages for Biomedical Sciences compared with Bioinformatics and Health and Society were significantly different (early admission percentages mean differences, 3.77 and 3.00 respectively; final admission percentage mean differences, 2.90 and 3.0 respectively, $p<0.05$), and for first-year GPA, Biomedical Sciences was significantly different from Bioinformatics (mean difference 0.23, $p<0.05$).

Reliability and Validity of the Raters' Scores on the Supplementary Application Information (SAI)

Of the 21 students who were reviewed for the final three positions in the Biomedical Sciences major, three were offered positions in that major (all

Table 1
 Descriptive Statistics of the Applicants Accepted Into the Various Majors
 of the BHSc Program

BHSc Major	N	Sex				Total N	Early Admission Percentage		Final Admission Percentage		Cumulative GPA (first year)	
		Male		Female			Mean	SD	Mean	SD	Mean	SD
Bioinformatics	7	50.0	7	50.0	14	92.0	1.9	90.7	2.3	3.54	0.3	
Biomedical Sciences	10	38.5	16	61.5	26	95.8	1.9	93.6	2.3	3.77	0.2	
Health and Society	4	26.7	11	73.3	15	92.8	1.7	90.6	2.5	3.70	0.2	
Total	21	38.2	34	61.8	55	94.0	2.6	92.1	2.8	3.69	0.2	

accepted), and 18 were offered their second choice of major in the program (11 accepted). Univariate and multivariate analyses were performed using 14 applicants who accepted the admission offer to the BHSc. Four raters reviewed all 21 SAIs. As mentioned above, the raters were provided with four categories by which to judge the supplementary material and asked to rank each category on a scale of 1-5 (no rubric was given). Internal consistency reliability (alpha) of the raters' results was 0.78. There was 100% agreement between raters for those applicants accepted into their first choice.

Correlation analysis of the raters' scores determined that all the categories were significantly correlated ($p < 0.01$). Analysis of variance comparing raters' scores for each category revealed that there were significant differences in three of the four categories (understanding of the BHSc $F = 8.0, p < 0.05$; knowledge of the essay topic $F = 7.2, p < 0.05$; written communication skills $F = 2.8, p < 0.05$; and participation in extracurricular components, $F = 2.490, p > 0.05$).

Exploratory Content Analysis

Table 2 depicts the results from the exploratory content analysis of all 55 SAIs. Statements that were most frequently used in support of a student's application were related to volunteer work (80.0%), playing sports (65.5%), academic awards (63.6%), school responsibilities (56.4%), hobbies (47.3%), and "want to do medicine" (43.6%). Two categories were significantly different by sex. Female applicants used "school responsibilities" ($\chi^2(1) = 10.67, p < 0.001$) significantly more than men to support their applications, and men used "sees research as a challenge" ($\chi^2(1) = 6.95, p < 0.01$) significantly more than women to support their application. One category was significantly different by major: "participated in IB" ($\chi^2(1) = 6.28, p < 0.05$) in the statements used by applicants.

Exploratory Predictive Validity of the High School Admission Averages and the SAI

There was significant correlation between the independent variables (early admission percentage and final admission percentage) and first-year GPA (dependent variable) for the entire sample of 55 (.48, .57 respectively, $p < 0.01$). To determine the variance that can be accounted for by these two variables, a backward stepwise linear regression was conducted. The most parsimonious model that significantly accounted for the greatest amount of variance for

Table 2
Supplementary Application Information (SAI) Information Categories

Categories	Total	Percentage	Male	Female	χ^2	BINF	BMSC	HSOC	χ^2
Volunteer work	44	80.0%	18	26	0.69	11	20	13	0.59
Plays sports	36	65.5%	15	21	0.54	7	18	11	2.01
Academic awards	35	63.6%	12	23	0.62	7	20	8	3.80
School responsibilities	31	56.4%	6	25	10.67***	7	18	6	3.61
Hobbies for relaxation	26	47.3%	9	17	0.27	9	10	7	2.44
Wants to do medicine	24	43.6%	11	13	1.06	4	14	6	2.47
Choir/orchestra or band	21	38.2%	8	13	0.00	7	10	4	1.67
Participated in IB classes	21	38.2%	10	11	1.28	9	9	3	6.28*
Likes science	20	36.4%	11	9	3.77	7	9	4	1.77
Plays musical instrument	19	34.5%	7	12	0.02	4	9	6	0.42
Member of a youth group/club	18	32.7%	7	11	0.01	5	9	4	0.35
Wants to do medical research	18	32.7%	10	8	3.42	4	10	4	0.75
Leadership skills	15	27.3%	3	12	2.90	1	10	4	4.50
Participated in AP classes	14	25.5%	6	8	0.17	3	6	5	0.69
Likes traveling	13	23.6%	4	9	0.40	3	6	4	0.12
Has done research	11	20.0%	6	5	1.56	3	6	2	0.59
Sees research as a challenge	11	20.0%	8	3	6.95**	3	7	1	2.46
Likes teamwork	10	18.2%	3	7	0.35	3	2	5	4.34
Program will be character-building	10	18.2%	3	7	0.35	3	4	3	0.27
Work	9	16.4%	4	5	0.18	2	3	4	1.65
Speaks a second language	7	12.7%	3	4	0.07	1	6	0	5.01
Communication skills	6	10.9%	3	3	0.40	2	3	1	0.45
Medical volunteer work	6	10.9%	2	4	0.07	1	3	2	0.31
Attended science fair	5	9.1%	2	3	0.08	1	3	1	0.36
Problem-solving ability	5	9.1%	3	2	1.11	2	3	0	2.15

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Note. Percentage is the frequency that each category was mentioned. IB: International Baccalaureate Program; AP: Advanced Placement Program;

School responsibilities: participated on student councils, involved with other student committees, etc.; plays musical instrument: plays an instrument outside a formal band or choir; hobbies: much like interests, those activities that the applicant chooses for relaxation; volunteer work: any volunteer work outside the hospital setting; work: pay-related work; communication skills: have listed that one of their strengths is communication.

first-year GPA was final high school admission percentage ($r=0.57$, $r^2=0.32$) ($F=25.1$, $p < 0.001$).

There was no significant correlation between the independent variables (early admission percentage, final admission percentage, total supplementary

information content and mean rater score) and first-year GPA (outcome variable) for the subgroup of 14 students who were reviewed. There was also no significant correlation between total rater score and first-year GPA ($r=-0.26$, $p=ns$).

The results of a backward linear regression analysis using the subgroup of 14 are shown in Table 3. The SAIs were summed for each applicant to determine if the quantity of information could be used for predicting scholarly performance in the first year. The most parsimonious model (model 3 in Table 3) that significantly accounts for the greatest amount of variance for first-year GPA includes the final admission percentage and the raters' overall score ($r=0.66$, $r^2=0.43$) ($F=4.1$, $p<0.05$).

Discussion

The major findings of the present study are: (a) there is evidence of reliability (e.g., interrater) and validity (e.g., predictive) for the admission procedures; and (b) nearly half the applicants indicated that they perceived the program as a route to medical school.

The early admission percentage was based on marks that were self-reported by the student without verification of the accuracy of the mark. For the 55 students enrolled in the first year of the program, there was a significant difference between the early and final percentages. This discrepancy, however, between the mean early admission percentage (94.0%) and the mean final admission average (92.1%) was small. This difference may be due to slight exaggeration by the applicants and/or the final exam results that were acquired after the early application. There were significant differences between early and final high school performance and first-year university performance. This difference could be attributable to the transition from high school to university systems, and although this difference in performance was significant, mean university performance was still exceptional (mean GPA=3.69).

There were differences in early and final admission marks between the three majors. This can be accounted for by the BHSc program offering those students who were not successful in their first choice early admission in their second choice major.

A combination of rater mark and final admission grades has criterion-related validity for selection and screening (i.e., predicting success in the first year). The analysis showed that all ratings were significantly positively correlated, but the analysis of variance showed a significant difference in rater response in three of the four questions presented. This suggests that there is some rater heterogeneity present. For the approach to be valuable there should be some consistency in how the applicants are rated. A clear rubric with specific criterion for the marking scale and training on the scale for raters should improve interrater agreement.

Our preliminary results show that neither the quantity nor the type of information presented in the supplementary application information was related to academic performance in first-year undergraduate sciences courses. This is not surprising given that two domains are being compared: cognitive (marks) and noncognitive (accomplishments as outlined in the supplementary application information). Furthermore, the classes of first-year undergraduate studies in the BHSc (introductory biology, chemistry, math, English, etc.) for

Table 3
Multiple Regression Analysis of First-Year Grade Point Average (GPA)
in Relation to Early Admission Percentage, Final Admission Percentage,
Supplementary Application Information (SAI), and Total Rater Score

<i>Independent Variable</i>	<i>Dependent Variables</i>	<i>Standardized Regression Coefficients</i>	<i>R</i>	<i>R²</i>
<i>Model 1</i>				
First-year GPA	Early admission percentage	0.13	0.70	0.49*
	Final admission percentage	0.61		
	SAI (total content)	0.18		
	Total rater score	-0.53		
<i>Model 2</i>				
First-year GPA	Final admission percentage	0.68	0.69	0.48*
	SAI (total content)	0.234		
	Total rater score	-0.53		
<i>Model 3</i>				
First-year GPA	Final admission percentage	0.64	0.66	0.43*
	Total rater score	-0.48		

* $p < 0.05$.

high-achieving students are similar to their senior year in high school, and so marks should be the best indicator of performance in the first year. This was indeed the case as final admission average was the best predictor for first-year GPA in both the total cohort and the pilot group.

The SAI may be most relevant on how students perform later in the program, the research activities that they engage in, and their choices once they have graduated from the program (i.e., graduate school, professional programs, or work experiences). Ferguson et al. (2000, 2003), for example, demonstrated that personal statements were not predictive of academic performance in first-year medical school, but did predict performance in clerkship.

The multiple linear regression analysis indicated that the final admission averages and total rater score accounted for the variance in GPA. The standardized regression coefficient, however, was negative for total rater score, suggesting that a rubric should be developed to provide a framework for the rating process. The outcome of total rater score is significant, suggesting that the total rater score should be used as a component for the admission process provided that there is adequate interrater reliability.

Despite the emphasis on research in the BHSc, nearly half the applicants stated that they intended to go to medical school. Few indicated that they were interested in research as a career, or even that they liked basic or social sciences. Although it is arguable that students at this age (mean 17.9) know little of what medicine, science, and research entails, to include a comment that their sole

ambition is to attend medical school (some even provided a specialty) has at least three implications. First, students' interests are inconsistent with the mandate of the program. As this program is administered through a faculty of medicine, the underlying perception is likely to be that this is a premedicine program. Second, it may be that students have limited understanding of the career options in health sciences. Third, perhaps students who are interested in medicine as a career wish to be educated in an environment that exposes them to more than the premedical courses required by most medical schools. Adolescents who express definitive career choices early, as some of the present participants did, may be in the "foreclosure" status of identity formation (Marcia, 1966). It will be interesting to conduct follow-up studies with these participants to evaluate their identity statuses.

Limitations and Future Directions

With a sample size of only 14, the validity and generalizability of the analyses using SAIs is tenuous. Sample homogeneity, generalizability, and lack of a comparison group limit the confidence of our findings. In Canada, there is only one other four-year undergraduate program in Health Sciences that uses supplementary application information for admissions (McMaster University), and accordingly, there is little comparable information. A longitudinal approach may help clarify the educational benefits for this type of cost-intensive research-based program and the identity formation of the students.

Summary and Conclusion

The BHSc is a new undergraduate program in which we have a unique opportunity to implement evaluation processes at the beginning to track the selection and progress of students who are interested in the health sciences. The expectation is that the students who participate in this program may be outstanding candidates in their future careers, whether in graduate school, professional programs, or work experiences. Alternatively, they may develop identity issues due to foreclosure status (Marcia, 1966). As the program is restrictive (only 75 students per year are admitted), it is a challenge to select students who will be most successful in this type of research-intensive environment. Although our small sample gives us reason to be cautious, the results of this study suggest that the admissions processes are adequate, but need to be fine tuned in order to better assess applicants. The use of the SAI appears to be largely descriptive and not good at predicting performance. Caution is also required in assessing the program after just one year based on grades alone. Our preliminary results, however, lay the groundwork for conducting a longitudinal program evaluation of the BHSc initiative.

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Appendix

Exploratory Content Analysis

The justification for analyzing the applicants' supplementary information was to try to determine the sorts of information applicants think are important for admission into the program. The supplementary application may also contain information about certain characteristics that may be predictors for those students who go on into biomedical research, medicine, or other areas. The reason for the exploratory analysis is to determine if there were certain key comments or phrases that were consistent among applicants that might account for a significant amount of variance in their performance in the program and their future decisions. In order to explore the application information, content analysis was used.

Content analysis is a technique to quantify the amount of information from documents (in this case supplementary application information) through a systematic, replicable technique of analyzing documents into content categories based on explicit codes of coding (Stemmler, 2001; Krippendorff, 1980). Briefly, a modified emergent coding strategy was used whereby applicants' comments were coded into categories by the author (KH) as outlined by Stemmler. A category is defined as a group of words that have similar meaning. The categories were then reviewed, and overlapping categories were combined to create the most parsimonious list. Using the modified checklist, the supplementary applications were then coded, 0 if there was no comment present, 1 if there was a comment present. These were then summed to reflect the amount of information present per applicant.

A single rater was used as this was meant as an exploratory component of the overall analysis used in this research.