Research Square

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Alignment Between Child Health Research and Disease Burden in Canada: A National Bibliometric Analysis

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Abstract

Purpose

To determine the extent to which research activity, as reflected in academic publications, maps to the burden associated with child health conditions and causes.

Method

We collected publication metadata from 2014–2023 for Canadian researchers from Elsevier's Scopus database. Publications were merged, deduplicated, and we subjected titles and abstracts to standardized preprocessing. We identified child health-related publications with supervised machine-learning trained on manually labeled data. These publications were then analyzed using Non-Negative Matrix Factorization to derive research topics, which we mapped to Global Burden of Disease (GBD) categories. Temporal trend analysis linked annual topic weights with GBD metrics to reveal alignment between research activity and changes in disease burden over time.

Results

A total of 98,160 publications were identified as child-health-relevant. Topic modeling revealed 74 coherent research areas. At the level of broad categories of causes of burden, there was a remarkable concordance between research attention and disease burden (R^2 of 0.92, $p = 0.001$), though this relationship was more complex at the subcategory level. Notably, the increase in infectious disease burden during the COVID-19 pandemic was accompanied by a corresponding rise in related research output, representing the research community's responsiveness to emerging health priorities.

Discussion

Child health research activity in Canada aligns closely with the broad health issues that drive child health outcomes. Although the relationship between research and health outcomes is complex, this finding underscores the general responsiveness of the child health research community to societal need.

Background

Children in Canada have poor health and wellbeing outcomes in comparison to other countries of comparable wealth [1] as highlighted in recent UNICEF report cards [2, 3]. Research in Canada, including that focused on child health, is largely publicly funded. Public funders mandate that research addresses critically important social and economic objectives. To this end, funders and policy makers are increasingly embracing 'grand challenges' to orient resources and efforts towards areas of strategic importance to realize these economic and societal benefits and impact. While such initiatives can

influence research directions, most research programs reflect individual choices of investigators pursuing research programs of varying scale and scope. This begs the question, does the resulting research activity align with the relative importance of the issues pursued?

The relationship between research investments and changes in health outcomes is complex and poorly understood [4]. One way to assess the relative importance of research areas is via the health burden associated with the issues targeted by that research. The Global Burden of Disease (GBD) series of studies provides a widely used and accepted framework and database that can be used to quantify the health burden associated with various diseases, injuries and risks [2, 5–7]. Using standardized indicators such as mortality and Disability-Adjusted Life Years (DALYs), the GBD offers the ability to quantify the health burden associated with issues of research focus.

For research to impact health, it must address a gap in knowledge that is impeding progress on some health-related issue. The identification of gaps in knowledge is a central activity within any research domain. Within the biological and biomedical sciences, this may take the form of structured problem agendas, in which a conceptual framework is created to address a set of coherent problems [8]. Discoveries and new technologies can also lead to new agendas. Within the social sciences, this process is more complex and tends to be consciously oriented towards theoretical constructs. In either case, there is rarely a simple relationship between the societal importance of a problem and research agendas. For example, poverty is the single greatest risk factor for child health [9]. Poverty is not, however, the central focus of child health research. Although there are gaps in knowledge relevant to this problem, much that is known is not implemented in terms of policy [10]. This may exemplify a disconnect between knowledge creation and its potential to address societal need.

In this work, we compare research output in Canada related to child health and wellness over a 10-year period to the childhood burden of disease for the issues of research focus based on the GBD database [11]. While earlier bibliometric work has addressed specific areas of child health research [12–17], and or the relationship between clinical trials activity and child health burden [18], we are not aware of other large-scale bibliometric analyses in relation to systematic quantification of the burden of disease. This analysis offers insight into the extent to which research communities self-organize around issues of societal importance, which is relevant to child stakeholders including funders, academic institutions and the public-at-large.

Methods

Study Design and Data Sources

We conducted a bibliometric analysis of Canadian child health research published between January 2014, and December 2023 (Fig. S1). The data was downloaded from Scopus API between (January–April 2024) via http://api.elsevier.com and http://www.scopus.com [19].

Disease burden data were obtained from the Global Burden of Disease (GBD) 2023 study for children and youth (< 20 years) in Canada and globally [11].

Identification of Canadian Child Health Research

Publications were identified using affiliation-based and author-based search strategies to generate a broad dataset of publications from which Canadian child health research could be extracted.

First, we performed an affiliation-based search using Scopus institution identifiers to collect publications from the Maternal Infant Child and Youth Research Network (MICYRN) and the 17 universities listed on the Pediatric Chairs of Canada website. Additional institutions were identified using child health–related keywords in English and French and verified manually (Table S1).

Second, we performed an author-based search using Scopus author identifiers to retrieve publications for researchers listed by MICYRN centers in 2021, including Alberta Children's Hospital Research Institute (ACHRI), British Columbia Children's Hospital Research Institute (BCCHRI), Bloorview Research Institute (BRI), CHU Sainte Justine (CHUSJ), Children's Hospital Research Institute of Manitoba (CHRIM), McMaster, Women and Children's Health Research Institute (WCHRI), Children's Hospital of Easter Ontario (CHEO), and SickKids. Publications were retained only for authors with Canadian affiliations.

Datasets from both methods were merged and deduplicated. We retained publications from 2014–2023 with available abstracts. Retracted articles, errata, articles in press, and non-English publications were excluded. Universities publications were further filtered using subject-area criteria derived from co-occurrence analysis of Child Health and Wellness (CHW) center datasets.

Classification of Child Health Relevance

To identify child health-relevant publications, we trained a supervised machine learning classifier using manually labeled data. From a random sample of 10,000 publications, 8,725 met inclusion criteria and were manually reviewed based on abstracts and metadata. Of these, 1,788 publications were labeled relevant. To address class imbalance, the non-relevant class was undersampled to match the relevant numbers. We used stratified sampling to obtain an 80/20 split for model fitting and validation sets.

Text features from titles and abstracts were transformed using term-frequency–inverse-document-frequency (TF-IDF). Journal, subject area, year, and MICYRN membership were included as additional features. A gradient-boosted decision tree model (XGBoost [20]) was trained using 5-fold cross-validation, optimizing the *F1* score.

The final model achieved an *F1* score of 87% (non-relevant) and 86% (relevant) on the test set (Table S2). Manual validation of 900 publications confirmed consistent classification performance, the model correctly classified 796 publications, with 104 false positives and 30 false negatives.

Topic Identification

Publications classified as child health–relevant were analyzed using non-negative matrix factorization (NMF) [21] applied to TF-IDF representations of titles and abstracts.

The number of topics was selected based on coherence scores and reconstruction error (Fig. S2). After manual review and consolidation of overlapping themes, 74 distinct topics were retained and labeled based on their highest-weighted terms.

Measures of Disease Burden

Disease causes in the GBD dataset were grouped into nine major categories and 30 subcategories (Table S3). Disability-adjusted life-years (DALYs) rates for 2014 to 2023 were summed and log transformed. A composite severity index was then calculated as the log of DALY to death ratio.

Mapping Topics to GBD Categories

The alignment between research focus and real-world health needs was explored by mapping the identified topics to categories (Fig. S3) and subcategories (Fig. S4) derived from the GBD framework using topic keywords and expert judgment.

Statistical Analysis

We used CV coherence metric to assess the semantic consistency of the identified topics. Topic prevalence was calculated by adding up topic weights from all publications and expressing each as a percentage of the total topic weight. To evaluate the alignment between research activity and disease burden, we compared topic prevalence within each GBD category and subcategory with corresponding DALY and severity index values. We used linear regression to assess the association between publication prevalence and disease burden, with model fit evaluated using R^2 and P values. To examine temporal trends, annual topic prevalence and annual DALY and severity index values were calculated from 2014 through 2023 and compared across major GBD categories.

Results

Identification of Child-Health Related Publications

Among 345,593 publications from Canadian institutions and authors, 98,160 (28.4%) were classified as relevant to child health. Productivity trended upwards, but with a peak in 2021 (Fig. 1a). The proportion of child health-related publications remained consistent (28.0% in 2014 and 26.5% in 2022), and similar to the manually labeled dataset. Within CHW centers, the proportion of child health publications was considerably higher (Fig. 1b).

Topic Modeling

Topic modeling produced 74 topics that represent coherent clusters of CHW research as evident in the top keywords for each topic (Fig. 2) and high semantic consistency (Fig. 3).

Distribution of Research Topics Across GBD Categories

Mapping topics to GBD categories revealed that Social Determinants were most prominent, accounting for ~ 30% of total topic prevalence (Fig. 4a). Chronic Disease, and Mental and Brain Health each contributed 17–18%. Maternal and Perinatal Health and Mendelian Disorders represented 13% and 10%, while Infectious Disease, Cancer, Neurodiversity and Other each contributed < 5%. At the sub-category level (Fig. 4b), approximately 25% of topic prevalence could not be mapped to a subcategory (No Fit), with Social Determinants accounting for about 80% of this group. Among mappable subcategories, Other Non-communicable Diseases, Neurological Disorders, and Mental and Substance Use Disorders were most prominent (10–15%).

Alignment Between Research Activity and Disease Burden

Research attention aligned with the health burden of major disease categories in Canada (Fig. 4c). We excluded Social Determinants and Other categories because these categories lack direct DALY equivalents in the GBD framework. The DALY burden and severity index were highest in Chronic Disease, Mental and Brain Health, and Maternal and Perinatal Health categories, which were also the most common categories in the publications. Across GBD categories, publication prevalence showed a strong positive association with DALY burden (R^2 = 0.92, p = 0.001). By contrast, Canadian child-health research output shows no significant association (R^2 = 0.09, p = 0.526) with global disease burden across GBD categories (Fig. 4c). At the subcategory level, correlation between the DALYs and publication weight was not significant (Fig. 4d).

Severity index values varied across both categories and subcategories (Figs. 4c and 4d). Among the main GBD categories, Chronic Disease, Mental and Brain Health, and Infectious Diseases had the highest values (SI = 6.6, SI = 6.1, and SI = 5.7, respectively). Mendelian Disorders and Maternal and Perinatal Health, and Cancer had moderate values (SI = 4.8, and SI = 4.7, SI = 4.5, respectively). Neurodiversity showed the lowest severity index due to the absence of its mortality measures in the GBD dataset.

Temporal Trends in Research Focus Versus Disease Burden

The COVID-19 pandemic provided an opportunity to track the responsiveness of the research community to a dramatic change in the health burden landscape and its societal implications. Figures 5a and 5b compare annual publications prevalence and the burden of disease for children and youth (< 20 years) between 2014 and 2023. Chronic Disease publications remained roughly constant in absolute numbers but decreased from 21% to 16% of the total. Brain and Mental Health publications increased from 17.5%

to 18.6% which implies a > 25% increase in absolute publication numbers. Figure 5c shows the relationship between year-to-year change in publication attention against change in health burden. A linear model with GBD category as a factor revealed a significant relationship between change in research attention and change in health burden. However, this relationship was driven primarily by changes in Infectious Disease and, specifically, to that related to COVID-19 pandemic. Publications related to COVID-19 pandemic first appeared in 2020, peaked in 2022 and declined only slightly in 2023 (Fig. 5d). The dramatic change in research attention related to Infectious Disease underscores the responsiveness of the research community to changes in health burden but also the tendency for that response to persist over time.

Discussion

This is the first comprehensive national study to map publication productivity to societal importance as measured by burden of disease. We found that research activity in Canada aligned remarkably with societal importance of topics under investigation. There was a strong correlation between broad categories of childhood burden of disease and publication prevalence. As the burden of health changed during the COVID-19 pandemic, research attention changed accordingly. These are striking and exciting findings that speak to the responsiveness of the academic research community to societal needs.

We show that combining machine learning-based classification with topic modeling can enable large-scale bibliometric analyses. Available subject identifiers tend to identify broad topics or disciplines poorly suited to tasks such as the identification of publications relevant to child health. Manual classification of very large numbers of publications is impractical. Machine learning for such a task is challenging because the subject-space of publications has high dimensionality and publications usually map to multiple topics. A paper on a developmental-genetic pathway, for example, may be relevant to aging, cancer and child health. Despite this inherent fuzziness, we show that such a task can be learned with high accuracy.

Topic modeling revealed thematic patterns within the high-dimensional publication metadata space that are internally consistent and representative of the diversity of topics relevant to child health. The theme labelled Placental Function and Fetal Growth, for example, includes pre-eclampsia, trophoblasts, fetal ultrasound and growth while School Environment and Bullying includes academic, school, policy, grade, victimization, and bully. Many topics overlap, as expected in a fuzzy classification task. Interestingly, topics represented by larger numbers of papers do not exhibit lower coherence which suggests that the coherence of a research topic is independent of the size of the corresponding research enterprise.

At the level of broad GBD categories, the correlation between publication prevalence and disease burden is very high. At the level of GBD subcategories, however, the picture is more complex. At the subcategory level, several topics deviate significantly from the trendline in both directions. The three subcategories of Maternal and Perinatal Health illustrate this as they span the range of disease burden but receive similar amounts of research attention. The net effect is that the sums of research attention and health burden

for these three areas fall very close to the overall trendline. To some degree, the lower correlation between research attention and disease burden at the lower GBD classification levels reflects increasing difficulty of relating the 74 topics to causes of health burden at lower levels of the GBD classification scheme. Roughly 25% of topics could not be mapped to GBD cause subcategories. Many such topics deal with social determinants of health rather than having a specific disease focus.

A future question enabled by this work is whether research in countries where drivers of health burden are dramatically different from Canada also show a similar concordance. A related question is to what extent the focus on the health burden drivers typical of high-income countries like Canada such as mental and brain health or chronic diseases is appropriate when globally, child health burden is driven to a much greater extent by infectious diseases such as malaria or tuberculosis that receive relatively little research attention by Canadian researchers.

There are several limitations to this study. Social determinants are not well captured in the GBD database, although they are reflected indirectly in estimates of the burden of risk factors such as low birth weight or access to safe water[22]. The difficulty here is that social determinants are more open-ended and context-specific than most of the causes of health burden captured in the database. Social determinants are often specific to cultural, geographic or political contexts as well as specific conditions such as regional conflict. But this also means that many studies that address social determinants of child health in a Canadian context [23, 24] are not easily mapped to either GBD causes or risk factors, especially at the more specific levels of the GBD classification scheme.

The COVID-19 pandemic offered a unique opportunity to examine the responsiveness of research communities to changes in health determinants. During the pandemic, the health-burden associated with infectious disease as well as knock-on effects such as depression and anxiety rose dramatically between 2020 and 2022 [25]. Publications related to Infectious Disease increased dramatically in 2021 and research attention to child and youth mental health also increased during this period. The increased attention to Infectious Disease is sustained beyond the health-burden peak of the pandemic but levels off in 2023. Much sustained effort was devoted to broader consequences of the pandemic such as mental health [13, 14], healthcare access [15] and family stress [16, 17]. These trends in the child health publication data reveal a tendency for research communities to respond to societal threats in real time but also the ability of researchers to move efforts from one domain to another in response to societal need.

The increased research productivity related to COVID-19 pandemic may relate to the substantial investment by funders. CIHR reported $450M in COVID-19-related investment from 2020–2023 [26] which compares to a total budget of roughly $5.2B for this period. While we cannot connect this funding directly to COVID-19-related publications, this period saw a striking increase in both funding opportunity and research interest and that the research interest appears to be sustained beyond the period during which COVID-19-related funding was specifically earmarked.

Health research is important for many reasons, but among them the hope that investigators choose to work towards solutions to problems of importance to society is central. There is rarely a direct connection or defined process between strategic prioritization with the research activity and the pathways to health outcomes within a specific country. For example, the United States is the largest national producer of health research but its health outcomes fall well below those expected relative to GDP. Small, wealthy countries can enjoy excellent health outcomes for health issues on which they perform little research. Health outcomes for children depend on the interplay of a wide range of social determinants, the availability of knowledge and appropriate translation of that knowledge. Since knowledge created by research is largely a public good, the health of children in specific settings appears more dependent on social determinants and knowledge translation than on differences in the availability of knowledge. But the availability of knowledge defines upper limits on health outcomes [27]. When a medical treatment is not known or a policy intervention not understood, knowledge translation cannot occur even under optimal socioeconomic conditions. For this reason, the finding of concordance between broad categories of health burden and research focus for academic publications in Canada is encouraging and important for funders of health research and the broader public whose interests they serve.

Abbreviations

ACHRI
Alberta Children's Hospital Research Institute
API
Application Programming Interface
BCCHRI
British Columbia Children's Hospital Research Institute
BRI
Bloorview Research Institute
CHEO
Children's Hospital of Eastern Ontario
CHRIM
Children's Hospital Research Institute of Manitoba
CHUSJ
CHU Sainte-Justine (Centre Hospitalier Universitaire Sainte-Justine)
CHW
Child Health and Wellness
CIHR
Canadian Institutes of Health Research
COVID-19
Coronavirus Disease 2019
CV

Coherence Value
DALYs
Disability-Adjusted Life Years
GBD
Global Burden of Disease
MICYRN
Maternal Infant Child and Youth Research Network
NMF
Non-negative Matrix Factorization
R^2
Coefficient of determination
TF-IDF
Term frequency–inverse document frequency
WCHRI
Women and Children's Health Research Institute
XGBoost
Extreme Gradient Boosting

Declarations

Ethics approval and consent to participate

Ethics approval was not required because this study analyzed publicly available bibliographic data and aggregated burden-of-disease data and did not involve human participants.

Consent for publication

Not applicable

Availability of data and materials

All code used for data processing, model training, hyperparameter optimisation, and evaluation is publicly available in the project repository (https://github.com/md-dehghan/child-health-bibliometrics-ml-pipeline.git).

The datasets analyzed during the current study are not publicly available because Elsevier's Scopus licensing terms prohibit redistribution of abstracts and bibliographic metadata. Data may be available from the corresponding author upon reasonable request, subject to the Scopus license agreement.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

All authors on the author list were presented at one or more of the discussions and contributed to formulation of the research concept and participated in the decision to initiate the project. M.D., M.A. and B.H. performed analyses of data and designed the research. M.D. and B.H. drafted the paper and produced figures. S.M.B., F.P.B., D.H., and K.E.R.G. performed extensive review and editing of paper drafts. Institute leads in MICYRN provided data on membership and interacted with M.D and C.L.H. All authors read, edited and approved the manuscript.

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Figures

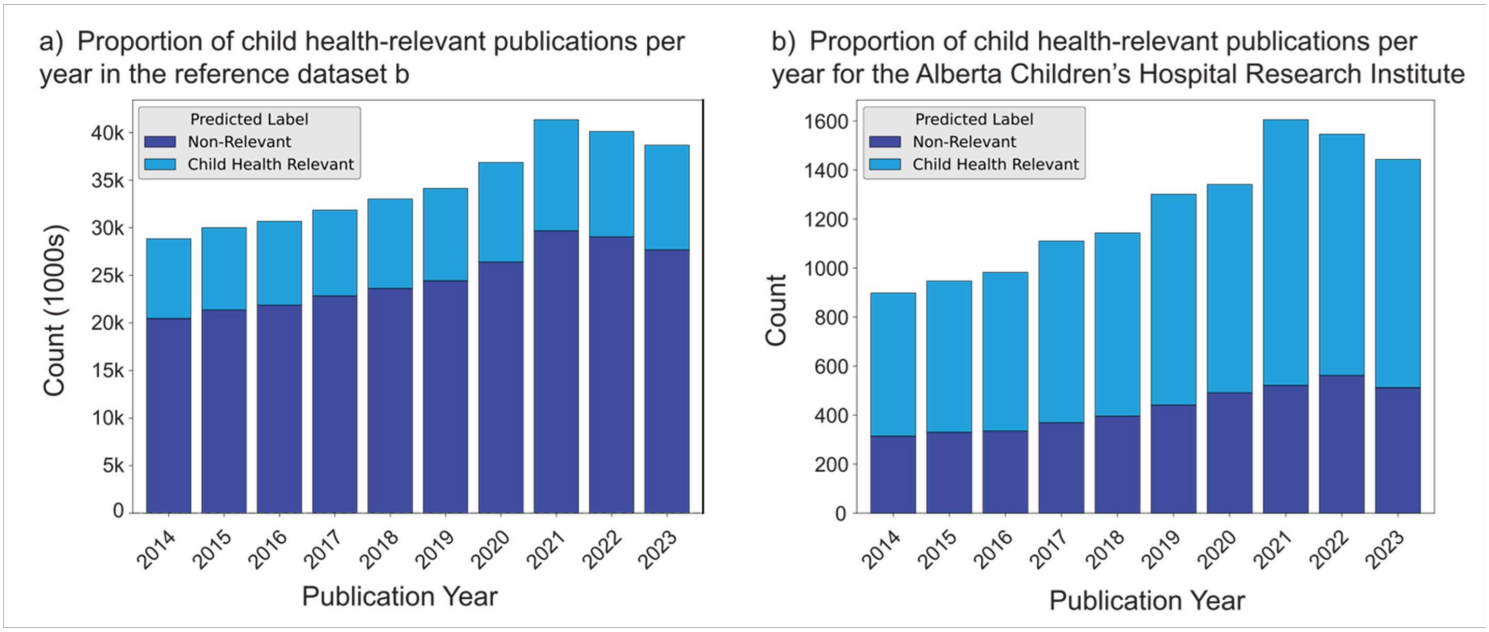


Figure 1

Trends in child health–related publications from Canadian institutions and CHW center, 2014–2023.



Figure 2

Word Cloud representation of topic keywords. Word weights within each topic are normalized and log-scaled for better visualization. Higher-weighted words are shown in warmer colors, while lower-weighted terms are displayed in cooler colors.

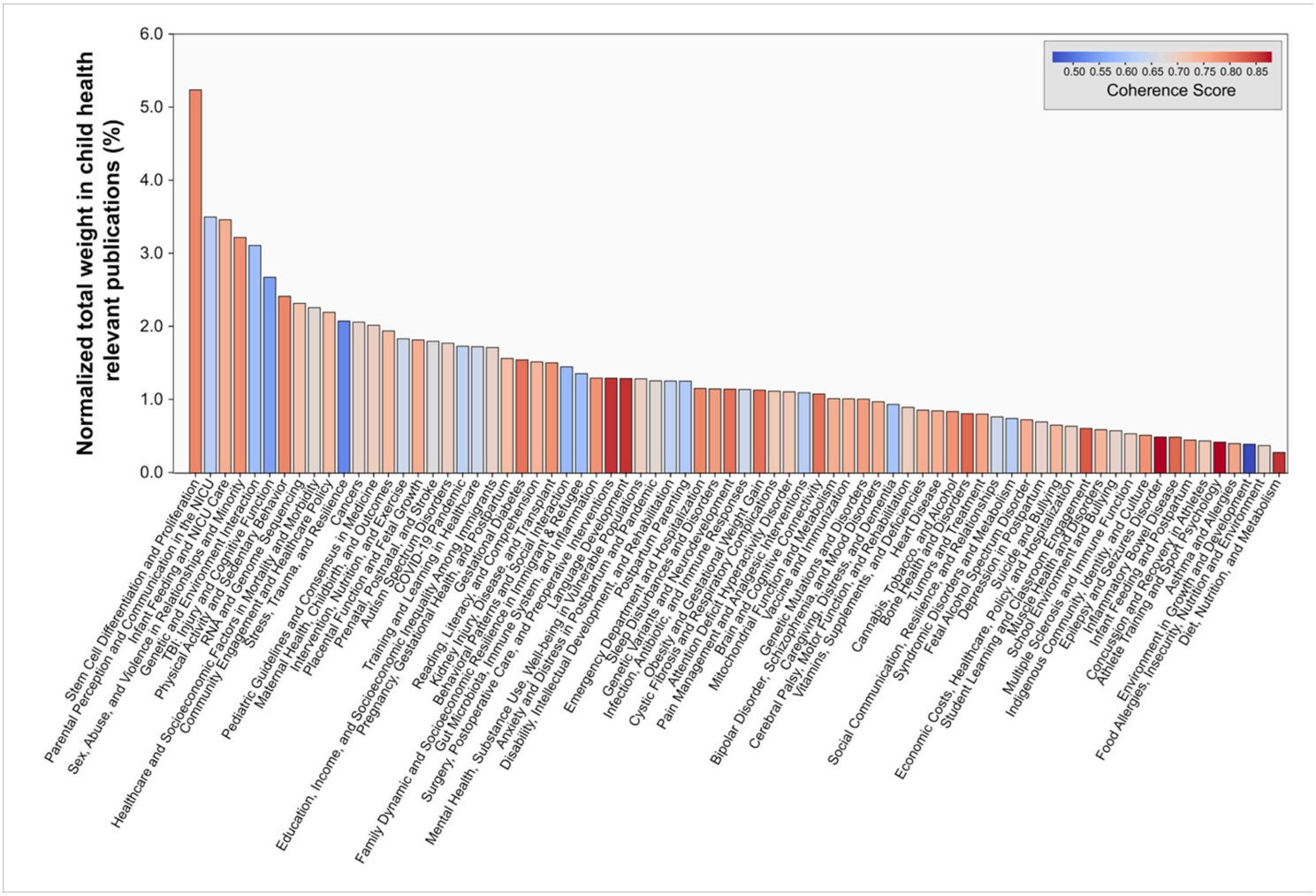


Figure 3

Distribution of research topics identified using NMF modeling on child health relevant publications.

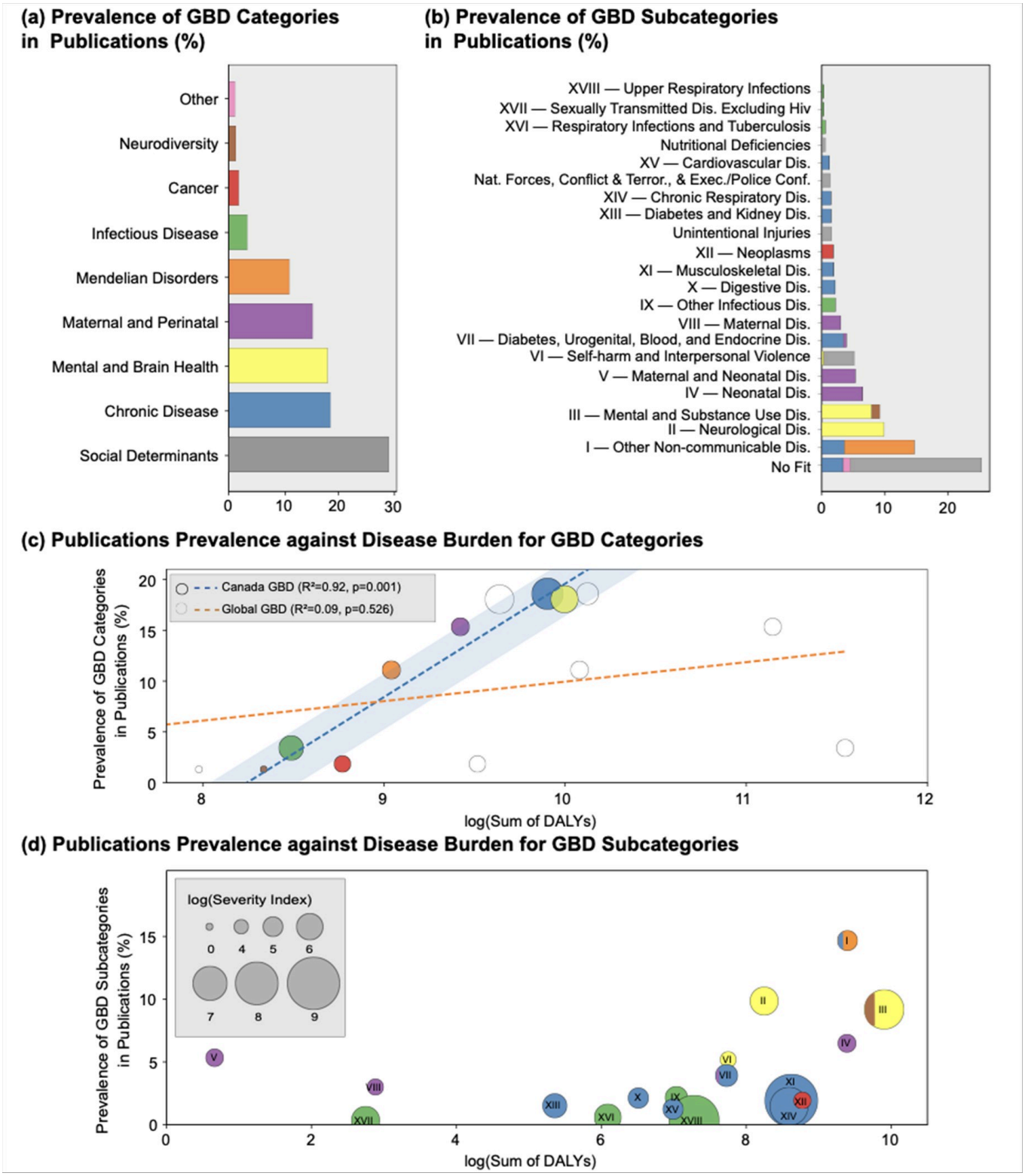


Figure 4

Distribution of child health research and its alignment with disease burden across GBD categories and subcategories.

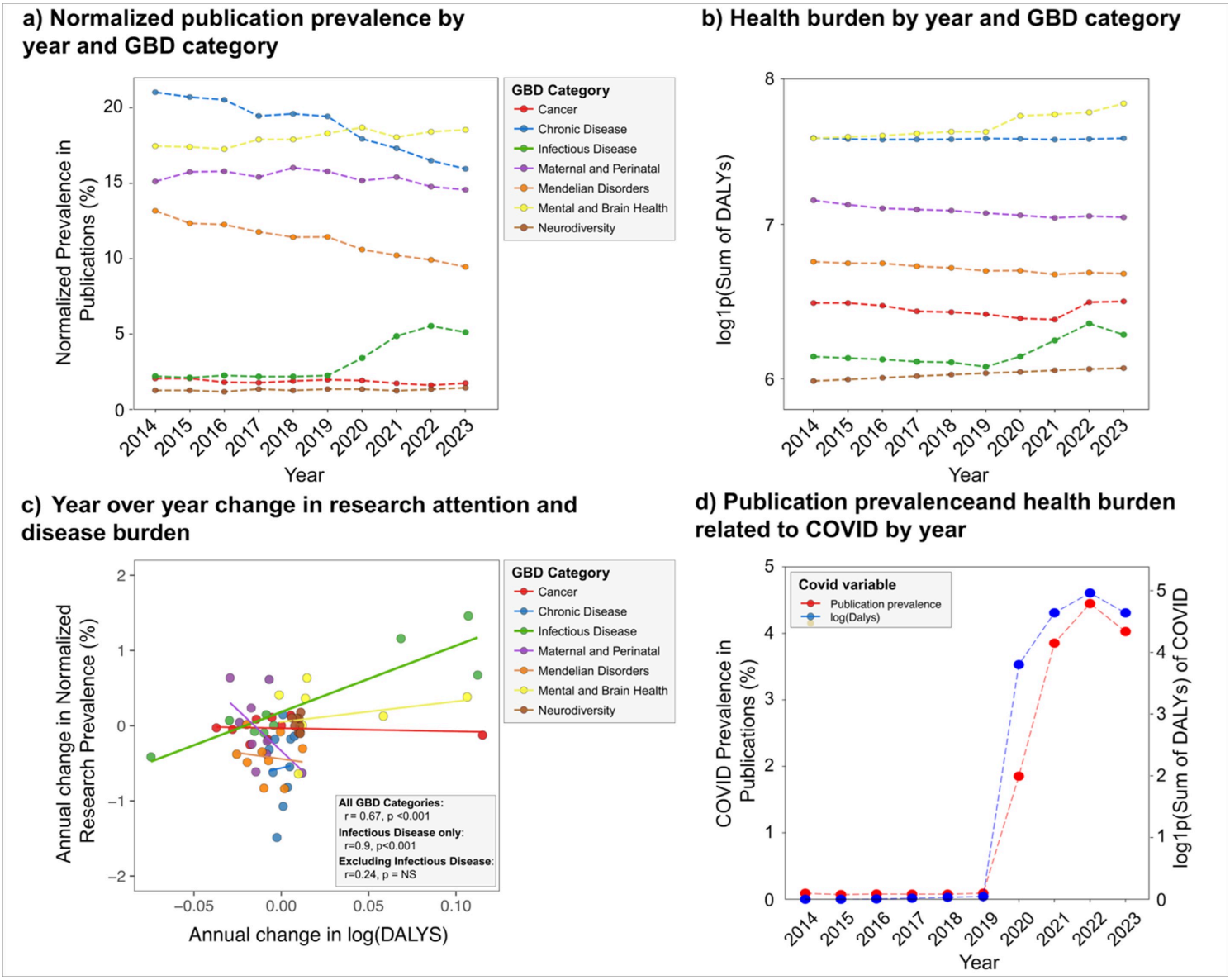


Figure 5

Temporal trends in publication prevalence and disease burden across GBD categories in Canada.

Supplementary Files

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