



and impact of the research that is produced (3, 4). Inclusion of scientists and engagement of community members from underrepresented groups is essential in understanding the clinical priorities, research barriers, and drivers of disparities within these communities and in informing scientific agendas in this context.

While there is a large body of literature describing the underrepresentation of women in medical scholarly initiatives, including guideline panel composition, authorship, and research grants (5–11), there is little data regarding other facets of diversity within these activities, such as ethnicity, professional roles, and academic age. Further, data are sparse regarding the representativeness and diversity of scientists who drive the research agenda, generate evidence that informs patient care, and publish on behalf of research consortia.

Within critical care medicine, several highly productive research consortia generate rigorous evidence that guides the care of critically ill patients around the world. Established in 1989, the Canadian Critical Care Trials Group (CCCTG) ([www.CCCTG.ca](http://www.CCCTG.ca)) is a national research consortium dedicated to improving the care of critically ill patients through investigator-initiated research, education, and advancement of research methodology (12–14). The CCCTG has grown from a founding group of 25 physician-members to more than 300 inter-professional members who share a vision to support and nurture clinical research, engage in community mentoring, and improve the care experience for patients and their families. Equity, Diversity, and Inclusion (EDI) are core values of the CCCTG, as expressed in the Diversity Policy (15) that aims for diverse representation within all CCCTG-related leadership structures and activities. One of these activities is peer-reviewed publications on behalf of the CCCTG. The objective of this study was to describe the demographic and professional diversity of the authors listed on CCCTG publications.

## METHODS

Dedicated to investigator-initiated clinical research by any of its members, the CCCTG is a highly collegial consortium that meets three times annually. All research proposals are formally presented and feedback is elicited to enhance their rigor, relevance, and fundability. Each proposal is discussed at one or more CCCTG meetings before gaining CCCTG-endorsement (open vote) by the membership; for ongoing studies,

operational progress and implementation challenges are discussed, serving as a forum for community mentorship and continuing education. All grant proposals and manuscripts are peer-reviewed for presubmission feedback to authors, and approved by the CCCTG Grants and Manuscripts Committee before submission to funding agencies or journals, respectively.

We conducted a quantitative content analysis of peer-reviewed articles that were published on behalf of the CCCTG. We compiled the final publication list by triangulating several sources: 1) the bibliography maintained by the CCCTG Grants and Manuscripts Committee; 2) a PubMed search conducted in October 2020 using the terms “CCCTG” or “Canadian Critical Care Trials Group”; and 3) direct enquiry of all CCCTG members who were first or senior authors on one or more of the identified publications. We included all articles published on behalf of the CCCTG between January 1994 and October 2020 except commentaries and editorials.

We obtained data about individual authors from the following sources, in this sequence: 1) the author was personally known to one of the investigators (S.M. or D.J.C.); 2) through email or telephone communication with the first and/or last authors of publications; 3) email queries to coauthors; and 4) internet searches of individual authors for demographic data and/or photographs. If the first and/or last author were uncertain about a coauthor’s visible minority status, they contacted the individual coauthors to ascertain this information. For pragmatic reasons, we did not communicate directly with each author.

From each publication, we recorded: the study design (e.g., observational cohort, randomized controlled trial [RCT], survey, protocol, systematic review, narrative review, guideline, qualitative, economic evaluation, or other); whether it involved collaboration with another national or international research consortium, as listed on the masthead; and the total number of authors and whether the authors came from different Canadian provinces/territories or different countries.

For the lead (first) author, senior (last) author and all coauthors listed on publications, we recorded their gender (man or woman), professional role (e.g., physician, nurse, research coordinator, patient, etc.), primary specialty for noncritical care physician-authors (e.g., hematology, gastroenterology), university, and province and country of residence at the time the research

was conducted. We also recorded whether each author was a trainee (undergraduate, medical, graduate, or post-graduate) or an early career faculty member (defined as within 5 yr of completing training) at the time the research was conducted. We recorded whether each author was a member of a visible minority group or a person of color, defined by the Employment Equity Act as “persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour” (16). Finally, we recorded whether the author was a former ICU patient and/or family representative. For group-authored publications, we gathered the data listed above for all members of the writing committee.

We conducted descriptive analyses and present data as *n* (%), mean (SD), or median (interquartile range [IQR]) as appropriate. We analyzed trends in the mean number of authors and the proportion of visible minority, trainee, early career, female total, female senior, and female lead authors for each year from 1994 to 2020 using linear regression.

## RESULTS

### Study Designs

We identified a total of 354 publications (Table 1) that included reports of observational cohort studies (39.0%), RCTs (20.6%), and surveys (14.7%) (Table 1). The remaining publications were systematic and narrative reviews, clinical practice guidelines, qualitative studies, study protocols, and economic evaluations of clinical trials. Most publications focused on adult

**TABLE 1.**  
Publication and Author Demographic Variables

| Study or Author Demographic Variable | <i>n</i> (%) |
|--------------------------------------|--------------|
| Total publications                   | 354          |
| Total authors                        | 4,246        |
| Female                               | 1,567 (36.9) |
| Male                                 | 2,679 (63.1) |
| Total unique authors                 | 1,205        |
| Female                               | 468 (38.8)   |
| Male                                 | 737 (61.2)   |

(Continued)

**TABLE 1. (Continued).**  
Publication and Author Demographic Variables

| Study or Author Demographic Variable                            | <i>n</i> (%) |
|---|--------------|
| Publications with female first author                           | 142 (40.1)   |
| Publications with female last author                            | 119 (33.6)   |
| Type of study   |              |
| Observational cohort study                                      | 138 (39.0)   |
| Randomized controlled trial                                     | 73 (20.6)    |
| Questionnaire study/survey                                      | 52 (14.7)    |
| Study protocol  | 29 (8.2)     |
| Systematic review   | 23 (6.5)     |
| Narrative review  | 15 (4.2)     |
| Clinical practice guideline                                     | 9 (2.5)      |
| Qualitative study   | 7 (2.0)      |
| Economic evaluation   | 3 (0.9)      |
| Other   | 5 (1.4)      |
| Early career faculty unique authors                             | 108 (15.4)   |
| Female early career faculty authors                             | 34 (31.5)    |
| Male early career faculty authors                               | 74 (68.5)    |
| Early career faculty is lead author, <i>n</i> (%) manuscripts   | 60 (16.9)    |
| Early career faculty is senior author, <i>n</i> (%) manuscripts | 20 (5.6)     |
| Trainee unique authors  | 122 (10.6)   |
| Female trainee authors  | 67 (54.9)    |
| Male trainee authors  | 55 (45.1)    |
| Trainee is lead author, <i>n</i> (%) manuscripts                | 43 (12.2)    |
| Trainee is senior author, <i>n</i> (%) manuscripts              | 2 (0.6)      |
| Visible minority unique authors                                 | 215 (18.0)   |
| Female visible minority authors                                 | 85 (39.5)    |
| Male visible minority authors                                   | 130 (60.5)   |
| Lead author is a visible minority, <i>n</i> (%) manuscripts     | 53 (15.0)    |
| Senior author is a visible minority, <i>n</i> (%) manuscripts   | 34 (9.6)     |

Data presented as *n* (%).

Early career faculty = within 5 yr of completing training.

Trainee authors = undergraduate, medical, graduate, or post-graduate trainee.

Visible minority is defined as persons, other than Aboriginal peoples, who are non-Caucasian in race or non-White in color.

critically ill patients (66.7%); 13.0% focused on neonatal/pediatric patients, and 20.3% included both adult and pediatric patients.

### Collaborations

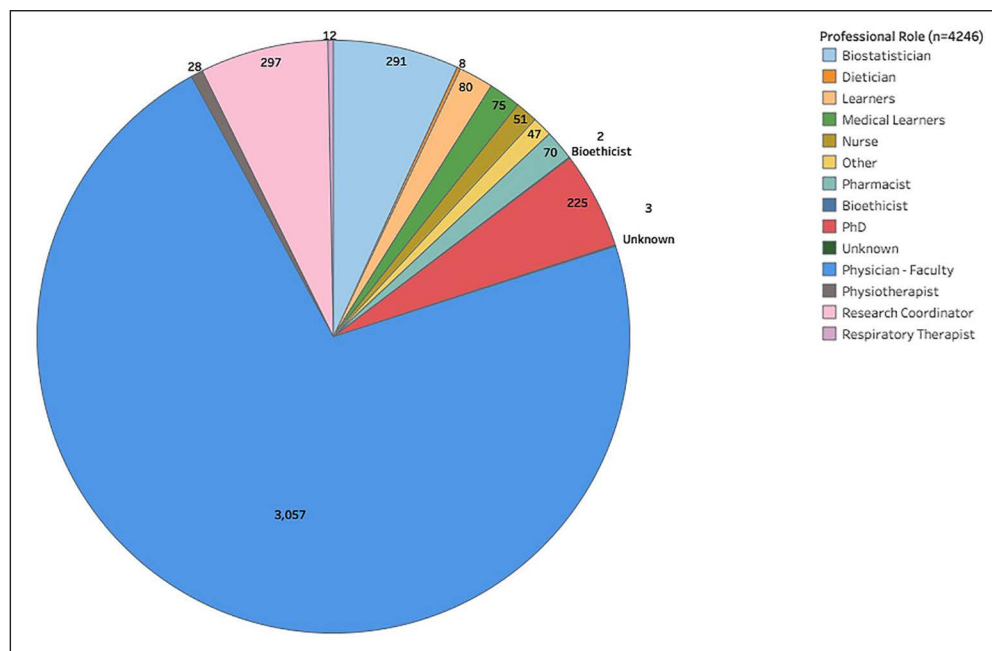
Three-quarters of publications (260/354, 73.4%) listed authors from more than one profession (e.g., physicians, nurses, pharmacists, etc.) (Fig. 1) and more than half (191/354, 53.9%) listed authors from more than one medical discipline (e.g., cardiology, nephrology). Authors from different provinces were listed in 66.9% (237/354) of publications; these included collaborators from 21 Canadian Universities across eight provinces (Fig. 2). The majority of Canadian authors arose from four provinces: Ontario, Quebec, Alberta, and British Columbia. Authors from different countries were listed in 140 of 354 publications (39.6%); these authors came from 31 countries on six continents. Overall, coauthors from low- and middle-income countries were uncommon; only three publications listed two authors from India. Publications included collaborations with 10 national and five international research consortia; most commonly the Australia and New Zealand Intensive Care Society (19 publications) and the Pediatric Acute Lung Injury and Sepsis Investigators (11 publications).

### Author Demographics

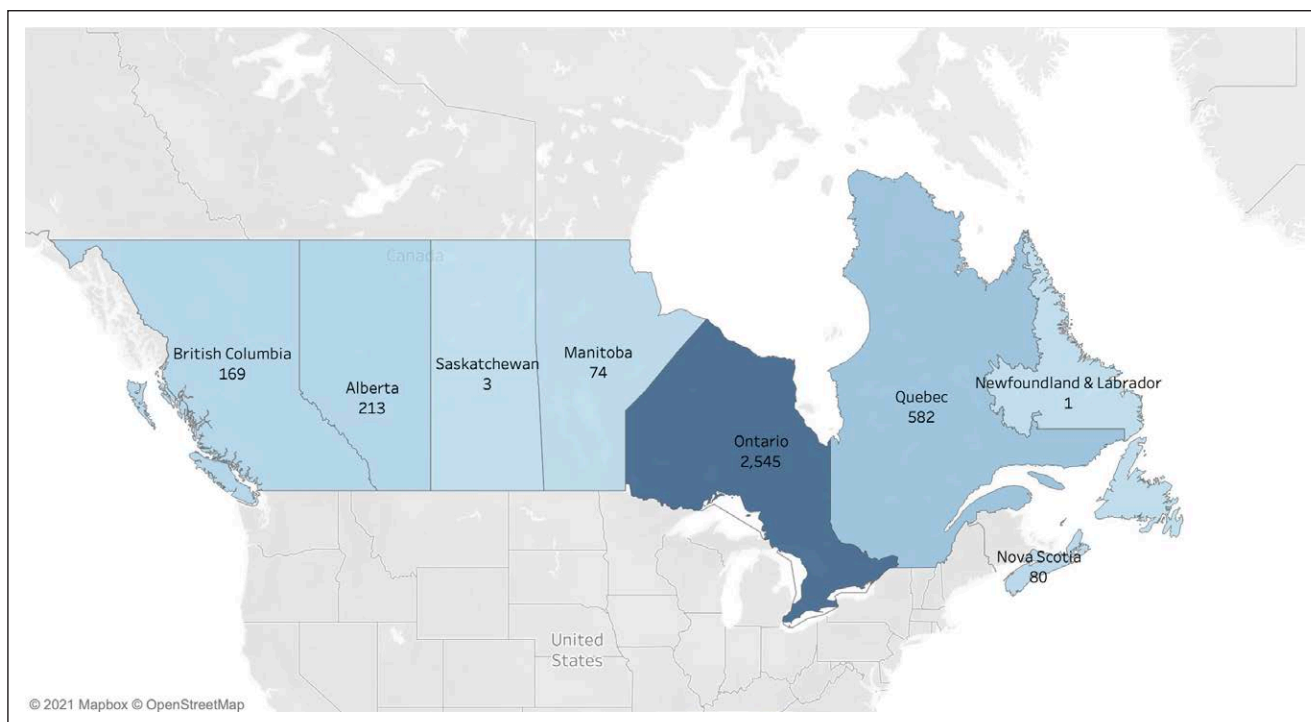
There were a total of 4,246 named authors; these were 1,205 unique individuals. The mean (SD) number of authors per publication was 12 (7.1). Over time, the mean number of authors increased (7.8, 9.2, 9.4, 11.6, and 15.1 for 1994–2000, 2001–2005, 2006–2010, 2011–2015, 2016–2020, respectively, but this did not meet statistical significance.

Of the 4,246 authors, 36.9% ( $n = 1,567$ ) were women. Women were the lead or senior author of 40.1% and 33.6% publications, respectively. The proportion of female lead authors remained constant over time, with a coefficient not statistically significantly different from zero ( $p = 0.148$ ) (Fig. 3A). The proportion of female senior authors increased by a mean absolute amount of 9.1% every 5 years (95% CI, 7.5–10.6%;  $p < 0.001$ ). The proportion of female total authors increased by a mean absolute amount of 3.8% each 5 years (95% CI, 1.3–6.3%;  $p = 0.006$ ) (Fig. 3A).

Of all authors, 10.6% were early career faculty, and nearly half of publications (159/354, 44.9%) included at least one early career faculty coauthor. The majority of publications (276/354, 78.0%) were first-authored by a physician. Of all authors, 4.2% were trainees and a third of publications (117/354, 33.1%) included at least one trainee author. Eighty (22.6%) of these manuscripts listed one trainee author, 23 (6.5%) listed two trainee authors, and 14 (4.0%) listed three or more trainee authors. Overall, 583 (13.7%) authors were considered to be members of a visible minority group. Lead and senior authors were members of a visible minority group on 53 of 354 (15.0%) and 34 of 354 (9.6%) publications, respectively. Overall, 237 of 354 (66.9%) manuscripts included at least one author who was a member of a visible minority group. Only five publications included an author who was a patient or family representative. The proportion



**Figure 1.** The pie chart presents the professional roles of 4,246 coauthors on 354 Canadian Critical Care Trials Group publications.



**Figure 2.** The representation of nonindependent authors from each Canadian Province. *n*'s represent number of authors from each province.

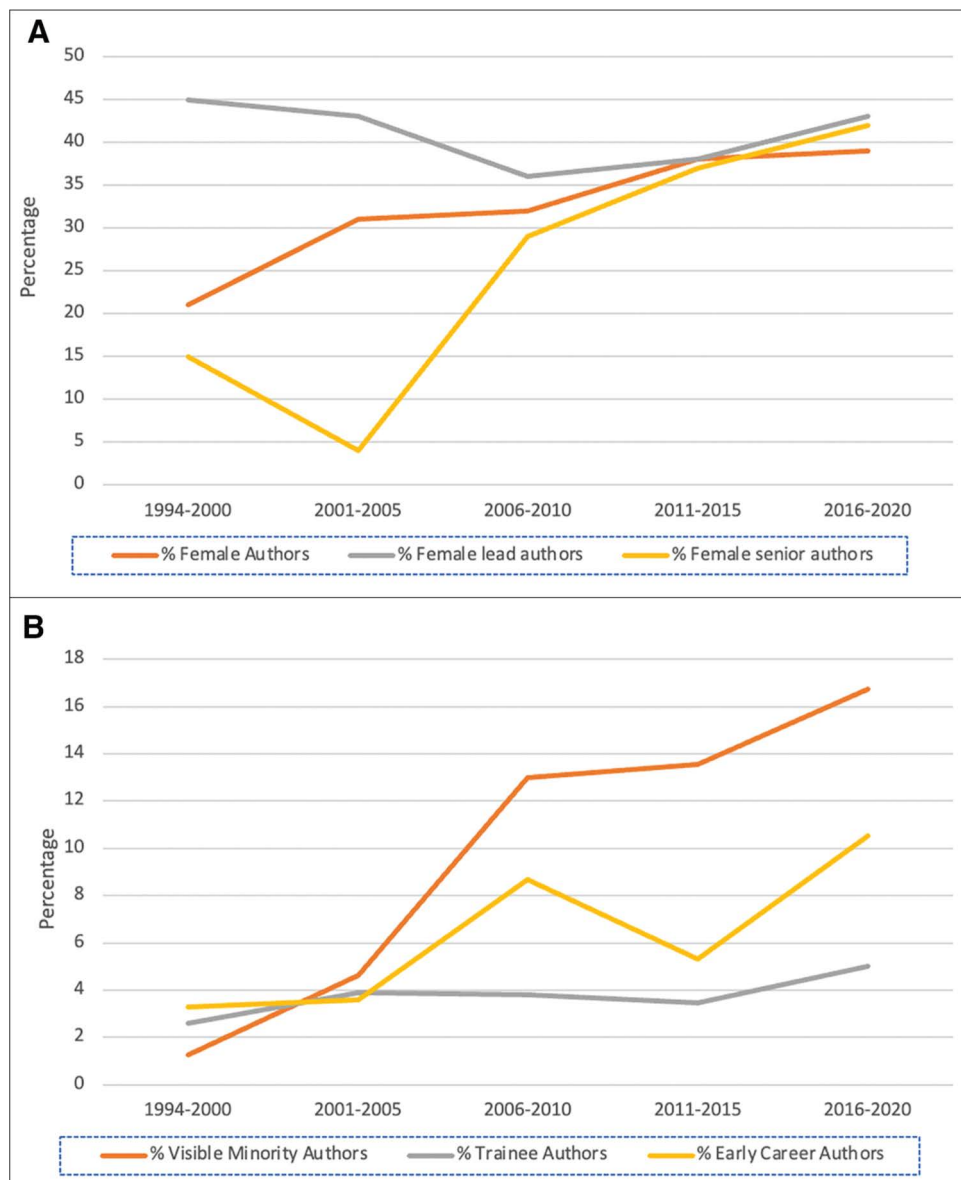
of visible minority authors increased by a mean absolute amount of 3.5% every 5 years (95% CI, 2.5–4.4%;  $p < 0.001$ ). The proportion of trainee authors increased by a mean absolute amount of 0.9% every 5 years (95% CI, 0.3–1.4%;  $p = 0.002$ ). Furthermore, the proportion of early career authors increased by a mean absolute amount of 1.5% every 5 years (95% CI, 0.2–2.8%;  $p = 0.027$ ) (**Fig. 3B**).

Analysis of unique individual authors was similar to analysis of all named authors. Of the 1,205 unique authors, 38.8% (468/1,205) were women, 10.4% (122/1,170) were trainees, 9.6% (108/1,130) were early career faculty, and 18.0% (215/1,194) were members of a visible minority group. Regarding professional role, 59.2% (713/1,205) were physicians, 7.6% (92/1,205) research coordinators, 4.3% (52/1,205) biostatisticians, 10.0% (121/1,205) PhD researchers, and 1.5% (18/1,205) pharmacists. Overall, 20.6% (248/1,205) of authors were from outside of Canada. The median (IQR) number of publications per author was 1 (1–3).

## DISCUSSION

To examine the diversity of authors who have contributed to publications emanating from the CCCTG, we reviewed 354 articles published between January 1994

and October 2020, which listed a total of 4,246 authors. We found that these authors were diverse with regard to gender, profession, discipline, geography, and trainee and faculty status. The percentage of women as lead and senior authors of CCCTG publications (40% and 34%, respectively) exceeded their percentage as authors in an analysis of 40 frequently cited critical care journals, documenting 31% female lead authors and 20% senior female authors, respectively (7). While 72% of authors were faculty physicians in the CCCTG publications, 28% of authors were learners and collaborators from other professions. This diversity of authorship reflects the interprofessional nature of critical care research and the inherent value placed upon collaboration with nurses, respiratory therapists, research professionals, and allied health partners by the CCCTG (14, 17). Early career faculty members and trainees were well-represented in the authors and manuscripts, which reflects the emphasis of the CCCTG on community mentorship of early career investigators. Overall, 18% of authors were considered to be members of a visible minority group, and 67% of publications included at least one visible minority coauthor. Only five CCCTG publications included patient or family partner coauthors; this is an area for future growth.



**Figure 3.** Representation of women, visible minority, trainee, and early-career authors in Canadian Critical Care Trials Group publications. **A**, Percentage of female authors overall (orange line), female lead (first) authors (gray line), and female senior (last) authors (yellow line). **B**, Percentage of visible minority authors (orange line), trainee authors (gray line), and early career authors (yellow line). The number of publications during each time period is 20, 28, 52, 141, 113, for 1994–2000, 2001–2005, 2006–2010, 2011–2015, and 2016–2020, respectively.

Inclusion of investigators with diverse perspectives and experiences may increase the scope of scientific input, the responsiveness of the research questions to various patient populations, and the breadth of views informing and interpreting clinical research (5). Collaborations also have greater scientific impact, as papers that are internationally collaborative are cited more often than domestic papers (18). With regard to

promotes inclusivity and deliberate and broader collaboration within these scholarly activities.

Patient and family engagement in research has garnered increased attention over the last few years; this impetus is aligned with mandates of funding agencies to ensure that research is patient and family centered (19). With their unique perspectives and experiences, patients, family members, and other ICU visitors can enrich

authorship, AlShebli et al (4) found that increased authorship diversity with regard to ethnicity, age, gender, and affiliation was associated with increased 5-year citation count, with ethnic diversity having the strongest association. Despite these benefits, scientists show a clear and consistent pattern of homophily in their choice of collaborators (4).

As recipients of public funding and at the goodwill of research participants, research consortia have a responsibility to the public to produce highly generalizable data. In this regard, addressing health inequities is a priority of our health systems. However, when research consortia lack Black, Indigenous, and other underrepresented minority groups, their health and social needs and challenges, perspectives and priorities are not directly incorporated into many steps in the research enterprise. Measuring diversity within academic endeavors identifies who is missing at the table and

research design and implementation; their contributions may also merit authorship. The fact that just five publications were coauthored by a patient or family member likely reflects the relatively recent phenomenon of study questions posed, answered, and interpreted with patient and family partnership, which is expected to increase in future CCCTG research.

The multidisciplinary and interprofessional nature of CCCTG membership is a natural precursor to rich and diverse collaborations. Valuing the contributions of allied professionals with authorship on publications provides a mechanism to engage and recognize colleagues in research design and implementation. By publicly sharing these CCCTG publication data, we hope to highlight the feasibility of interprofessional, interdisciplinary, interinstitutional, and international collaboration. We encourage other research consortia to measure and share their diversity data, to guide their steps and gauge their progress in advancing diversity.

To achieve diversity within research initiatives, we suggest the following strategies for research consortia: 1) diversity and inclusion policies; 2) a deliberate structure of academic collaboration; 3) prospective collection of broad membership demographic data; 4) celebration of visibility and intersectional innovation (20); 5) emphasizing mentorship and promotion of underrepresented groups and individuals from developing countries when training the next generation of scientists; 6) outreach to underrepresented community citizens' groups; 7) documenting diversity data in consortia publications; and 8) diversity, equity, inclusivity, and anti-racism training for all members. We also suggest that journals invite all authors to self-report their demographic data and that these data be publicly available.

Our work has several strengths including the comprehensive assessment of publications from a large well-established research consortium, triangulation of multiple data sources to identify CCCTG publications, analysis of diversity data at the level of individual contributing authors and use of multiple data sources to ascertain selected demographic data (i.e., gender, minority status). We considered independent (unique authors) as well as nonindependent authorship status in our analyses to reflect the range of authorship opportunities. Our study has limitations. First, gender categories were binary. Second, because gender and visible minority status were not self-reported by authors, these assessments may not be congruent with

their self-identified gender and minority status. In this regard, it was infeasible to obtain more granular data on ethnicity or to identify Indigenous identity accurately without directly contacting all authors. We did not seek data on sexual identity and disability, nor on author age at study completion or final publication. However, we realize that senior CCCTG members may contribute more publications, including beyond retirement from clinical duties, compared with junior or mid-career members. We recognize that author sequence is somewhat arbitrary, and lead or final author status may not indicate the greatest contribution to the article in any single dimension, or overall. Finally, we cannot contrast authorship diversity with CCCTG membership diversity, as we lack detailed demographic membership data during the period of this project.

The CCCTG places great value on EDI. Authorship of CCCTG publications reflects the gender, career stage, and interprofessional diversity of our membership and our national and international collaborative research initiatives. This generative approach reflects the longstanding objectives of the CCCTG to improve the care and outcomes of critically ill patients and their families, to advance research methodology, and create educational experiences for the membership beyond the mentoring of individual investigators. Nevertheless, there is room for improvement. Future directions to enrich CCCTG diversity include prospective collection of broad demographic variables for all members, increased Black, Indigenous, and underrepresented minority representation in our membership and citizens' advisory groups, and increased patient/caregiver participation.

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the American Thoracic Society. The remaining authors have disclosed that they do not have any potential conflicts of interest.

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## REFERENCES

1. Flores LE, Frontera WR, Andrasik MP, et al: Assessment of the inclusion of racial/ethnic minority, female, and older individuals in vaccine clinical trials. *JAMA Netw Open* 2021; 4:e2037640
2. Nguyen HT, Zheng A, Gugel A, et al: Asians and Asian subgroups are underrepresented in medical research studies published in high-impact generalist journals. *J Immigr Minor Health* 2021; 23:646–649
3. Freeman RB, Huang W: Collaboration: Strength in diversity. *Nature* 2014; 513:305
4. AlShebli BK, Rahwan T, Woon WL: The preeminence of ethnic diversity in scientific collaboration. *Nat Commun* 2018; 9:5163
5. Mehta S, Burns KEA, Machado FR, et al: Gender parity in critical care medicine. *Am J Respir Crit Care Med* 2017; 196:425–429
6. Merman E, Pincus D, Bell C, et al: Differences in clinical practice guideline authorship by gender. *Lancet* 2018; 392:1626–1628
7. Vranas KC, Ouyang D, Lin AL, et al: Gender differences in authorship of critical care literature. *Am J Respir Crit Care Med* 2020; 201:840–847
8. Mehta S, Rose L, Cook D, et al: The speaker gender gap at critical care conferences. *Crit Care Med* 2018; 46:991–996
9. Burns KEA, Straus SE, Liu K, et al: Gender differences in grant and personnel award funding rates at the Canadian Institutes of Health Research based on research content area: A retrospective analysis. *PLoS Med* 2019; 16:e1002935
10. Khan YA, Ali A, Bell CD, et al: Women, visible minorities and residents of lower-middle income countries are underrepresented in leading respiratory and critical care journals. *Am J Respir Crit Care Med* 2019; 199:A4167
11. Goldstone K, Edgley C, Mehta S, et al: Peer review for the Canadian Journal of Anesthesia in 2016 and 2017: A retrospective analysis by reviewer and author gender. *Can J Anaesth* 2020; 67:336–342
12. Cook DJ, Todd TRJ: The Canadian Critical Care Trials Group: A collaborative, educational organisation for the advancement of adult clinical ICU research. *Intensive Care World* 1997; 14:68–70
13. Marshall JC, Cook DJ; Canadian Critical Care Trials Group: Investigator-led clinical research consortia: The Canadian Critical Care Trials Group. *Crit Care Med* 2009; 37:S165–S172
14. Burns KEA, Yan SD, Thorpe K, et al: Three decades of collaboration in critical care research. *Am J Respir Crit Care Med* 2020; 201:872–875
15. Canadian Critical Care Trials Group: Diversity policy, 2018. Available at: <https://www.ccctg.ca/ccctg/media/Banners/PDF%20Documents/CCCTG-Diversity-Policy-11-April-2018.pdf>. Accessed May 26, 2021
16. Statistics Canada: Visible minority of person definition. 2015. Available at: <https://www23.statcan.gc.ca/imdb/p3Var.pl?Function=DEC&Id=45152>. Accessed May 26, 2021
17. Rose L, Smith O, Burry L, et al: Multiprofessional speaker diversity at critical care conferences. *Crit Care Med* 2020; 48:1044
18. Adams J: Collaborations: The fourth age of research. *Nature* 2013; 497:557–560
19. Burns KEA, Misak C, Herridge M, et al; Patient and Family Partnership Committee of the Canadian Critical Care Trials Group: Patient and family engagement in the ICU. Untapped opportunities and underrecognized challenges. *Am J Respir Crit Care Med* 2018; 198:310–319
20. Eckstrand KL, Eliason J, St Cloud T, et al: The priority of intersectionality in academic medicine. *Acad Med* 2016; 91:904–907