Modernising Physician Resource Planning: A National Interactive Web Platform for Canadian Medical Trainees

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Abstract

Background: Healthcare systems rely heavily upon human resources to ensure high-quality access to care for the general population. With significant health worker shortages predicted worldwide in the coming decades, maximizing the current workforce by means of a physician resource planning (PRP) strategy that ensures the right number, mix, and distribution of physicians to meet population needs is warranted. In Canada, there is an insufficient number of primary care providers, and disproportionately low numbers of specialist physicians in rural compared to urban regions. Currently, Canadian medical students are not effectively included in PRP strategy and lack the required information for career orientation to help rebalance the population's workforce needs. This paper aims to present the *Health Human Resource (HHR) Platform*, a comprehensive web tool that includes relevant workforce data to empower medical students in choosing a discipline based on both personal interests and social accountability.

Results: Physician workforce data, comments from Canadian residency program directors, and career planning resources were collected by the Canadian Federation of Medical Student's (CFMS) HHR Task Force. This information was consolidated to create a national interactive platform that uses a map, comparison table, and trends graph to illustrate over 500,000 unique data points from 37 datasets, including specific information and resources spanning 62 medical specialties from 2015 onwards. There was a 24.6% response rate for program director comments. During the first four months of the *HHR Platform* launch, there were 2463 different users, of which 998 were returning, with an average of 20.2 users per day spending on average 3 minutes and 4 seconds on the platform.

Conclusions: The *HHR Platform* constitutes a bottom-up national approach to PRP informing medical students on the mix and distribution of physicians needed for a better alignment with residency positions, and ultimately meet the future healthcare demands of the Canadian population.

Background

Healthcare accounts for a significant portion of public expenditure in many countries globally, and human resources occupy a majority of this spending [1]. Imbalances in healthcare workforce supply and demand negatively impact the provision of health services and ultimately strain overall public expenditure [2–4]. Even under universal healthcare systems, such as the Canadian framework, these imbalances result in adverse sequelae. For example, between 2005 and 2019, the physician to 100,000 population ratio increased from about 190 to 240, representing one of the greatest rises of physician supply in Canadian history, while the proportion of Canadians without a family physician increased from 13.6–14.5% during this period [5–7]. This mismatch may be attributed to decades of overtraining specialist physicians, which has resulted in undersupply of family physicians [8]. Furthermore, there is a geographic dichotomy: only 10% of the total physician workforce and only 2% of specialized physicians practice in rural Canada where 18% of the population is situated [9].

To address this, Health Canada invested $1.8 million in 2010 to review postgraduate medical education in Canada [10]. One of their recommendations was to iteratively re-evaluate medical training programs to ensure the right "physician mix, distribution, and number" of generalist and specialist positions to serve the Canadian population. Part of the solution, therefore, must address medical students' specialty choice and its effect on society. At a national level, Canadian medical residency training has historically seen a deficit of students applying to primary care programs, such as family medicine, resulting in unfilled training positions. Meanwhile, there has been an enormous difficulty maintaining access to primary care services due to the lack of trained individuals within this field [11–14]. In 2020, there were 169 unfilled training positions in family medicine after the first iteration of the residency match [15]. In contrast, a 2019 survey showed that 66% of the total specialist physicians surveyed were unable to secure employment within 12–17 months of graduation [16].

Reduced access to essential health services is simply one consequence of the physician supply-demand mismatch. Attrition or underemployment of highly trained physicians due to unfavourable job prospects results in a decreased return on investment in the health sector, as medical training is heavily subsidized by Canadian taxpayers [17]. Additionally, a population whose health needs are critically underserviced experiences poorer health outcomes which is more costly in other facets of public spending, such as those related to illness and disability [8, 18, 19].

Health human resource (HHR) planning is a necessary endeavour to optimize the quantity and skillset of our healthcare workforce, which in turn ensures that population health needs are adequately serviced [2]. Within the Canadian context, not only is HHR planning beneficial from a population health perspective, but it is the most sustainable approach to procuring long-term stability of our universal healthcare system. Physician resource planning (PRP), a subset of HHR strategy, aims to optimize physicians' available supply to meet population demands. Canada's universal healthcare system is provincially governed; thus, many elements of care delivery such as healthcare coverage, physician licensure, physician reimbursement, and referral logistics are typically moderated within provincial boundaries [20] However, provincially mandated healthcare results in difficulties with evolving physician practice habits, such as interprovincial locums and telemedicine providers who tend to serve remote populations [20].

Many nations, including Canada, are predicted to face critical deficits in physician supply over the next thirty years [21]. The quality of a nation's HHR planning and PRP are reflected in patient outcomes: morbidity and mortality are known to rise when supply of care providers does not match population needs [22–24]. The goal is not to simply train a set number of physicians, but rather to train the right types of physicians based on population needs. This avoids the present circumstance of simultaneously having too many physicians, and yet, not enough. These shortages may be effectively overcome by improving PRP strategies for domestically trained physicians to close gaps in attrition and supply-demand mismatch [8]. However, due to the paucity of concerted national PRP efforts, Canadian medical trainees are not equipped to make evidence-informed decisions regarding specialty choice, and thus, the cycle persists [25]. Medical training is an arduous, lengthy, and costly process that can—and should—be optimized by a national PRP strategy.

Currently, there are two main checkpoints in the medical training process that affect the number, mix, and distribution of future physicians; thus, acting as a component of national PRP strategy. First, undergraduate medicine admissions; second, postgraduate residency admissions. These checkpoints represent top-down approaches to PRP, such that admissions decisions are made to steer the future physician workforce to match societal demand. These checkpoints

attempt to direct medical trainees towards specific specialties and practice locations, but have yet to deliver a supply of physicians that sustainably meets the Canadian population demand. However, to the best of our knowledge, there are no national bottom-up approaches to PRP targeting Canadian undergraduate medical trainees—whereby students make an evidence-informed decision regarding their specialty choice to match societal demand. Our objective was to create an interactive web-based tool, the *HHR Platform*, for medical trainees as a bottom-up national PRP strategy within the Canadian context. Our tool empowers future physicians with the technology and data to make evidence-informed decisions regarding specialty choice. This work was undertaken by the Canadian Federation of Medical Students' (CFMS) HHR Task Force with the goal of shifting the decision-making process for Canadian medical trainees towards both personal interests and social accountability.

Implementation

The *HHR Platform* was created by FireNet Designs (FireNet Designs, Winnipeg, AB, CA) on a DigitalOcean (DigitalOcean Inc, New York City, NY, US) server to host the backend database using MySQL (Oracle Corp., Redwood Shores, CA, US). Construction of the platform spanned from November 2019 to September 2020. The backend is composed of a comma separated value (CSV) parser application used for adding data to the database, and flexible application programming interface (API) endpoints for querying data. The frontend is constructed using React (Facebook Inc, Menlo Park, CA, US) to manage user functionality and Material UI (Material-UI SAS, Paris, FR) to simplify data processing. Lastly, Leaflet (Vladimir Agafonkin, Kyiv, UA) and Google Charts (Google LLC, Menlo Park, CA, US) are utilized for the map and graph views, respectively. Geographic representation was aided by a public API acquired from the Environmental Systems Research Institute (ESRI) (ESRI, Redlands, CA, USA). The HHR Platform is hosted publicly and free-of-cost on the CFMS website [26].

The *HHR Platform* coalesces data from the following Canadian agencies: Canadian Institute for Health Information (CIHI), Canadian Medical Association (CMA), Canadian Post-MD Education Registry (CAPER), Canadian Resident Matching Service (CaRMS), Ontario Medical Students' Association (OMSA), and ESRI. Appropriate permissions and data-sharing contracts were obtained prior to construction of the platform. The unique datasets obtained from these agencies are categorized in Table 1. The delimiters included in the *HHR Platform* are categorized in Table 2. Aside from Ontario, program directors of all Canadian residency programs were identified via the CaRMS and Royal College websites and contacted via a standardized email template for their feedback regarding physician needs pertaining to their specialty and region of practice. Program director responses from Ontario in 2019 had already been collected by OMSA, and were accordingly shared with the CFMS. Consent was obtained to share their de-identified responses publicly. Members of the HHR Task Force—comprising nine medical students from across Canada—also performed a standardized search on the public domain for specialty-specific resources, which were amalgamated and included as part of the *HHR Platform*. Google analytics was integrated to demonstrate the utilization of the HHR platform in the first four months following the day of its official launch.

Table 1
Data points obtained from CIHI, CMA, CAPER, CaRMS, OMSA, and ESRI.

Agency	Data obtained
Canadian Institute for Health Information (CIHI)	Number of working physicians
	Physician to 100,000 population ratios
	Physicians by age groups
	Gross wage
	Number and rural and urban
	Number and male and percentage female
Canadian Medical Association (CMA)	Number of vacancies
	Number of working physicians
	Physicians by age group
	Number of male and female
Canadian Post-MD Education Registry (CAPER)	Number of residents exits per year
	Number of fellow exits per year
	Percentage of residents pursuing fellowship training
	Number of physicians working in province 2 years after having graduated in the same province
Canadian Resident Matching Service (CaRMS)	Number of CMG seats (school-specific)
	Number of CMG distinct applicants (Canadian region-specific)
	Number of CMG applicants who ranked discipline as first choice (Canadian region-specific)
Ontario Medical Students' Association (OMSA)	All Ontario program director comments
Environmental Systems Research Institute (ESRI)	Hospitals map layer 2016 population census map layer

Table 2
Datasets generated from CIHI, CMA, CAPER, CaRMS, OMSA, and ESRI.

Dataset	Class	Subclass
Specialties	*Non-surgical disciplines*	Anatomical pathology
		Anesthesiology
		Cardiology
		Clinical immunology and allergy
		Clinical pharmacology and toxicology
		Critical care medicine
		Dermatology
		Diagnostic radiology
		Emergency medicine
		Endocrinology and metabolism
		Family medicine - Care of the elderly
		Family medicine - Emergency
		Family medicine - General practice
		Family medicine - Palliative care
		Family medicine - Total
		Gastroenterology
		General internal medicine
		General pathology
		Geriatrics
		Hematology
		Infectious diseases
		Medical genetics
		Medical microbiology
		Medical oncology
		Nephrology
		Neuropathology
		Nuclear medicine
		Pain medicine
		Palliative medicine
		Pediatrics - Adolescent medicine
		Pediatrics - Clinical immunology and allergy
		Pediatrics - Developmental
		Pediatrics - Emergency medicine
		Pediatrics - Endocrinology and metabolism
		Pediatrics - Gastroenterology
		Pediatrics - General
		Pediatrics - Hematology-oncology
		Pediatrics - Infectious diseases
		Pediatrics - Neonatal-perinatal medicine
		Pediatrics - Nephrology
		Pediatrics - Neurology

Dataset	Class	Subclass
		Pediatrics - Respirology
		Physical medicine and rehabilitation
		Psychiatry
		Public health and preventive medicine
		Radiation oncology
		Rheumatology
	Surgical disciplines	Cardiac and thoracic surgery
		Neurosurgery
		Nuclear medicine
		Obstetrics and gynecology
		Ophthalmology
		Orthopedic surgery
		Otolaryngology - Head and neck surgery
		Plastic surgery
		Urology
		Vascular surgery
Jurisdictions	**Provinces and territories**	**Health regions**
	Newfoundland and Labrador	Eastern Health
		Central Health
		Western Health
		Labrador–Grenfell Health
	Prince Edward Island	Health PEI
	Nova Scotia	Western Zone
		Northern Zone
		Eastern Zone
		Central Zone
	New Brunswick	Zone 1 (Moncton Area)
		Zone 2 (Saint John Area)
		Zone 3 (Fredericton Area)
		Zone 4 (Edmundston Area)
		Zone 5 (Campbellton Area)
		Zone 6 (Bathurst Area)
		Zone 7 (Miramichi Zone)
	Québec	Bas-Saint-Laurent Region
		Saguenay–Lac-Saint-Jean Region
		Capitale-Nationale Region
		Mauricie et Centre-du-Québec Region
		Estrie Region
		Montréal Region
		Outaouais Region
		Abitibi-Témiscamingue Region
		Côte-Nord Region

Dataset	Class	Subclass
		Nord-du-Québec Region
		Gaspésie–Îles-de-la-Madeleine Region
		Chaudière-Appalaches Region
		Laval Region
		Lanaudière Region
		Montérégie Region
		Nunavik Region
		Terre-Cries-de-la-Baie-James Region
	Ontario	Erie St. Clair LHIN
		South West LHIN
		Waterloo Wellington LHIN
		Hamilton Niagara Haldimand Brant LHIN
		Central West LHIN
		Mississauga Halton LHIN
		Toronto Central LHIN
		Central LHIN
		Central East LHIN
		South East LHIN
		Champlain LHIN
		North Simcoe Muskoka LHIN
		North East LHIN
		North West LHIN
	Manitoba	Winnipeg Regional Health Authority
		Prairie Mountain Health
		Interlake–Eastern Regional Health Authority
		Northern Health Region
		Southern Health — Santé Sud
		Saskatchewan
		Sun Country Health Region
		Five Hills Health Region
		Cypress Health Region
		Regina Qu'Appelle Health Region
		Sunrise Health Region
		Saskatoon Health Region
		Heartland Health Region
		Kelsey Trail Health Region
		Prince Albert Parkland Health Region
		Prairie North Health Region
		Mamawetan Churchill River Health Region
		Keewatin Yatthé Health Region
		Athabasca Health Authority
	Alberta	South Zone

Dataset	Class	Subclass
		Calgary Zone
		Central Zone
		Edmonton Zone
		North Zone
	British Columbia	East Kootenay HSDA
		Kootenay–Boundary HSDA
		Okanagan HSDA
		Thompson/Cariboo HSDA
		Fraser East HSDA
		Fraser North HSDA
		Fraser South HSDA
		Richmond HSDA
		Vancouver HSDA
		North Shore/Coast Garibaldi HSDA
		South Vancouver Island HSDA
		Central Vancouver Island HSDA
		North Vancouver Island HSDA
		Northwest HSDA
		Northern Interior HSDA
		Northeast HSDA
	Yukon Territory	Yukon Territory
	Northwest Territory	Northwest Territory
	Nunavut	Nunavut
Data sets	*Gender demographics*	Number of physicians
		Number male
		Number female
		Number sex unknown
		Percentage female
		Percentage male
	Age demographics	Average age
		Median age
		Age group: younger than 30
		Age group: 30–39
		Age group: 40–49
		Age group: 50–59
		Age group: 60–64
		Age group: 65–69
		Age group: 70–74
		Age group: 75–79
		Age group: 80 and older
		Age group: Unknown
	Location distribution	Number in rural areas

Dataset	Class	Subclass
		Number in urban areas
		Number unknown urban or rural
		Percentage rural
		Percentage urban
	Training metrics	Number of CMG seats
		Number of CMG applicants
		Number of CMG applicants who ranked specialty as first choice
		Number of 2 year post graduates working in same province
		Number of resident exits per year
		Number of fellow exits per year
		Percentage of residents pursuing fellowship training
		Ratio of number of CMG applicants who ranked specialty as first choice to number of CMG seats
	Employment metrics	Number of vacancies
		Number of graduates from province 2 years ago
		Ratio of number of graduates from province 2 years ago to number of 2 year post graduates working in same province
		Ratio of number of vacancies to number of physicians
		5 year projected need
		10 year projected need
		Physician-to-100,000 population ratio
		Gross wage
	Additional resources	Program director responses
		Specialty resources
		Provincial resources

Sustainability was a key consideration in determining the backend database architecture. Thus, we prioritized construction of the database to be flexible such that new datasets may be added on an annual basis and that complex datasets may be promptly queried. Data presented in the platform was unmanipulated with one exception: data were averaged if the same metric was provided by multiple separate sources; averaged data were indicated by parentheses next to the values to indicate the number of sources contributing to the presented data. The range of the data is available in the graph view. Additionally, per CMA privacy policy, cells with fewer than five data points were suppressed. Specialties on the *HHR Platform* are defined per CIHI's catalogue. Specialities represented in the platform are shown in Table 2. Jurisdictions are computed on the basis of provincial boundaries and further subclassified by regional health authorities. Further information regarding data construction and considerations may be found in the *HHR Platform* user guide, which supplements the web tool [27].

Results

The *HHR Platform* includes information and resources for 62 specialties with over 500,000 unique numerical data points obtained from 37 datasets. Data summarized in the *HHR Platform* is from 2015 onwards, with succeeding data added on an annual basis. There were 96 program director comments in 2019, representing 24.6% of the total individuals contacted. In the first four months (September 20, 2020, to January 20, 2021) of the *HHR Platform* being hosted publicly on the CFMS website, there were an average of 20.2 users per day with a total of 2463 different users, of whom 998 returned to the platform. The average time spent on the platform was 3 minutes and 4 seconds. The HHR Platform was designed to present data in a customized fashion, whereby users select their preferred view between a map, table, or graph view. Each view utilises the same database but provides a unique purpose based on user needs.

Table View

Table view allows for comparative visualization of granular data (Fig. 1). "Step 1" allows the user to select their preferred view. In "Step 2," the user selects the year for which wish to access data. "Step 3" allows the user to decide whether they wish to compare multiple specialties across one jurisdiction ('compare specialty'), or multiple jurisdictions for one specialty ('compare jurisdiction'). In "Step 4" and "Step 5," the user selects their jurisdiction(s) and specialty(ies) of interest, respectively. "Step 6" allows the user to choose between the various available datasets.

Graph View

Graph view allows for visualization of trends (Fig. 2). This view uses the same steps as above for the table view. A single dataset is chosen over a selected range of time. Hovering over the error bars demonstrate the range of the data coming from the different sources.

Map View

Map view allows for interactive visualization of data across health regions (Fig. 3). The user can compare one specialty across the country for a maximum of five datasets at a time, and the map will refresh as the user interacts with the different zoom levels and geographical locations within the map. Layers can also be superimposed, for example, Canadian hospitals and population density as shown in **Fig. 3**.

Useful Resources Tabs

Below the data window are four tabs with additional information that are specific depending on the information queried (Fig. 4). The first tab displays available program director responses specific to the selected year, specialty, and jurisdiction. The second tab displays available specialty resources specific to the selected specialty. The third tab displays available provincial resources. The fourth tab displays data sources and other useful information, such as tools that may provide support in interpreting the data or other helpful resources for medical trainees.

Discussion

The *HHR Platform* is a first-of-its-kind comprehensive career planning resource for medical students in Canada. It is a national, interactive, web-based tool that uses a map, comparison table, and trends graph to illustrate the most relevant public data on current and projected physician workforces across Canada. The goal is to facilitate medical student specialty choice to be based on both personal interest and population healthcare needs. Over time, these decisions comprise a component of national PRP strategy to help correct the physician supply-demand mismatch across Canada.

In Canada, current national PRP strategies aimed at the medical training process focus on two checkpoints: admissions into medical school and admissions into a residency program—representing top-down approaches. Both checkpoints will be discussed regarding most recent PRP initiatives which have paved the course for the *HHR Platform* as a contemporary, bottom-up PRP strategy targeting undergraduate medical trainees in Canada.

PRP via admissions into medical school

In Canada, medical school admissions represent the number of physicians who will be eligible to practice medicine within the next decade—barring minor exceptions such as visa trainees, immigration or emigration of graduated students, and attrition from medical training. Increasing the total number of medical school positions results in a greater supply of physicians. The decision to add or remove these positions is a result of complex processes between the provincial Ministry of Health and their health authorities, the faculties of medicine, and the respective provincial and territorial medical association [28].

Historically, the medical school admissions process has affected the physician workforce composition in two ways. First, individuals originally from a rural region are more likely to stay and practice medicine in a rural region [29–31]. Following this concept, the Northern Ontario School of Medicine (NOSM) was established to train students from Northern Ontario to respond to the region's need for physicians in rural, Francophone, and Indigenous communities [32]. The school was established in 2005, and consistently above 90% of each incoming class are individuals from Northern Ontario [33]. In 2020, the rate of medical students pursuing residency programs at NOSM and then practicing in Northern Ontario averaged 40% and 94%, respectively, with similar rates for the past ten years. Several other institutions have similar admissions pathways for individuals from underserved or rural communities [34].

Secondly, individuals who share similarities with a particular demographic tend to practice and stay in these communities [29]. Therefore, quotas reserved for applicants meeting certain characteristics, such as indigenous and/or lower socioeconomic status, have been applied in some Canadian medical faculties. Additionally, the admission selection process now includes coefficients accounting for diversity and/or criteria for Black and refugee applicants in some schools [35]. In 2017, seven schools had a set number of seats allocated for indigenous students, and now all 17 Canadian medical faculties ensure a minimum number of indigenous students are admitted [36]. At least six institutions have constructed admissions pathways to recruit historically underrepresented and/or culturally diverse individuals, with many more institutions formally dedicated to developing similar streams [37]. Improving access to high-school and undergraduate mentorship is also an essential component to many of these initiatives. There is presently a paucity of data for the admissions outcomes of such initiatives due to their recency [38]. However, the University of Toronto's Black Student Admission Program, which was launched in 2017, has shown promising early outcomes. In 2020, there were 20 Black medical students among a cohort of 259 learners—compared to one Black medical student in 2016—despite Black Canadians comprising 10% of Toronto's population [39]. The overarching goal of such initiatives is to restructure the composition of our physician workforce to better reflect and serve the Canadian population.

The checkpoint of admissions into medical school has an influence on PRP in regards to determining the anticipated number of physicians, as well as their distribution by utilising quotas and geographical location of training sites. There are currently no mechanisms in place at this level that have been shown to impact specialty choice. Canadian medical students, therefore, begin medical school with the possibility of pursuing a residency in any discipline offered as part of the CaRMS.

PRP via admissions to residency

The CaRMS is a service that aims to match medical students to Canadian residency training positions through a Nobel prize winning algorithm [40]. The service centralizes all available Canadian residency training positions into one portal. A small minority of programs have also instituted return-of-service agreements upon completion of training in exchange for a residency position [41]. Once a student is matched to a residency program via the CaRMS, they are

legally bound to that program. This helps to ensure an equitable and accountable system for residency program matching. Overall, the CaRMS represents residency admissions and affirms the importance of PRP as it pertains to the quota of residency positions and mix of specialties required by the Canadian population.

While PRP via residency and medical school admissions have helped to improve physician-based HHR in Canada, there remain critical gaps in this approach. The CaRMS match outcomes are a testament to the shortcomings of the current top-down PRP strategy. The most recent example is the significant rise in the number of unmatched Canadian medical graduates (CMG), reaching a peak of 169 in 2018 after both iterations of the match [16, 42]. Estimates place the tax-base investment at approximately $260,000 per medical graduate prior to entering residency, representing at least $43.9M of unrealized investment in 2018 alone [17]. This has led to important advocacy efforts in 2018 and action in the following year whereby the Nova Scotia Health Ministry added 25 new spots at Dalhousie University as well as $23 million invested over six years for new positions in Ontario [42, 43]. Concurrently, the number of unmatched CMGs has dropped to 98 in 2019 and 67 in 2020 [44]. Whether this is a direct result of the addition of these new positions has not been studied. Nonetheless, each unmatched CMG represents ineffective use of health human resources and subsequent loss of return-on-investment of Canadian taxpayers.

While the unmatched CMG phenomenon is multifactorial, a factual observation is that certain specialties are more competitive than others, as represented by the ratio of positions divided by applicants' first choice discipline, thus correlating with medical student interests. In the 2020 residency match, the most competitive specialty was ophthalmology with a ratio of 0.51, and the least competitive specialty was general pathology with a ratio of 4.5 [44]. Family medicine was the sixth least competitive specialty with a ratio of 1.65. Even now, two years after the unmatched CMG peak, the interests of medical students have remained largely similar to what they were five years ago [15]. Importantly, these competitive specialties are not necessarily those that correlate to the highest population demand, which currently comprise family medicine and geriatrics [9, 45].

One example of a bottom-up approach was the Québec Health Ministry's rearrangement of their available residency positions in 2018 to reflect 55% of seats reserved for family medicine, and 45% to all other specialties [46]. In that year alone, there were 65 vacant positions following both iterations of CaRMS Québec family medicine programs [47, 48]. In response, the Fédération Médicale Étudiante du Québec (FMEQ) promoted family medicine education under the pretense that disinterest in family medicine stems from the medical students' lack of knowledge about this specialty [49]. In the following year, there was a drop to 23 vacancies, combined with a greater interest in family medicine demonstrated by an increase from 373 to 440 matched applicants between 2018–2019 in the first iteration [47, 50]. The FMEQ approached PRP by targeting and educating medical students about the mix and demand of specialties, particularly with respect to the need for family physicians in the Québec population, with promising outcomes.

Altogether, it could be argued that the strategy to add residency positions after the unmatched CMG peak in 2018 imparted a positive impact on the numbers, but contributed little in terms of addressing the PRP challenges of specialty mix and distribution. Therefore, there is a need to reimagine new PRP strategies after the checkpoint of admission into medical school but prior to participating in the CaRMS match. The goal is to cultivate an interest among medical trainees to choose a specialty which aligns with the quota depicted by the CaRMS checkpoint for admissions to residency.

Role of HHR Platform

Despite efforts occurring at the admissions checkpoints surrounding medical school, which mostly represent top-down PRP approaches, strategies aimed at informing medical students' specialty choice remains a largely untapped area for effective and large-scale PRP at the national level. Differentiation of the physician body occurs during medical training, thus the decisions made by medical trainees regarding specialty choice have a substantial impact on their nation's health workforce composition. This in turn impacts physician attrition, resource allocation, system sustainability, and favours adequate access to care. The *HHR Platform* is a bottom-up approach towards improving transparency regarding population health needs and associated practice opportunities to guide medical student specialty choice to be concordant with population health needs.

For example, a medical student user of the *HHR Platform* who is interested in job prospects for diagnostic radiology in Nova Scotia may notice the decreasing trend for number of physicians and number of job vacancies with higher saturation in the central health region of Nova Scotia. Knowing this type of information for multiple specialties of interest is important in making an informed decision on specialty choice that meets personal needs and those of the population.

The CFMS has approximately 8,300 active medical student members across Canada. With over 2,400 different users in the first four months of the *HHR Platform* launch, and over 20 daily users on average, there is significant outreach and interest shown by aspiring physicians. The *HHR Platform* has been designed to become increasingly comprehensive over time, therefore functioning as a reliable and up-to-date Canadian resource for career planning among medical trainees. Future directions include incorporating subspecialty data, additional information about workforce composition and demographics, predictive modelling of physician supply-demand dynamics, and inclusion of allied health professionals into the *HHR Platform*. Future analyses may be performed to explore how the *HHR Platform* and population-needs data specifically inform medical student specialty decision-making. The *HHR Platform* is currently equipped for and awaiting datasets for the projected demand of specialties in 5 or 10 years. This is likely the most anticipated and relevant dataset to inform medical students of societal needs prior to choosing a specialty, and continued advocacy for its public availability is warranted [51].

Limitations

The data amalgamated in the *HHR Platform* is limited by the inclusion and exclusion criteria of the original datasets, which does not allow for exact comparability. For example, the collection of the datasets are undertaken at different points in time depending on the organization, while in the *HHR Platform*, they are grouped per annum. Furthermore, the datasets that are available nationally are a result of provincial data collection and sharing, which is not standardized between provinces, and is inconsistent across the various population demographics within Canada [52]. However, the primary limitation remains that the *HHR Platform* depends on continued public release and sharing of data by the collaborating organizations in a format that is compatible with their previous releases.

Conclusion

There is mounting evidence that Canadian medical students have limited information and data on the determinants of PRP, thereby lacking the tools to inform their specialty decision to be socially accountable based on population needs [53–55]. The purpose of the *HHR Platform* is to provide a bottom-up approach to PRP which informs undergraduate medical trainees on the number, mix, and distribution of physicians to meet population health needs of Canadians. Modernising health data delivery by depicting the workforce needs of the population to medical students prior to making their specialty choice may function to improve the utilisation of current human resources, thus alleviating the impending shortage of health workers. Given the worldwide physician shortage, such a platform may be modelled in other countries as well with the goal of optimizing their physician workforce composition to better align with the needs of their population.

Abbreviations

Abbreviation	Meaning
HHR	Health Human Resource
PRP	Physician Resource Planning
CFMS	Canadian Federation of Medical Students
CSV	Comma Separated Value
API	Application Programming Interface
ESRI	Environmental Systems Research Institute
CIHI	Canadian Institute for Health Information
CMA	Canadian Medical Association
CAPER	Canadian Post-MD Education Registry
CaRMS	Canadian Resident Matching Service
OMSA	Ontario Medical Students Association
NOSM	Northern Ontario School of Medicine
CMG	Canadian Medical Graduates
FMEQ	Fédération Médicale Étudiante du Québec

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

The data generated or mentioned in study are included on the *HHRplatform* publicly available at https://www.cfms.org/resources/health-human-resources-platform/. As of March 5th 2021, the datasets were available in the CIHI [56], CAPER [57], CaRMS [58] and CMA [59] registries. The platform as a service with all data removed, is available in the supplementary file. For the datasets regarding website activity, they are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

DB, BC, and ST contributed in the conception and design of the *HHR Platform*, contributed to the results interpretation, and were major contributors in writing the manuscript. MB and AS contributed to the design of the *HHR Platform*, data collection and results interpretation. SM and AD contributed to the design of the *HHR Platform* and data collection. MB contributed to the literature review, data collection, results interpretation, and writing the manuscript. HM and GP contributed to the literature review and results interpretation. All authors read and approved the final manuscript.

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Availability and requirements

Project name: CFMS Health Human Resources Platform

Project home page: https://www.cfms.org/; https://www.cfms.org/resources/; https://www.cfms.org/resources/health-human-resources-platform/

Operating system(s): Platform independent

Programming language: MySQL (C and C++), React and Material UI (JavaScript)

Other requirements: No other requirements

License: N/A

Any restrictions to use by non-academics: No restrictions

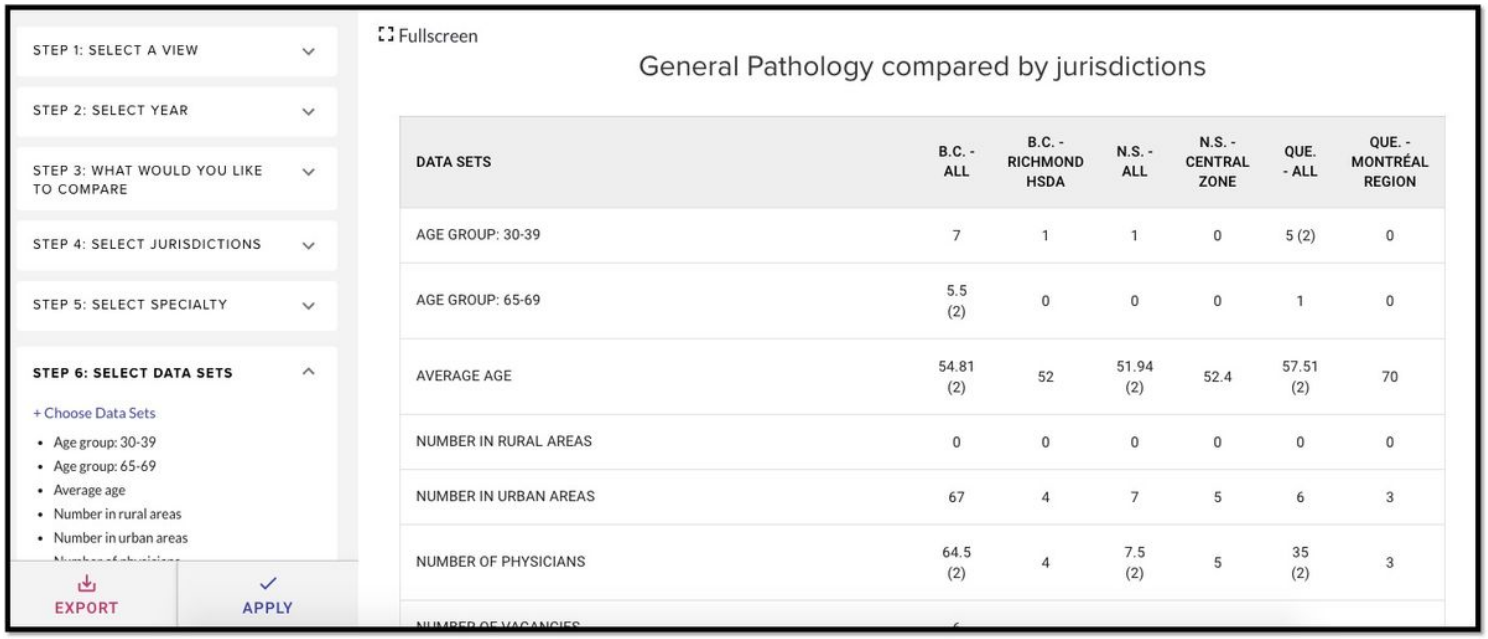
References

1. Bloor K, Maynard A. Planning human resources in health care: towards an economic approach. Can Heal Serv Res Found. 2003. https://www.hrhresourcecenter.org/node/274.html. Accessed 14 Jan 2021.
2. Birch S. Health human resource planning for the new millennium: inputs in the production of health, illness, and recovery in populations. Can J Nurs Res. 2001;33:109–14.
3. Roberfroid D, Stordeur S, Camberlin C, Voorde C, Van De, Vrijens F, Leonard C. Physician workforce supply in Belgium: current situation and challenges. Heal Serv Res. 2008;150.
4. Stokker J, Hallam G. The right person, in the right job, with the right skills, at the right time: A workforce-planning model that goes beyond metrics. Libr Manag. 2009;30:561–71.
5. Statistics Canada. Health Fact Sheets - Primary health care providers, 2017. Stat. Canada, Cat. no.82-625-X. 2019. https://www150.statcan.gc.ca/n1/en/pub/82-625-x/2019001/article/00001-eng.pdf?st=h7UdG51j. Accessed Dec 20 2020.
6. Canadian Institute of Health Information. Summary report: Physicians in Canada 2019. 2019. https://www.cihi.ca/sites/default/files/document/physicians-in-canada-2018.pdf. Accessed 18 Dec 2020.
7. Statistics Canada. Access to a regular family physician. 2014. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310048401. Accessed 5 Dec 2020.
8. Smith ER. Health care human resources. Can J Cardiol. 2007;23:235–6.
9. Malko A, Huckfeldt V. Physician Shortage in Canada: A Review of Contributing Factors. Glob J Health Sci. 2017;9:68.
10. The Association of Faculties of Medicine of Canada. A collective vision for postgraduate medical education in Canada. 2012. https://afmc.ca/sites/default/files/pdf/2012-FMEC-MD_EN.pdf. Accessed Dec 2 2020.
11. Da Silva RB, Pineault R. Impact of physician distribution policies on primary care practices in rural Quebec. Can J Rural Med. 2012;17:92–8.
12. Freund T, Everett C, Griffiths P, Hudon C, Naccarella L, Laurant M. Skill mix, roles and remuneration in the primary care workforce: Who are the healthcare professionals in the primary care teams across the world? Int. J. Nurs. Stud. 2015;727–43.
13. Landry M, Schofield A, Bordage R, Bélanger M. Improving the recruitment and retention of doctors by training medical students locally. Med Educ. 2011;45:1121–9.
14. Scott IM, Wright BJ, Brenneis FR, Gowans MC. Whether or wither some specialties: A survey of Canadian medical student career interest. BMC Med Educ. 2009;9.
15. Canadian Residency Matching Service. R-1 match interactive data - CaRMS. 2017. https://www.carms.ca/data-reports/r1-data-reports/r-1-match-interactive-data/. Accessed 16 Jan 2021.
16. Frechette D, Shrichand A, Manogaran M. Employment patterns of Canada's newly certified medical specialists: findings from the Royal College Employment Study. Ottawa R Coll Physicians Surg Canada. 2019. https://www.royalcollege.ca/rcsite/health-policy/employment-study-e. Accessed 14 Dec 2020.
17. Official Languages Community Development Bureau. Overview of the Cost of Training Health Professionals. 2008. http://publications.gc.ca/collections/collection_2009/sc-hc/H29-1-2009E.pdf. Accessed 12 Jan 2021.

18. Adams O, Chauhan TS, Buske L. Assessing the prospects for physician supply and demand in Canada: Wishing it was rocket science. Healthc Manag Forum. 2017;30:181–6.
19. Freeman TR, Petterson S, Finnegan S, Bazemore A. Shifting tides in the emigration patterns of Canadian physicians to the United States: A cross-sectional secondary data analysis. BMC Health Serv Res. BioMed Central Ltd.; 2016;16.
20. Canadian Medical Association. Virtual care in Canada: discussion paper. C Heal Summit. 2019. https://www.cma.ca/sites/default/files/pdf/News/Virtual_Care_discussionpaper_v2EN.pdf. Accessed 13 Nov 2020.
21. Britnell M. Human: solving the global workforce crisis in healthcare. Oxford University Press; 2019.
22. Anyangwe SCE, Mtonga C. Inequities in the global health workforce: The greatest impediment to health in Sub-Saharan Africa. Int J Environ Res Public Health. 2007;93–100.
23. Kirch DG, Henderson MK, Dill MJ. Physician workforce projections in an era of health care reform. Annu Rev Med. 2012;435–45.
24. Starfield B, Shi L, Grover A, Macinko J. The effects of specialist supply on populations' health: assessing the evidence. Health Aff. 2005;Suppl Web.
25. Phillips RL, Petterson S, Fryer GE, Rosser W. The Canadian contribution to the US physician workforce. CMAJ. 2007;176:1083–7.
26. Canadian Federation of Medical Students. Health Human Resource Platform. 2020. https://www.cfms.org/resources/health-human-resources-platform/. Accessed Jan 30 2021.
27. Bourcier D, Collins B, Tanya S, Basu M, Sayal A, Moolla S, et al. CFMS Health Human Resources Platform - User Guide -. 2020. https://www.cfms.org/uploads/hhrtf/User_Guide_CFMS_HHR_Platform.pdf. Accessed 26 Jan 2021.
28. Ruth Wilson C, Bordman ZN. What to do about the Canadian Resident Matching Service. CMAJ. Canadian Medical Association; 2017. pp. E1436–7.
29. Grobler L, Marais BJ, Mabunda S. Interventions for increasing the proportion of health professionals practising in rural and other underserved areas. Cochrane Database Syst. 2015. https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD005314.pub3/full. Accessed 15 Feb 2021.
30. McGrail MR, O'Sullivan BG, Russell DJ. Rural training pathways: The return rate of doctors to work in the same region as their basic medical training. Hum Resour Health. 2018;16:56.
31. Dolea C, Stormont L, Braichet JM. Evaluated strategies to increase attraction and retention of health workers in remote and rural areas. Bull World Health Organ. 2010;88:379–85.
32. Strasser RP, Lanphear JH, McCready WG, Topps MH, Hunt DD, Matte MC. Canada's new medical school: The northern Ontario school of medicine: Social accountability through distributed community engaged learning. Acad. Med. 2009;1459–64. https://pubmed.ncbi.nlm.nih.gov/19881443/.
33. Northern Ontario School of Medicine. NOSM Facts. 2020. https://www.nosm.ca/about/about-nosm/nosm-facts/. Accessed 17 Jan 2021.
34. ACCESS Pathway Applicants - Schulich Medicine & Dentistry Admissions. - Western University. https://www.schulich.uwo.ca/med_dent_admissions/medicine/access_pathway_applicants.html. Accessed 21 Jan 2021.
35. Association of Faculties of Medicine of Canada. Admission requirements in 2021. 2021. https://afmc.ca/sites/default/files/pdf/2021_admission-requirements_EN.pdf. Accessed on 20 Feb 2021.
36. Vogel L. Medical schools to boost numbers of Indigenous students, faculty. Can Med Assoc J. 2019;191:E621.
37. Mercer C. Medical school reserves seats for low-income students to increase diversity [Internet]. CMAJ. NLM (Medline); 2018 [cited 2021 Jan 17]. p. E1314–5. Available from: https://www.cmaj.ca/content/190/44/E1314.
38. Mian O, Hogenbirk JC, Marsh DC, Prowse O, Cain M, Warry W. Tracking Indigenous Applicants Through the Admissions Process of a Socially Accountable Medical School. Acad Med. NLM (Medline); 2019;94:1211–9. http://journals.lww.com/10.1097/ACM.0000000000002636. Accessed 12 Jan 2021.
39. Adams S, Saddler N. Increasing Diversity in Medicine: The 'BSAP'Approach at the University of Toronto. 2020. https://first10em.com/increasing-diversity-in-medicine/. Accessed 23 Jan 2021.
40. The Canadian Resident Matching Service. How does the Match Algorithm work? 2019. Available from: https://www.carms.ca/the-match/how-it-works/. Accessed 17 Jan 2021.
41. Ministry of Health Parliement of BC. Ministry of Health Return of Service Program Policy Health Human Resources and Labour Relations Division. 2019. https://www2.gov.bc.ca/assets/gov/health/practitioner-pro/ros-policy-2020.pdf. Accessed 30 Dec 2019.
42. Lakoff J, Cofie N, Dalgarno N, Howse K, Heeneman S. Analysis of factors affecting Canadian medical students' success in the residency match. Can Med Educ J. 2020;11:43–55.
43. Hansard. Nova Scotia House of Assembly Standing Committee on Health. 2019. https://nslegislature.ca/legislative-business/committees/standing/health/archive/health/he2019aug13. Accessed 5 Jan 2021.
44. The Canadian Resident Matching Service. 2020 CaRMS Forum. 2020. https://www.carms.ca/pdfs/2020-carms-forum.pdf. Accessed Jan 13 2021.
45. Rochon P, Stall N. Supply versus demand: Extending the reach of geriatric medicine to match the needs of our aging population. Hosp News. https://hospitalnews.com/supply-versus-demand-extending-the-reach-of-geriatric-medicine-to-match-the-needs-of-our-aging-population/. Accessed 21 Jan 2021.
46. Collège des médecins du Québec. Une année de changements 2018/2019 Rapport annuel. 2019. http://www.cmq.org/pdf/aga-2019/rapp-annuel-2018-2019-def.pdf. Accessed 20 Jan 2019.
47. Canadian Residency Matching Service. List of unfilled positions by university List of unfilled positions after the second iteration of the 2019 R-1 Main Residency Match - by discipline. 2019. https://www.carms.ca/pdfs/3asv86WkbpG_R1_2_OverviewByDiscipline_EN.pdf. Accessed 30 Dec 2020.
48. Croteau M. Quebec wants more family medicine students. Press. 2019. https://www.lapresse.ca/actualites/sante/2019-06-07/quebec-veut-plus-d-etudiants-en-medecine-de-famille. Accessed 17 Jan 2021.

49. Archambault M, Beaura S, Bourque M-L, Cloutier E, Groulx M, Levasseur-Fortin P, et al. La médecine de famille au coeur de la première ligne. Fédération Médicale Étudiante du Québec. 2019. https://fmeq.ca/wp-content/uploads/2020/11/Memoire-Valorisation-Medecine-Familiale.pdf. Accessed 3 Jan 2021.
50. Canadian Residency Matching Service. List of unfilled positions after the first iteration of the 2020 R-1 Main Residency Match - by university. 2020. https://www.carms.ca/pdfs/5ruh39TJkpN_R1_1_OverviewByDiscipline_EN.pdf. Accessed 29 Dec 2020.
51. The Royal College of Physicians and Surgeons of Canada. Royal College - National Specialty Societies Understanding, Agreement and Alignment. 2016. https://www.royalcollege.ca/rcsite/documents/health-policy/2016-human-resources-for-health-dialogue-metting-report-e.pdf. Accessed 10 Jan 2021.
52. Bourgeault I, Simkin S, ChamberlandRowe C. Poor health workforce planning is costly, risky and inequitable. Cmaj. 2019;191:E1147–8.
53. Busing N, Harris K, Maclellan AM, Moineau G, Oandasan I, Rourke J, et al. The future of postgraduate medical education in Canada. Acad Med. 2015;90:1258–63.
54. Bourcier D, Collins B, Tanya S, Wade R, Jarrar A, Holland P, et al. Outlook on the Atlantic Physician Workforce. 2018. https://www.researchgate.net/publication/340265283_Outlook_on_the_Atlantic_Physician_Workforce. Accessed 10 Dec 2020.
55. Khalik HA, Manzoor F, Yan A, Ndoja S. Increasing medical student involvement in ontario's health human resources planning. 2019. https://omsa.ca/sites/default/files/policy_or_position_paper/96/position_paper_increasing_student_involvement_in_ontario_hhr_planning_2019_apr.pdf. Accessed 2 Jan 2021.
56. Canadian Institute of Health Information. Physician in Canada. 2020. https://www.cihi.ca/en/physicians-in-canada. Accessed September 28, 2020.
57. Canadian Post -MD Education Registry. Annual Census. 2020. https://caper.ca/postgraduate-medical-education/annual-census. Accessed September 29, 2020.
58. Canadian Resident Matching Service. R1 Data and Reports. 2020. https://www.carms.ca/data-reports/r1-data-reports/. Accessed September 29, 2020.
59. Canadian Medical Association. Canadian Physician Data. 2020. https://www.cma.ca/canadian-physician-data. Accessed September 29, 2020.

Figures



DATA SETS	B.C. - ALL	B.C. - RICHMOND HSDA	N.S. - ALL	N.S. - CENTRAL ZONE	QUE. - ALL	QUE. - MONTRÉAL REGION
AGE GROUP: 30-39	7	1	1	0	5 (2)	0
AGE GROUP: 65-69	5.5 (2)	0	0	0	1	0
AVERAGE AGE	54.81 (2)	52	51.94 (2)	52.4	57.51 (2)	70
NUMBER IN RURAL AREAS	0	0	0	0	0	0
NUMBER IN URBAN AREAS	67	4	7	5	6	3
NUMBER OF PHYSICIANS	64.5 (2)	4	7.5 (2)	5	35 (2)	3

Figure 1

Table view from the HHR Platform showing general pathology compared between selected jurisdictions. The authors have the rights to the images depicted in this figure.

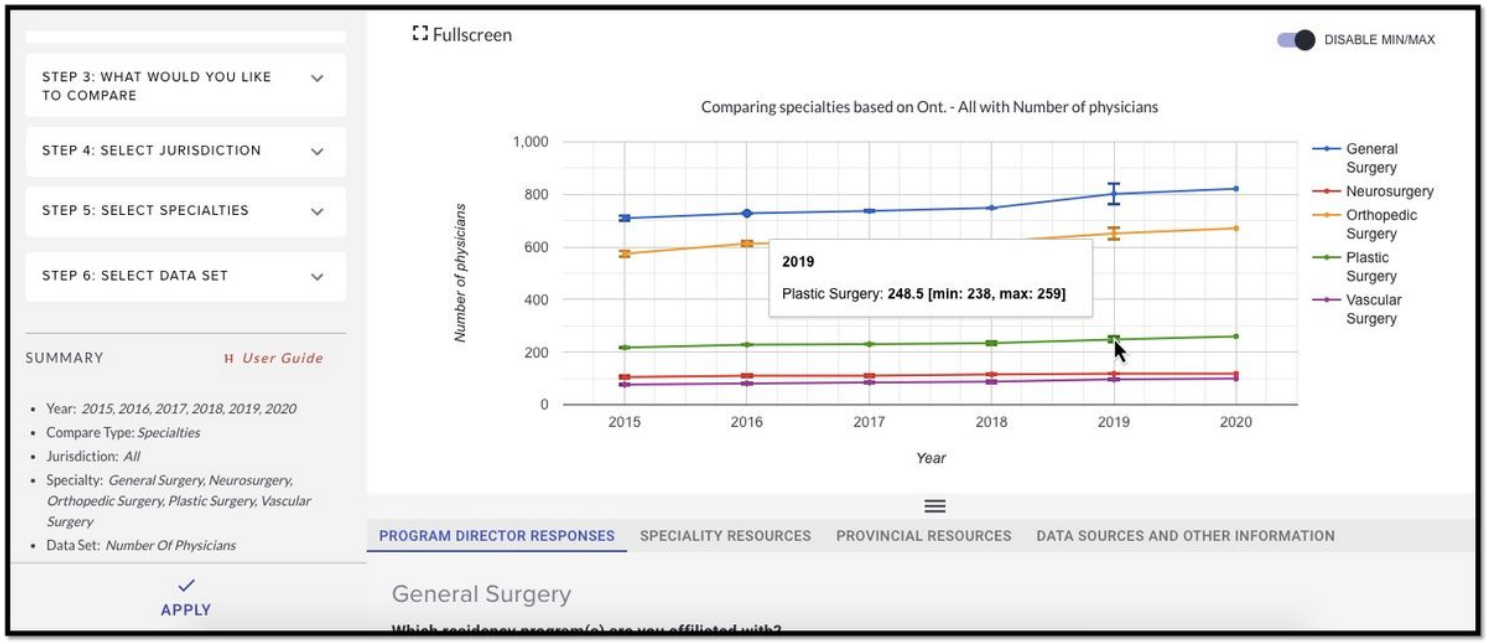


Figure 2

Graph view from HHR Platform showing number of physicians for various surgical specialties. The authors have the rights to the images depicted in this figure.

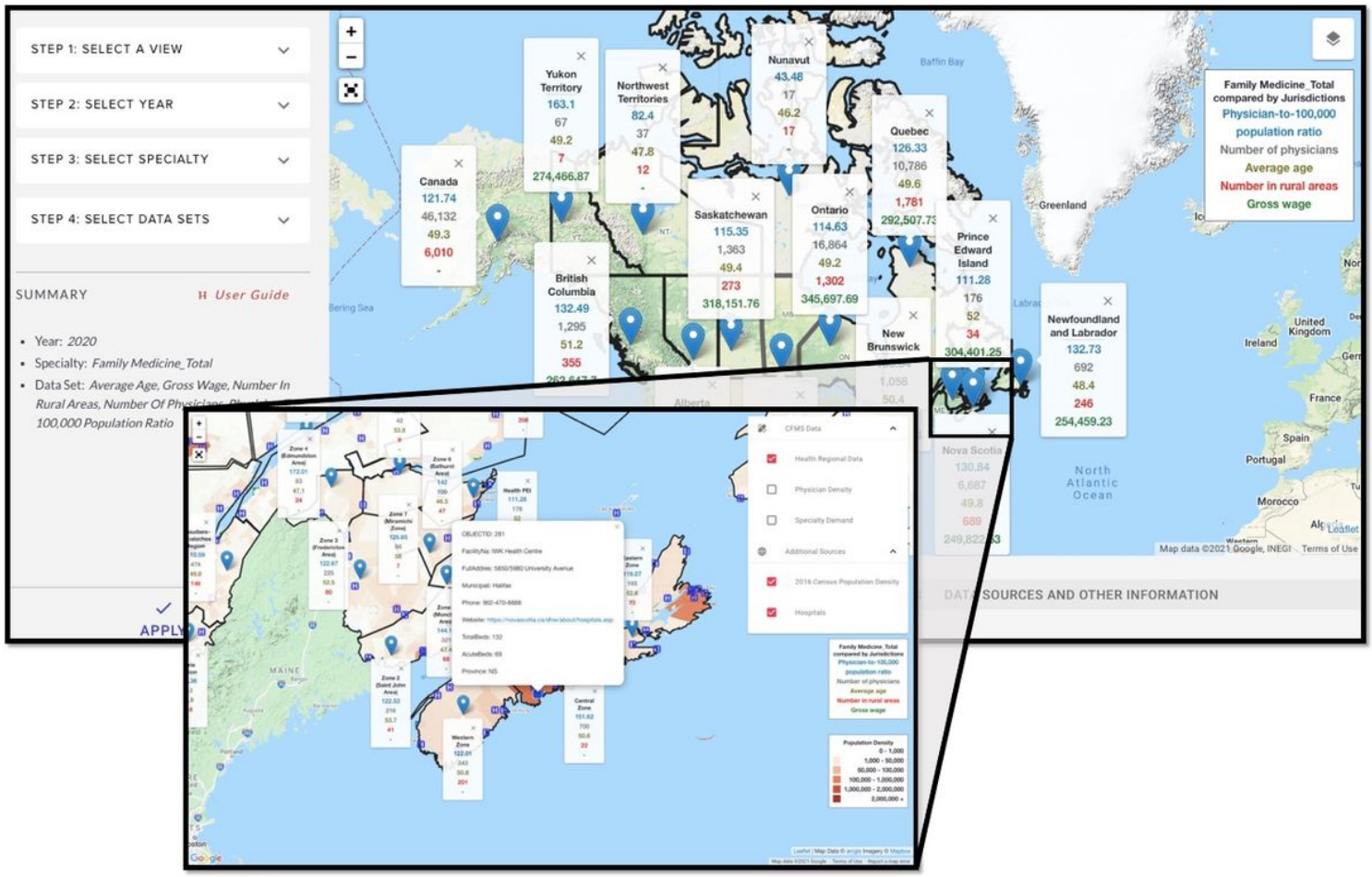


Figure 3

Map view from the HHR Platform, with a magnified view showing layers for family medicine. The authors have the rights to the images depicted in this figure. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of

Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

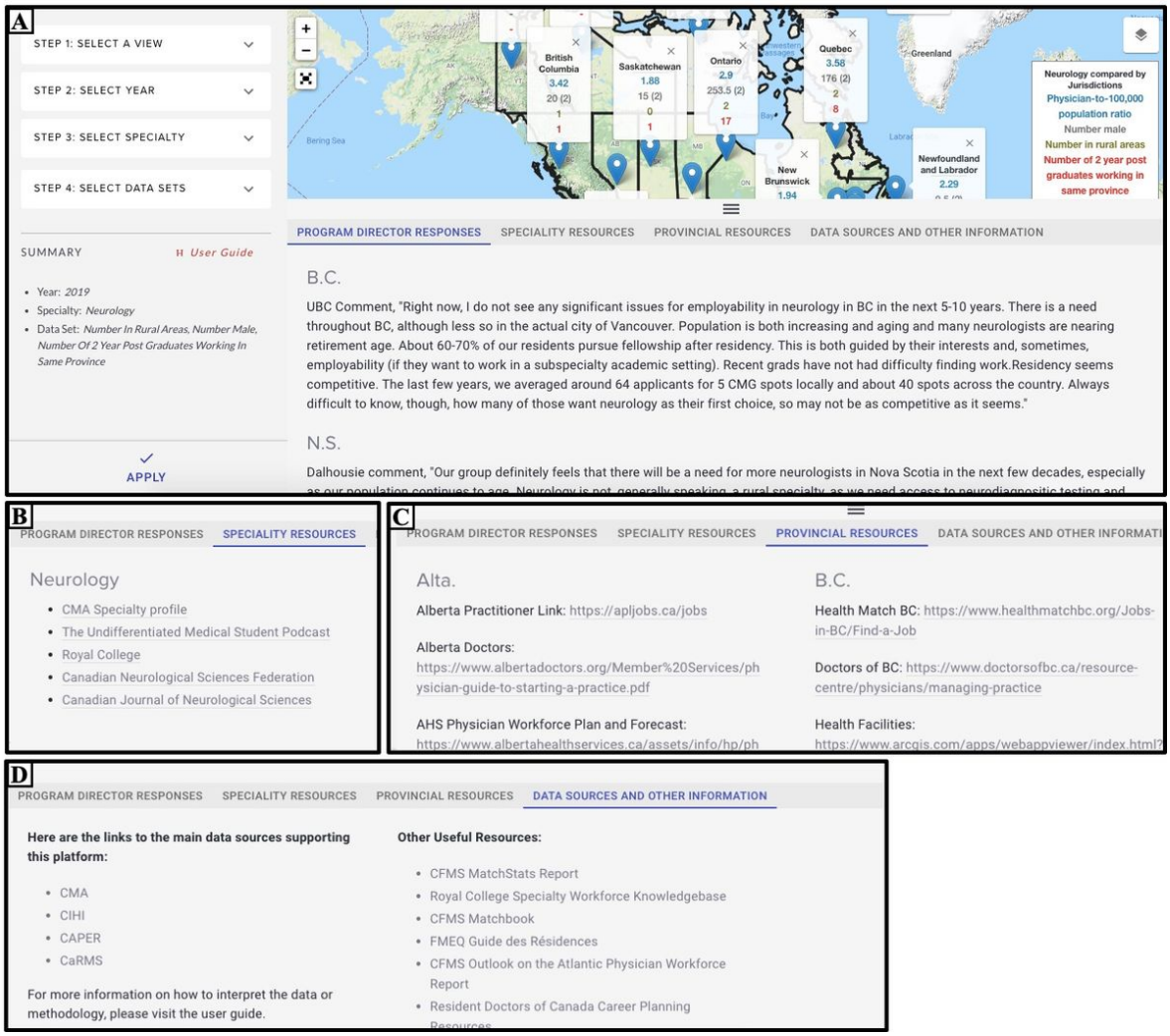


Figure 4

Useful resources of HHR Platform. The authors have the rights to the images depicted in this figure. Legend: Program director responses (A), specialty resources (B), provincial resources (C), and data sources and other information (D) for neurology in 2019. The authors have the rights to the images depicted in this figure. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.