Health Science Inquiry IN REVIEW

A decade of graduate student-run health science publishing

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Scientific communication is a core facet of the academic process. Universities and research institutions expend considerable resources on student didactics and training to engage them in the pursuit of elusive research questions. However, dedicated training on scientific writing and exposure to the peer-review process are comparatively rarer; knowledge is typically acquired experientially and through mentorship. With a growing pressure on the scientific community to disseminate articles, the "publish or perish" aphorism succinctly embodies this frenetic rate of publication that has evolved the scientific journal article into a unit of research productivity [1]. It is increasingly crucial that, as part of the academic apprenticeship process, graduate students receive dedicated scientific communication training and ample opportunities exposing them to the peer-review process.

Publishing experience is an invaluable part of research training. Students develop an appreciation for the submission, peer-review, and acceptance/rejection phases of the peer-review process. Additionally, they learn to formulate and defend hypotheses while being held to account for reported research findings. Most importantly, the ability to critically appraise emerging research findings and to appreciate their implications in the context of contemporary literature is a fundamental cornerstone of post-graduate education. Experience of the various roles in the scientific communication pipeline, whether as an author, reviewer, proofreader, or editor, can be tremendously rewarding and promotes the development of the requisite soft skills for both academia and the industry workplace [2].

For those interested in pursuing scientific communication more seriously, formal training for a career in scientific publishing is not only rare, it is a growing concern given the need to staff the growing number of biomedical

TABLE 1 | Annual Publication Themes and Subthemes for the past 11 volumes

Vol. No.	Publication Cycle	Volume Theme	Subthemes
1	2009-2010	The H1N1 Pandemic	• Development & Deployment of Vaccinations • Surveillance & Response to H1N1 • H1N1 as a Global Pandemic
2	2010-2011	Cancer	• Treating & Pursuing a Cure for Cancer • Prevention of Cancer • Life after Cancer
3	2011-2012	Obesity & Diabetes	• Advances in Molecular, Genetic, & Clinical Research • A Sociological View of Obesity & Diabetes • Impact of Nutrition on Obesity & Diabetes
4	2012-2013	Mental Health & Neurological Diseases	• Social, Economic, and Environmental Determinants of Mental Health • Age-Related Neurodegenerative Disorders • Advances, Challenges, and Controversies in Diagnosis, Treatment, & Management
5	2013-2014	Primary Health Care & Health Care Reform	• Exploration of Challenges & Opportunities for Primary Care Delivery • Role of Primary Health Care in Prevention & Control of Acute & Chronic Disease • Public Engagement in Reform Initiatives
6	2014-2015	Advancing Human Genetics into Health Action	• Personalized Medicine & Gene Therapy • Ethical & Social Challenges Surrounding Human Genomics • Impact of the Environment on the Human Genome
7	2015-2016	Allergies, Autoimmunity, and Microbiome	• Current Research Advances in Allergies & Autoimmunity • Role of our Microbiome in Shaping & Regulating the Immune System • Environmental Influence on Allergies & Autoimmune Disorders
8	2016-2017	Gene Editing & Personalized Medicine	• Clinical Applications of "-omics" Technologies in Personalized Medicine • The Role of Genome Editing in Health Care • The Social & Ethical Implications of Genome Editing
9	2017-2018	Obesity & Diabetes	• Nature • Nurture • Consequence
10	2018-2019	Chronic Disease	• The Future of Medicine & Treatment • The Future of Technologies in Health & Research • The Future of Health & Society
11	2019-2020	Determinants of Health	• Natural Environment • Technology • Socioeconomic Environment

journals. Not only are opportunities lacking, but the requisite competencies for training an individual in journalology are not fully understood [3]. Promisingly, there exist a [possibly growing] number of graduate-student run biomedical journals in Canada and abroad which provide opportunities to young scholars and early-career scientists to engage in the scientific publication process. In Canada alone, there exist eight active medical student-run journals which collectively publish over 200 articles each year [4]. Here, a meta-analysis of a pan-Canadian, graduate student-run, health science journal is presented in the hopes of exploring both the successes and impact on graduate students and the broader scientific community.

THE HEALTH SCIENCE INQUIRY JOURNAL

The Health Science Inquiry (HSI) is an entirely graduate student-run journal which relies on contributed articles and volunteered time from master's, doctoral, post-doctoral, and medical students across Canada. In the inaugural issue of HSI in 2010, then managing editor, Inderjeet Sahota eloquently captured the essence of what HSI was to embody as a medium for scientific discourse [5]:

> "Writing is an integral part of academia. The free flow of information is what allows science to continue developing, and without the ability to write these ideas down in a coherent and comprehensive manner, this transmission would not be possible. As students of science, the ability to write and allow for this exchange is an important component of our training. Scientific advancement, and arguably human advancement on many levels, relies strongly on this element of discussion. Through dialogue we are able to communicate our perspectives and hear the perspectives of others. In this we have the opportunity to gain new insight, develop new ideas and expand our knowledge of the world."

"Writing is an integral part of academia.

A retrospective review of the past volumes revealed that the ensuing decade saw the publication of 284 peer-reviewed articles by student-scholars from over 27 Canadian institutions. Every year, a timely theme was selected with three sub-themes serving as a guide to orient contributed articles (Table 1). Notably, the topics covered a broad array of health systems, including the epidemiological facets of the H1N1 pandemic, oncologic research, genomic engineering, and anticipated future developments within medicine. To visualize the relative frequency of the most common terms appearing in each year's issue, the text was extracted for all articles in each issue and a wordcloud was generated (Figure 1); the terms for all years were also combined to generate a wordcloud representative of the decade. While the first nine volumes focused on specific health systems, as seen with word frequencies generally matching the volume theme, the tenth and current themes were more open-ended and amenable to research across the health sciences or to any medical system. Interestingly, the subthemes of the latter half of the decade generally included some element of social impact, environmental influence, technological development, or contemporary medical research (Table 1). With the increasingly interdisciplinary nature of heath science research, the selection of open-ended

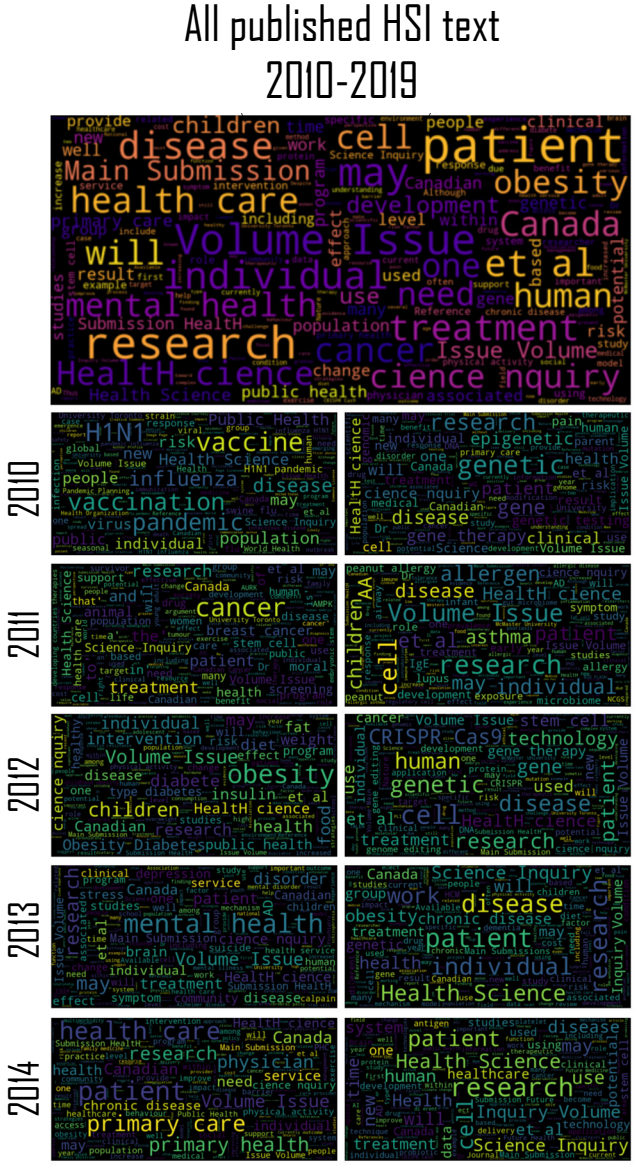

FIGURE 1 | Wordcloud representation of each HSI issue & of all published text.

A combined wordcloud representative of all published HSI text (top) as well as individual wordclouds for each issue.

(sub)themes will enable student-scholars with more diverse educational backgrounds, such as engineering and computer science, to contribute their work.

The year-to-year analysis of the number of contributed articles reveals several notable trends (Figure 2). HSI publishes peer-reviewed articles under two branches: *Main Submissions* are externally-contributed technical articles from student-scholars while *Developed Content* comprise internally-contributed news articles, "ask an expert" articles, and "spotlight on career" articles. While externally-contributed artwork and short fiction are also accepted and published, these pieces were excluded from the following analyses. Figure 2 compares the number of annually published pieces by type in addition to the volume total. The main submissions comprised the bulk of published content for the first five years, then fell to all-time lows in 2015 and 2016 before recovering again in the latter three years. As externally-contributed work, volatility can be expected; innumerable factors influence the reception of submitted articles while staff have limited ability to control or stimulate contribution. Conversely, staff have direct control over the generation of internally-contributed content-type articles. We observe a progressively increasing trend in the number of published content-type articles over the course of the decade, roughly converging towards parity.

PAN-CANADIAN VOLUNTEERING

The publication of such a large number of articles could not have been possible without the dedicated time and effort of the small army of volunteers supporting HSI year-over-year. A retrospective analysis of the home institutions of HSI volunteers reveals a strong representation of staff among four institutions with the University of Toronto (UoT), McGill University, McMaster University, and the University of Western Ontario (UoWO) comprising the top-four institutions when sorted by total volunteer-years over the last decade. The measure of "volunteer-years" (Vys) considered in this work is analogous to that of "person-hours ": we count the amount of time dedicated to volunteering regardless of the individual(s) who volunteered that time. Tenure for all positions, regardless of the actual number of worked hours, is held for a single Vy which, though naïve, simplifies the aggregation of contributed effort. For example, the three Vys contributed by Carleton University (Figure 3) may all have been attributed to a single Carleton-based volunteer holding different roles over three years, or to three unique individuals, each only volunteering for a single year. Fortunately, HSI enjoys a consistent retention of volunteering staff where we see many of the same individuals returning, resulting in a strong representation among the most involved institutions.

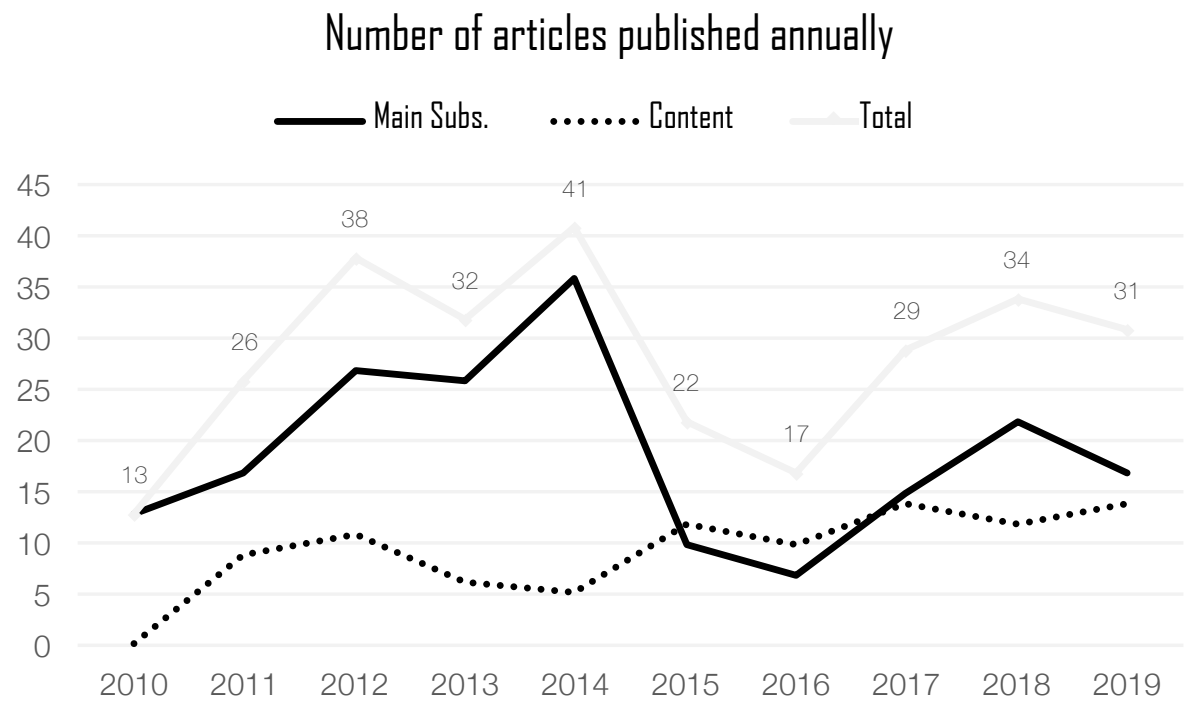

FIGURE 2 | Number of articles published annually by HSI over the past decade.

The main submissions generally comprise the bulk of the published materials except in 2015 and 2016 where the number of main submissions fell to an all-time low and were surpassed by the content-type articles. Since main submissions are externally-contributed we can expect volatility; conversely, content-type articles are internally-contributed and therefore controllably stable. Notably, the latter type are generally annually increasing.

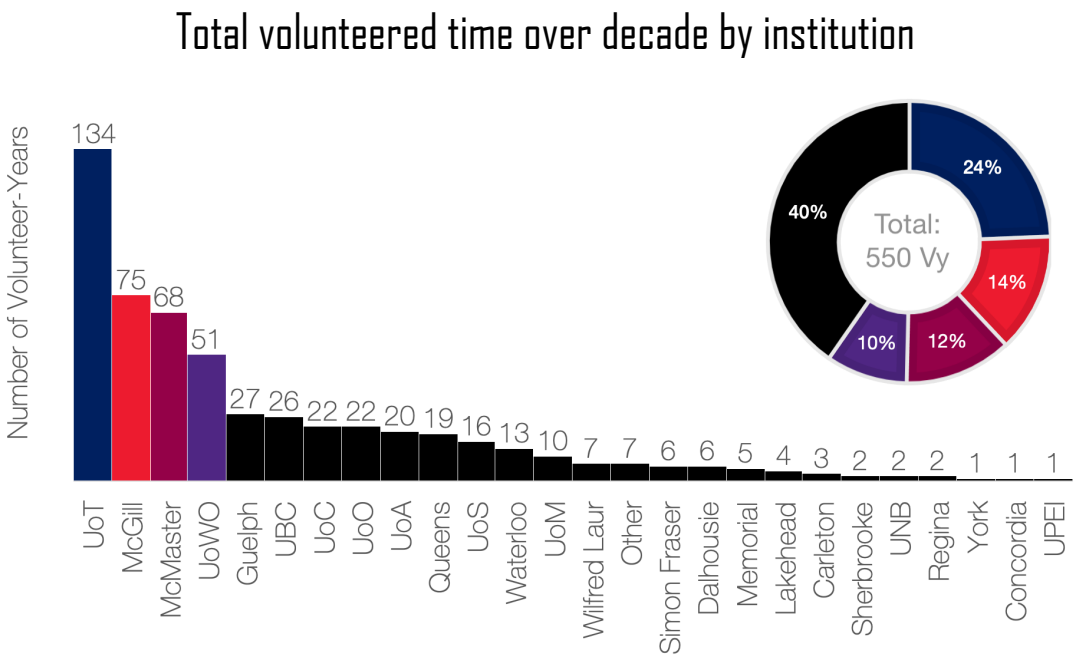

FIGURE 3 | Total volunteered time by institution through the previous decade.

The top-four institutions are highlighted as having contributed the majority of volunteer-years to HSI (~60 per cent). The long-tailed distribution demonstrates the relative contributions of other institutions around Canada. A total of 550 volunteer-years have been dedicated to HSI over the last decade (including 2020 staff). Impressively, UoT comprise approximately a quarter of all dedicated volunteer-years, which might be expected of the founding institution.

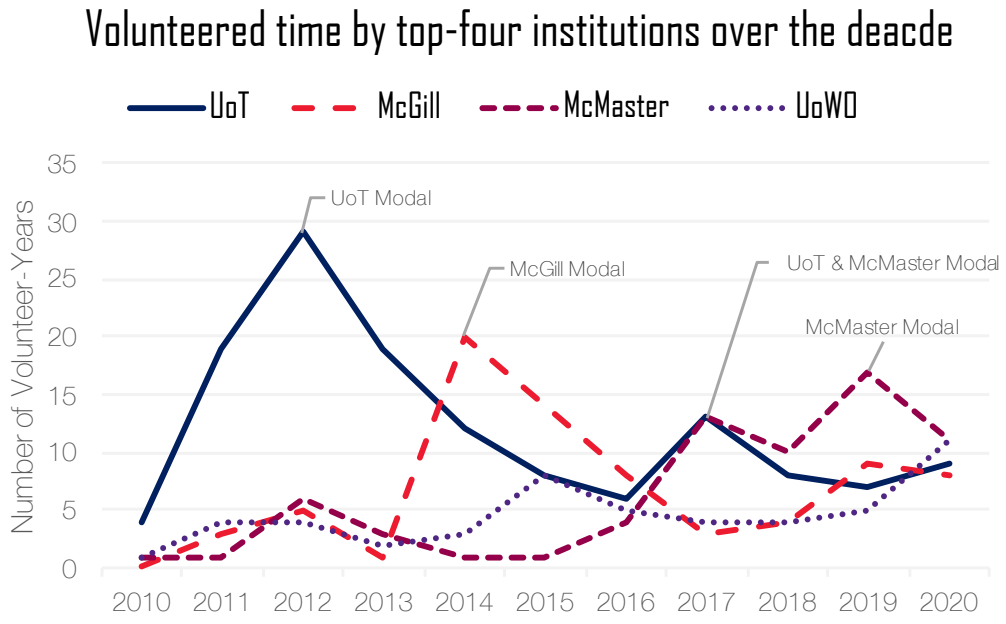

FIGURE 4 | Volunteer-years of the top-four institutions throughout the decade.

Illustration of the waxing and waning trend of volunteer contribution among the top-four4 institutions over ten years. Notably, UoT was the modal contributor within the first four years, which might be expected as the founding institution. McGill then became the modal institution for three years, peaking in 2014. Both UoT and McMaster shared a modality peak in 2017 with the latter taking modality last year. Promisingly, these four institutions share approximately equal contribution in this year's staff. A desirable trend within this next 2020 decade might see an approximately uniform contribution of volunteer-years among these four institutions as well as among the other Canadian institutions.

An impressive 550 Vys supported HSI over the last decade (including the current staff) averaging to approximately 50 staff members annually (Figure 3). The contribution of Vys by institution depicts a long-tailed distribution, where the top-four institutions, highlighted in Figure 2, represent approximately 60 per cent of all volunteered time. The University of Toronto alone comprise approximately 25 per cent of all Vys.

A more in-depth analysis of the contributed volunteer time among the top-four institutions throughout the decade revealed interesting trends in *modality*: the institution from which the greatest number of Vys are contributed (Figure 4). The four years following its founding, UoT was the modal contributor, then overtaken by McGill for the next three years. Both UoT and McMaster shared modality in 2017 and McMaster has been modal since (Figure 4). Promis-

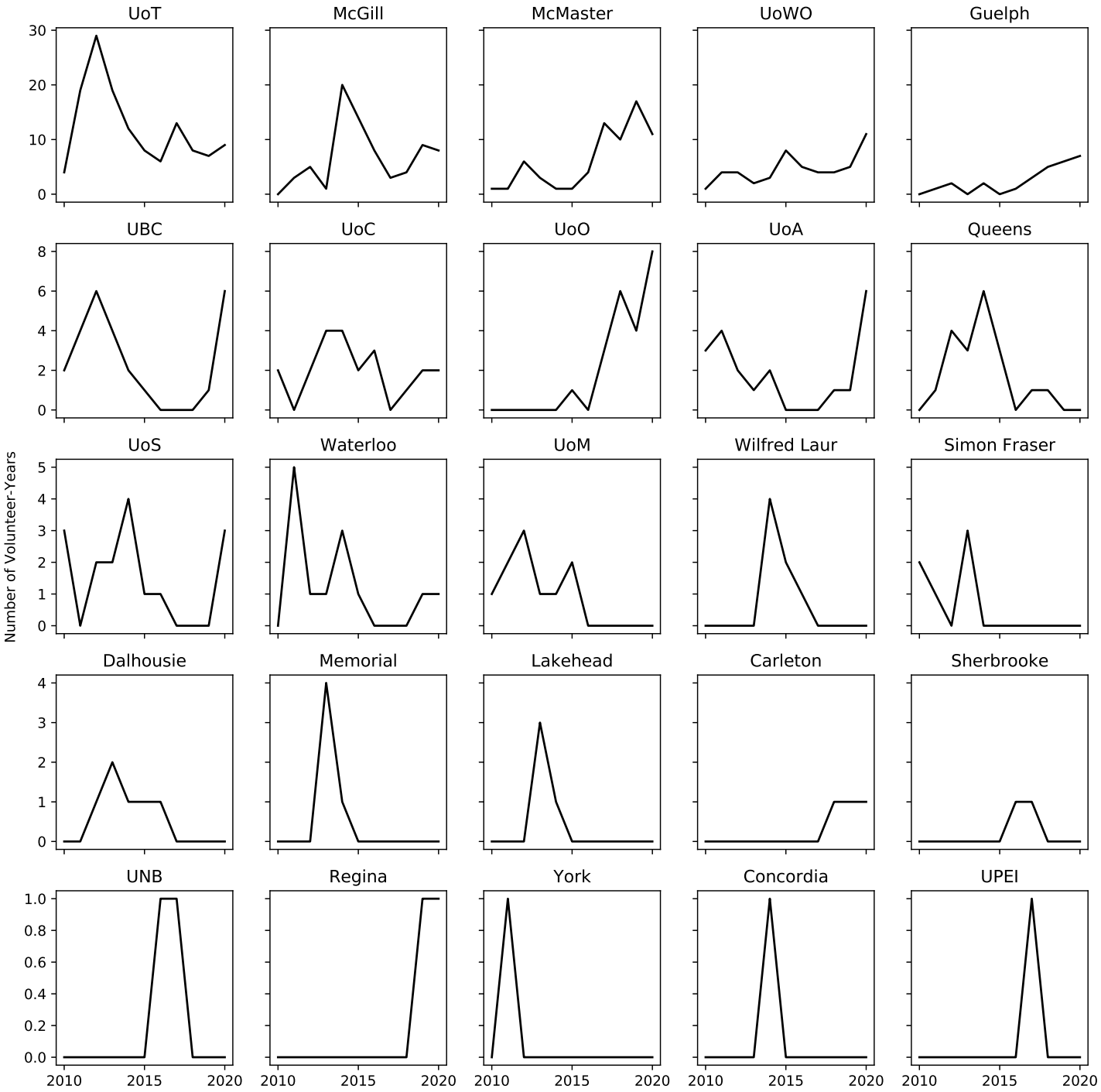

FIGURE 5 | HSI volunteer-year distributions by canadian institutions.

Note that the shared y-axis scale varies by row; the top row ranges from (0,30) while the bottom row depicts binary spikes in the range (0,1).

ingly, the top-four institution each have approximately equal representation among this year's staff, perhaps establishing a desirable level of representation for the HSI staff of the coming decade. The same analysis of institution-specific contribution over the decade was extended to all participating Canadian institutions and is depicted in Figure 5.

INSIGHTS FOR THE FOLLOWING DECADE(S)

Reflecting on the selected themes, the trends in published articles, and the in-depth view of volunteering effort from institutions across Canada, a number of insights might be drawn to orient the HSI as we move into the next decade(s).

Viral & Timely Themes

Ironically, HSI's founding issue theme was selected due to the timeliness of the H1N1 influenza pandemic. With the health concerns of the Zika virus circa 2016 and the present Coronavirus pandemic, it can be expected that viral outbreaks will be thematic in the next decade(s). Furthermore, the recent focus of subthemes on societal, technological, and environmental factors (Table 1) also highlights certain timely issues that may be expected of future themes en route to 2030 and beyond: climate change, globalization, nationalism, digital health, telemedicine, natural disasters, indigenous affairs, urban water crises, data privacy, overpopulation, immigration, the $100 genome, and healthcare in the age of artificial intelligence and quantum computing.

HSI HAS CONTRIBUTED A TOTAL OF **550** VYS OF EXPERIENCE IN SCIENTIFIC PUBLISHING TO GRADUATE STUDENTS FROM OVER **25** CANADIAN UNIVERSITIES.

Towards Article-Type Parity?

The past decade has seen a varied number of published articles, year-over-year. Figure 2 highlights the volatility in externally-contributed articles, although the majority of lower-tier journals suffer from the same challenge resulting in the over-solicitation of articles from potential authors [6]. The inability to control submissions raises a number of questions related to balancing the ratio of main submissions to internally-developed content: what is an appropriate ratio? What is the *ideal* ratio? Should a minimum be established? Should parity be enforced? With the waxing and waning of contributing staff and individual interests, perhaps it is simply best to allow content to develop organically. Perhaps the coming decade will see convergence or express new trends; you, who is writing the future HSI meta-analysis, what insights have you found?

Towards Equal Representation across Canadian Institutions

Past and present, HSI volunteers hail from over 25 Canadian universities (Figure 3), yet Figure 5 demonstrates that in the majority of cases volunteer participation flashes in and out, with little sustained continuity. While it is promising that the majority of Canadian universities have shared *some* participation as part of HSI, ideally the next decade(s) would see a growing, if not eventually equal, representation from each institution. HSI benefits from its diversity of perspectives and current staff should engage in a concerted outreach effort to solicit future staff from under-represented institutions.

CONCLUSION

The Health Science Inquiry has enjoyed a successful decade of soliciting, peer-reviewing, and publishing the contributed articles of student-scholars throughout Canada. As an organization, HSI has contributed a total of 550 Vys of experience in scientific publishing to graduate students from over 25 Canadian universities. An in-depth examination of the number of contributed articles and the number of volunteers reveals that HSI continues to grow as an organization, promising increased opportunity to present and future graduate students. It is the hope of this article that the reflections of the trends through the past decade will orient future HSI staff members, as well as members of other graduate student-run journals, on aspects of theme selection, the rate of publishing, and contributed volunteer time. With great eagerness, I anticipate HSI's evolution through the next decade(s).

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