

Space Medicine Training in Canada

Adam Sirek; Kathleen Samoil; Michael F. Harrison

INTRODUCTION: Aerospace medicine training is often difficult to obtain outside of military education streams. Undergraduate medical trainees and residents may undertake training opportunities, but often have trouble locating programs and/or receiving credit for their experiences and learning. In many countries, no formal aerospace medicine training program or pathway exists and trainees must search out opportunities on their own. Canada is used as an example of a country which, until recently, had no defined civilian aerospace medicine training program or credentialing pathway. Recent development of a Diploma in Aerospace Medicine certified by the Royal College of Physicians and Surgeons now outlines a series of competencies for trainees and medical professionals seeking advancement in aerospace medicine. Growth of the aviation and aerospace fields will require more training opportunities and more aerospace medicine professionals to support the increased number of aviators and the spacefaring population. This will be particularly important as commercial space companies develop the potential for civilian spaceflight. While few opportunities exist for training, we highlight the major aerospace medicine training opportunities that have been recently available to Canadians. It is our hope that highlighting previous and current opportunities may aid in the development of a formal training program leading to certification in aerospace medicine for Canadians and act as an example for other nations.

KEYWORDS: medical education, aerospace medicine, Canada, training, education.

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Since the creation of the “flight surgeon” in 1918 by the United States, the small field of aerospace medicine has grown and developed. Outside of the United States, formal training programs are limited. Establishment of aerospace medicine as subspecialty of the American Board of Preventive Medicine in 1953 defined a set of requirements and competencies for American aerospace medicine professionals. Countries such as the United Kingdom have had aviation medicine training since 1945, but, like Canada, do not have a defined board specialty in the field.

Many countries have developed military training programs to prepare flight surgeons for aircrew and operations-specific management requiring specialized knowledge and novel approaches. The advancement of aerospace safety and human ability has long served as a platform for interdepartmental and international cooperation, even between hostile countries.¹⁶ Civilian training often remains sparse and limited to retired military, persons with a previous aviation history, or those with a special interest who pursue opportunities outside of normal curricular streams.

Canada has a proud history of aviation training, including the preparation and training of a large majority of pilots during World War II as part of the British Air Commonwealth Training Program. Canadian aviation history is rich in research and

technological advancements, including the Wright Flying Suit, which first allowed fighter pilots to extend their physiological tolerance to G forces. As the third country in space, Canada also has a rich history of expanding human and technological limits through development of technologies and preparation of astronauts for spaceflight.

The goal of this manuscript is to outline the available knowledge of civilian aerospace training opportunities for future aerospace medicine professionals with a focus on Canadians. Aerospace medicine professionals often enter the field from nontraditional pathways and, while exciting, it can be challenging to access new opportunities. With the development of the Diploma of the Royal College of Physicians and Surgeons of Canada (DRCPSC) in Aerospace Medicine, it is anticipated that

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these experiential requirements will likely define the direction of civilian aerospace medicine training in Canada.

Historical Canadian Aerospace Medicine Training Opportunities

In 1999, a joint civilian-military program was envisioned and launched through the University of Toronto.¹⁴ The initial class consisted of a military physician and a civilian physician from Saudi Arabia. The 2-yr program was designed to provide physicians with extensive operational experiences, environmental training, and a Master of Health in occupational and environmental medicine similar to the American aerospace medicine residency programs requiring completion of a Master of Public Health (MPH) degree.

Following a joint-agreement between the Canadian Space Agency (CSA) and NASA in 2000, the CSA previously selected and sent senior medical students or residents to attend 1-mo immersive educational opportunities at the Johnson Space Center Aerospace Medicine Clerkship, the Kennedy Space Center Aerospace Medicine Clerkship, or UTMB's Principles of Aerospace Medicine course. These medical trainees were exposed to advanced space medicine by interacting with current flight surgeons and thought leaders at the National Aeronautics and Space Administration (NASA) while more recently gaining exposure to commercial spaceflight operations and medical considerations. A research project was produced by each clerk and many of these projects led to award-winning publications for the clerk and the Canadian Space Agency. Foremost, the clerks were able to get hands-on, operational training experience in aerospace medicine and experience the breadth of space medicine. Many of these trainees continue to participate in aerospace medicine following their clerkship and a review of the finalists in the 2017 CSA astronaut recruitment demonstrates several alumni were considered.

Up to the closure of the program at Wright State University (WSU), physicians from various nationalities, including Canada,⁹ undertook advanced training in the field of aerospace medicine in pursuit of board certification in the United States. While rich in history,⁹ the closure of this program has reduced international formal training opportunities in Aerospace Medicine to be exclusively limited to one position annually at Mayo Clinic. Periodically, Canadians (often resident trainees) have highlighted the void and their interest in formal training within the field,^{3,4} though homegrown opportunities continue to be sparse.

Present Canadian Aerospace Medicine Training Opportunities

The primary route for Canadian medical trainees to obtaining aerospace medicine training and experience in Canada is currently enrolment and service in the Canadian Forces (CF). The CF have programs, often in conjunction with the Canadian Forces Environmental Medicine Establishment (CFEME) located at Defense Research and Development Canada (DRDC) Toronto to train medical officers in aerospace medicine. Selection of medical officers to a residency in aerospace medicine (RAM) with the U.S. Navy (USN) and U.S. Air Force (USAF) are also possible. Civilian physicians may have the opportunity

to participate in the CF Flight Surgeon course and obtain CME credit; however, opportunities are limited based upon the operational needs of the military.

Conversely, no formal Canadian civilian training opportunities exist. Learners who are passionate about aerospace medicine often find independent training opportunities. It is not unheard of to have individuals contact an aerospace medicine specialist and create "one-off" training opportunities. These may be in concert with large civilian organizations or the CF.

The major source of aerospace medicine training opportunities for Canadians is the United States, though opportunities are becoming increasingly limited.⁴ In the United States, the civilian opportunities have changed over the years from institutions such as Harvard and Stanford to, more recently, the University of Texas Medical Branch (UTMB) and Mayo Clinic. Among the most recent generation of civilian training programs in the United States, only Mayo Clinic and WSU could offer positions to foreign nationals on visas while UTMB requires United States citizenship due to its affiliation with NASA. However, WSU recently announced it was discontinuing its residency training within this specialty and Mayo Clinic accepts only one applicant per year.

The fellowship in aerospace medicine program at the Mayo Clinic follows a 2-yr training schedule and prepares fellows for the American Aerospace Medicine Board examination. It includes completion of an MPH at the University of Minnesota and a year of operational training experiences that include training rotations at NASA, the Federal Aviation Administration (FAA) Civilian Aerospace Medicine Institute (CAMI), the USAF School of Aerospace Medicine (USAFSAM), regional hyperbaric centers, and flight training at the University of North Dakota's John D. Odegard School of Aerospace Sciences. However, admission to this program is competitive, with capacity limited to one trainee per academic year and requires prior completion of at least a 3-yr residency and certification by one of the American Board of Medical Specialties (ABMS).

Due to the proximity and generally friendly relations between the countries, students may access civilian training with the FAA and other facilities such as UTMB. The UTMB offers a 4-wk course, Principles of Aerospace Medicine, annually in the summer in Galveston, TX, USA. This course engages trainees in the breadth of the aerospace field in general; topics range from principles of general aviation, rotary wing aviation, diving medicine, and space medicine. Didactic and experiential teaching sessions expose the learner to experts in the field, including NASA flight surgeons, commercial space organizations, and general space medicine opportunities.

Since 1988, the International Space University (ISU) has hosted an annual generalized aerospace intensive course termed the Space Studies Program (SSP). While the format has evolved over time, the curriculum has consistently focused on covering a broad selection of aerospace topics at the graduate level. Applicants must have achieved a bachelor's degree or higher prior to admission and the program welcomes students from many fields of study, including medicine. The SSP stresses interdisciplinary, international collaboration in an international

environment. Faculty is composed of members of the ISU in addition to visiting lecturers from space agencies, private and public enterprise, and other academic institutions. The SSP is divided into lectures, self-selected department activities or workshops, and then a team project. This program provides aerospace exposure in a short time frame with strong academic support. ISU also offers a master's program in space studies for those wishing to expand their knowledge base further.

Other international training opportunities do exist and can often be found as diploma or master's programs. Canadians can apply to the certificate, master's, or Diploma of Aviation Medicine program at King's College in London or to 1-yr diploma programs at either the Université René Descartes or the Université de Bordeaux in France.

In 2014, the Royal College of Physicians and Surgeons of Canada (RCPSC) developed the Competency Training Requirements for aerospace medicine.¹² This specialist certification pathway for a DRCPSC in Aerospace Medicine was designed for actively practicing Canadian physicians. It outlines the recommended criteria that a physician practicing in the field of aerospace medicine in Canada would need in order to demonstrate competency in the field.¹³ While this does not constitute a board certification comparable to the United States aerospace medicine specialty, it can serve as a guidepost for Canadian civilian practitioners seeking to obtain aerospace medicine training by outlining experiences and competencies expected for active practitioners in the field. The college highlights that these training opportunities must be distinct and separate from training opportunities gained in any other program. Thus, candidates may not "double dip" or use research or elective time during one training program toward the DRCPSC pathway. It is anticipated that this pathway to certification will be replaced by a designated training program in the future. Finally, while this document outlines the anticipated set of experiences and knowledge that the college would expect of practitioners, it is targeted at practicing physicians and not undergraduate medical trainees.

At the time of the publication of this competency document, no Canadian pathway was defined for learners to obtain this or any similar credential. Required training experiences are listed below.

1. Perform clinical assessments of individuals with a broad range of medical issues and the full range of involvement in aviation, including but not limited to aircrew, passengers, and aeromedevac patients, to evaluate fitness to fly.
2. Participate as members of interprofessional boards making decisions regarding fitness to fly.
3. Observe flight operations in multiple operational environments, including:
 - a. aeromedical evacuations and/or critical care transport;
 - b. flight experience as a passenger or aircrew; and
 - c. other aircrew work environments.
4. Investigate an aircraft accident or complete an aircraft accident investigation course that includes a simulated investigation.

5. Participate in a variety of worksite assessments of an aviation environment, which must include interpretation of occupational hygiene assessment results.
6. Complete a course that includes all core components of a typical ground school training program for a Canadian private pilot's license.
7. Complete a course in basic diving medicine or hyperbaric medicine.
8. Participate in occupational medicine clinics to observe the breadth and variety of clinical, regulatory, and administrative activities that occur therein.
9. Observe the application of aeromedical standards in a regulatory authority office, military or civilian.

The competency document further lists a set of recommended training exposures that would be reasonably expected of any aerospace medicine trainee. These encompass extended operational exposures to better prepare the practitioner to understanding and making decisions about the aircrew in question. Recommended training experiences as outlined by the college document are listed below.

1. Participate in aircrew vision assessments in an optometry or ophthalmology clinic.
2. Participate in an infectious diseases clinic related to airborne communicable diseases or complete a course in infectious diseases or tropical medicine.
3. Complete an operational experience with one of the space agencies listed below or complete a course in space medicine.
 - a. Canadian Space Agency (CSA);
 - b. European Space Agency (ESA); or
 - c. National Aeronautics and Space Administration (NASA).
4. Participate in:
 - a. Centrifuge training;
 - b. Disorientation training;
 - c. Hypobaric chamber exposure;
 - d. Night vision goggle training;
 - e. Survival training;
 - f. Underwater escape training.
5. Present scholarly work at an aerospace medical association scientific meeting.
6. Observe work environments in multiple areas, including but not limited to:
 - a. Aerobatics, small/large transport aircraft, and rotary wing aircraft;
 - b. Air traffic control;
 - c. Flight line/ground-based operations; and
 - d. Aircraft maintenance.
7. Experience flight as a student pilot.

Future Canadian Aerospace Medicine Training Opportunities

Currently, plans are under development for an aerospace medicine fellowship training program. Through various inter-agency agreements, Canadian fellows will have the opportunity to partake in operational experiences and train in aerospace medicine. It is anticipated that this program will prepare

individuals to obtain the competency requirements for certification as aerospace medicine diplomates. It is anticipated that this will become the springboard for future DRCPSC in Aerospace Medicine training.

The CSA has been queried about the possibility of redeveloping the previously successful Aerospace Medicine Clerkship hosted by NASA biannually at the Johnson Space Center. At the time of writing, while there is interest on behalf of the agency and the previous participants to continue the training opportunity, a final agreement between the two stakeholder space agencies has not been finalized.

Discussion

Following the formalization of criteria for certification with the DRCPSC in Aerospace Medicine by the RCPSC, Canadian physicians have a set of competencies to measure their aerospace practice against. Learners also have clear guideposts as to the Canadian expectations of an aerospace medicine professional and may begin to obtain training and experience in the areas outlined by the DRCPSC document. While the document provides the expected training opportunities and extended training recommended, how to obtain that training remains uncertain and highly dependent upon the motivation of the individual. Operational exposures are typically difficult to obtain without industry experience or previous career opportunities. The development of a structured fellowship which meets all training requirements would place Canada in the position to increase the number of available aerospace medical practitioners locally.

While exact demographics for Canada are not available, the average age of the aviation medical examiner (AME) population in the United States is increasing (2011: 60.0 yr; 2015: 61.5 yr) while the numbers of individual providers dwindles.⁶ These numbers are similar to the statistics related to the entire population of all physicians in the United States⁸ and in Canada;⁷ it would not be unreasonable to hypothesize a similar trend in the population of AMEs in Canada. The statistics that are available indicate the vast majority of Canadian physicians in the specialties of “occupational medicine” are over the age of 65 (27/56, 48.2%) while “public health and preventive” physicians are very likely to be over the age of 55 (247/497, 49.6%).² Aerospace medicine plays a large role in public safety through the surveillance and maintenance of aviator health as well as the prevention of in-flight medical occurrences through regulation and preflight guidance. Many of these experienced providers may no longer be practicing aerospace medicine when their successors need training.

Difficulties will no doubt arise due to the single-payer model of Canadian medicine and the determination of who should fund a small cohort of specialists. Transport Canada is responsible for the training and appointment of the civil aviation medical examiner (CAME) to assess pilots and air traffic controllers. Seminars are held to update and provide information for CAMEs across the country. This seminar is not a formal, directed, training program for undergraduate students, but

meant to be a refresher for practicing physicians with a background knowledge in aviation.

The net benefit to the aerospace community and industry as well as the public resulting from the continued production of aerospace medical specialists, however, is clear and produces many tangible public health benefits through increased flight safety and research for improved human performance. Occupational screening and management of pilots and crew improve their health and effectiveness,⁵ while increased awareness and effectiveness of ground-based medical support and preflight screening has reduced the number of in-flight medical emergencies.¹⁵ If a medical provider is not competent as a professional CAME, aviation accidents and tragedies can claim the lives of more than just the pilots involved¹⁰ and, given the media coverage of aviation events, it can have implications for the general population as well.

As we progress into the age of commercial space tourism as well as supersonic commercial aviation, public health interests will make it even more important to maintain sufficient ranks of qualified aviation medical specialists with knowledge of topics related to chronic disease management and health maintenance in an aviation environment. To do so, resources need to be directed to developing and maintaining a training pipeline to meet the needs before a critical shortage occurs.

While a vast nation, Canada's small population (approximately 10% of the population of the United States) makes it understandable why no formal training programs have existed for aerospace medical professionals. The Accretion Council on Graduate Medical Education of the United States consists now of only two aerospace medicine programs producing 3–5 possible graduates annually (Mayo, $N = 1$; UTMB, $N = 2-4$). Canada could therefore be expected to need an aerospace medicine professional once every 3 to 5 years. Career options, while exciting, are limited¹ and many trained physicians leave to pursue options abroad.¹⁷ Gaps in training could be filled by allied health professionals who have exposure and training in aerospace medicine. For example, the CF trains physician assistants to become basic aviation medicine providers. Flight nursing has also long been considered an important, though challenging field.¹¹ A collaborate and multidisciplinary approach is likely to be successful for Canada and other nations without the population and industry of the United States.

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