Ontario Thoracic Society | Winter 2022 Volume 34 Issue 1

Ontario Thoracic Reviews

Ontario Thoracic Reviews ***(OTR)*** is the official publication of the Ontario Thoracic Society. It is written by and for physicians and researchers in the field of respiratory care. Articles include educational reviews and updates on clinical and scientific topics, written by subject matter specialists working in all fields of respiratory health. The OTR is edited by Dr. Christopher Li and Dr. Mark Soth. The beginning section is a snapshot. Click "Read more" directly linked to the full articles below.

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A Message from the Editors of the Ontario Thoracic Reviews

Christopher Li MD, FRCPC, DABSM
Mark Soth MD, FRCPC

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Editorial

Mobile Health: A Complex Intervention for a Complex World

Samir Gupta, MD, FRCPC, MSc

If you are wondering what mobile health is, you are not alone. The term mobile health ("mHealth") still means different things to different people. According to the World Health Organization, mHealth involves the application of health services through mobile technologies -predominantly smartphones and tablets.(1) And although that definition is still crystalizing in both health and technology domains, there is no better evidence than the multibillion dollar global health app market that mHealth is not just coming – it is here. If you are a provider, it is one of several technology tools that will hopefully make your life easier and enable you to do your job both better and more efficiently. If you are a patient, you are more likely than not to already have an mHealth app on your smartphone.

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Feature Article

Mobile Health in Asthma

Andrew Kouri, MDCM, FRCPC

As smartphones and digital technologies have gradually become integral to our daily lives over the past 20 years, the use of these tools in healthcare has also rapidly expanded. Mobile health (mHealth) technologies are now widely used to collect heath data, provide patient education, promote health behaviour change, and enhance connectivity between healthcare providers and patients.1 In the US, 60% of adults have downloaded one of the more than 300,000 health and wellness apps currently available, with more than 200 being added daily.[2,3] Investment into digital health is equally booming, with the global mHealth app market valued at $12.4B in 2018, up from $4.4B in 2016.[2,3] The COVID-19 pandemic has accelerated this growth even further, as the widespread move to remote care and monitoring has put a spotlight on healthcare's "digital revolution".[4]

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Better Breathing 2022

The **39th annual Better Breathing Conference** will take place from Wednesday January 26 to Friday January 28, 2022 as part of a larger Better Breathing Week. Pre-Conference sessions include Policy Forums on Airways disease asthma, COPD, Lung Cancer, and Infectious Respiratory Disease; the ORCS Research in Action: a Celebration of Achievements; and a TB Gathering. Once again, Better Breathing Week will be delivered virtually.

Many thanks to Dr. Geneviève Digby and the planning committee for their help in developing such an excellent program even in the face of the unprecedented difficulties caused by the pandemic.

Popular traditional programming will return, including the Respirology Year in Review, the venerable André Péloquin clinical case series, and the Resident Case Presentations.

More information, including the program and the link to register are available at **betterbreathing.ca**.

Registration will remain open until Friday January 28, 2022 upon conclusion of the conference. Be sure to register for any sessions you may like to view even if you can't attend as recordings will be made available for 3 months upon conclusion of the conference only to those who've registered to attend.

We look forward to seeing you there!

Events and Education

The Lung Health Foundation hosts various continuing medical education programs including 3 annual conferences (Better Breathing, Respiratory Health Forum, and TB) and periodic webinars on a wide range of topics related to respiratory lung health, many of which are Mainpro+ certified. For more information or to set up a workshop for your healthcare team or organization please contact pep@lunghealth.ca.

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https://pubs.rsna.org/doi/10.1148/radiol.2021210198

Development and validation of an open-source, disposable, 3D-printed *in vitro* environmental exposure system for Transwell culture inserts - Abiram Chandiramohan, Mohammedhossein Dabaghi, Jennifer A. Aguiar, Nicholas Tiessen, Mary Stewart, Quynh T. Cao, Jenny P. Nguyen, Nima Makhdami, Gerard Cox, Andrew C. Doxey, and Jeremy A. Hirota
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https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7737429/

Risk of asthma in children diagnosed with bronchiolitis during infancy: protocol of a longitudinal cohort study linking emergency department-based clinical data to provincial health administrative databases - Kawsari Abdullah, Deshayne B Fell, Dhenuka Radhakrishnan, Steven Hawken, David W Johnson, Piush Mandhane, Teresa To, Gary Joubert, Amy C Plint
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https://www.biorxiv.org/content/10.1101/2021.02.11.430865v1

Respiratory Symptoms Are Associated With Frailty in Older Adults With Normal Spirometry, Independent of Smoking, in the Canadian Longitudinal Study of Aging - Chris P Verschoor, Robert E Dales, MyLinh Duong, Caitlyn Bourque, Oxana Mian, Jinhui Ma and Lauren E Griffith
http://rc.rcjournal.com/content/early/2021/10/05/respcare.09225

Airways flow limitation in symptomatic adult cannabis smokers - N. T. Vozoris, T. M. To, C. M. Ryan, C-W. Chow
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The Ontario Thoracic Review is the official publication of the Ontario Thoracic Society, a medical section of the Lung Health Foundation.

A Message from the Editors of the Ontario Thoracic Reviews

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Regrettably, this edition of the Ontario Thoracic Reviews will be the last. The Ontario Thoracic Reviews was the brainchild of founding editor Dr. Stan Epstein, and since 1985 it has served as the official publication of the Ontario Thoracic Society. Dr. Epstein saw the importance of providing pithy, contemporary reviews of topics relevant to practicing Respirologists, and grew the publication from a truly grass-roots level. In the first issue of the publication, he wrote "*We are fortunate in Ontario in being home to many world class professionals who are involved in the fight against lung disease. Many of these individuals are well published in their special interest journals. It is disappointing that their valuable knowledge is not widely distributed in this province; especially, to the practicing physicians and consequently to the public suffering from respiratory disease…the OTRs can help to remedy this situation by acting as a vehicle for distribution of this fund of knowledge."*

In 1993, Dr. Epstein was succeeded by Dr. Bob Hyland, who expanded upon this mandate and continued to showcase some of the incredible work being done by both established experts and rising stars in Respiratory Medicine, across the province. In 2009, Dr. Hyland passed the editorial baton to us, with the task of ushering in the digital age of the publication while seeking to preserve the core mandates set out by our predecessors.

The past two years have seen transformation in the parent organizations that have historically supported and housed our publication. In 2020, the Ontario Lung Association became the Lung Health Foundation, and announced an expanded national advocacy mandate, with the goal of improving the lung health of all Canadians. Because the new governance structure of the Lung Health Foundation can no longer include a professional society, the Ontario Thoracic Society will be steering its membership towards the umbrella of our national body, the Canadian Thoracic Society. With these realignments – and in light of an increasingly crowded virtual space in Continuing Medical Education – we have decided that our efforts going forward are best focused on supporting the Canadian Thoracic Society and its publication, the Canadian Journal of Respiratory, Critical Care, and Sleep Medicine.

As editors, we are particularly indebted to Ontario Thoracic Society administrator Ms. Natalie Bennett. Ms. Bennett has been a tremendous help with all coordination aspects of the publication, and has done so invariably with a smile – even when gentle prodding has been required. To be the last to hold the editorial post of the Ontario Thoracic Reviews is a distinction towards which we held no aspirations, but in the words of the philosopher Heraclitus, "*Nothing endures but change*", and change we must. It has been a great privilege to have had the opportunity to serve the Ontario Thoracic Society and its membership for the last 13 years. We will always be tremendously grateful to the authors for their many contributions, and to the readers who have made this publication so meaningful to the Ontario Respiratory Medicine community.

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Editorial

Mobile Health: A Complex Intervention for a Complex World

Samir Gupta, MD, FRCPC, MSc

This issue of the Ontario Thoracic Reviews features a comprehensive review of mobile health technologies for asthma, by respirologist and eHealth researcher Dr. Andrew Kouri.

If you are wondering what mobile health is, you are not alone. The term mobile health ("mHealth") still means different things to different people. According to the World Health Organization, mHealth involves the application of health services through mobile technologies -predominantly smartphones and tablets.(1) And although that definition is still crystalizing in both health and technology domains, there is no better evidence than the multibillion dollar global health app market that mHealth is not just coming – it is here. If you are a provider, it is one of several technology tools that will hopefully make your life easier and enable you to do your job both better and more efficiently. If you are a patient, you are more likely than not to already have an mHealth app on your smartphone.

As Dr. Kouri outlines, potential uses of mHealth can be as diverse as technology allows, which means that there is already an eclectic set of use cases, and that applications will continually evolve. A basic tool could simply be a smartphone app that patients use to track and monitor symptoms and/or medication use.(2) A more complex software might integrate technologies such as a chat bot to help extract and contextualize symptoms through an interface that feels more familiar and less clinical.(3) An add-on peripheral hardware device could collect and transmit biometric data to render monitoring more granular and accurate.(4) Finally, an "intelligent" system, ideally aided by artificial intelligence algorithms,(5, 6) could process patient inputs to predict and even avert worsenings by prompting patients to take corrective measures. Though none are in common clinical use, each of these use cases has already been built and studied in both asthma and COPD (with the caveat that impacts on patient-relevant outcomes are inconsistent).

In fact, Dr. Kouri makes a strong case for asthma being a prototypical disease to target with an mHealth intervention - it is not only common, but carries an outsized healthcare system burden, that burden is related to well-documented gaps between best care and actual care, and many of those gaps can be addressed by the technologies described above: suboptimal inhaler technique, environmental trigger exposure, missed inhaler doses, and failure to recognize and act on flare-ups. I would argue that the same advantages apply to COPD.

However, at least as exciting as the potential of these technologies, is how daunting their effective implementation will be. The first question we must ask, is "if you build it, will they come?" Most of us can attest to having a graveyard of seldom-used, forgotten apps on our smartphone. Although initial excitement easily translates into a download, it has proven more challenging to get patients to use health apps in a sustained and meaningful way, particularly for intermittent diseases such as asthma, which are quickly forgotten in between flares.(7) Challenges are even greater in COPD, where most users would have been introduced to smart devices past middle age (if at all). Unlike millennials, to whom smartphones and tablets are not only intimately familiar but an essential part of daily life, older adults face barriers relating to technology *use*, *trust* and *acceptance*, particularly considering privacy and safety of health information. Although these concerns will evaporate as the "Smartphone Generation" ages, they will represent a significant challenge for decades to come.

If mHealth is to become a staple of high-quality care, we must also address access. With 21% of Canadians reporting a mother tongue other than English or French,(8) tools must be made available across languages and cultures. Although 94% of Canadian households have fixed broadband Internet,(9) only 84% of Canadians possess a smartphone, leaving 16% on the other side of the "digital divide."(10) Furthermore, many who possess a device experience slow and/or metered data connections – whether cellular or wifi. A case in point is that only 24% of indigenous Canadian households have high-speed internet access.(11) Although these numbers will gradually improve, our principles of universal and equitable access(12) will continue to be challenged for the foreseeable future.

Lastly, given that mHealth technologies usually "reside" with patients, questions abound regarding if, when, how, and how often providers should be included in the patient-technology "loop." As peripherals and apps become more ubiquitous, there will be no shortage of data. But whose responsibility will it be to make sense of these data of varying sorts and qualities? In an ideal world, mHealth data could automatically populate electronic medical record system (EMR)-integrated clinical decision support systems to guide providers in optimizing evidence-based care.(13) However, even in such a model,

remuneration strategies will require consideration of this increasingly time-consuming activity. And as these applications start interfacing directly with EMRs, what will be the medico-legal implications, particularly when high-risk signals arrive at odd hours? Finally, given the well-documented relationship between almost universally poor EMR design and physician burnout,(14) we must ensure that any new EMR mHealth data interfaces are *truly* user-friendly.

In summary, mHealth represents an exciting frontier in healthcare which can allow us and our patients to realize the benefits of rapidly advancing technology. However, like most worthwhile things in life, success will require work. The coming years will hopefully bring much more evaluation, some regulation, and lots of cooperation – including from our patients and from us – as both the users and the benefactors of the technology.

References

1. World Health Organization (WHO). Tuberculosis: Global task force on digital health 2015 [cited 2021 October 12th]. Available from: http://www.who.int/news-room/q-a-detail/tuberculosis-global-task-force-on-digital-health.
2. Chan YY, Wang P, Rogers L, Tignor N, Zweig M, Hershman SG, et al. The Asthma Mobile Health Study, a large-scale clinical observational study using ResearchKit. Nat Biotechnol. 2017;35(4):354-62.
3. Innovation e. Breathe [Available from: https://ehealthinnovation.org/project/breathe/.
4. Brennan V, Mulvey C, Greene G, Hale EM, Costello RW. A Clinical Perspective on the Role of Electronic Devices in Monitoring and Promoting Adherence in Airways Disease. Frontiers in Medical Technology. 2021;3(10).
5. Exarchos KP, Beltsiou M, Votti CA, Kostikas K. Artificial intelligence techniques in asthma: a systematic review and critical appraisal of the existing literature. Eur Respir J. 2020;56(3).
6. Wu CT, Li GH, Huang CT, Cheng YC, Chen CH, Chien JY, et al. Acute Exacerbation of a Chronic Obstructive Pulmonary Disease Prediction System Using Wearable Device Data, Machine Learning, and Deep Learning: Development and Cohort Study. JMIR Mhealth Uhealth. 2021;9(5):e22591.
7. Morita PP, Yeung MS, Ferrone M, Taite AK, Madeley C, Stevens Lavigne A, et al. A Patient-Centered Mobile Health System That Supports Asthma Self-Management (breathe): Design, Development, and Utilization. JMIR Mhealth Uhealth. 2019;7(1):e10956.
8. Statistics Canada. Linguistic Characteristics of Canadians 2018 [Available from: https://www12.statcan.gc.ca/census-recensement/2011/as-sa/98-314-x/98-314-x2011001-eng.cfm.
9. Statistics Canada. Access to the Internet in Canada, 2020 2021 [updated May 31 2021. :[Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/210531/dq210531d-eng.htm.
10. Satista. Number of smartphone users in Canada from 2018 to 2024 (in millions) [Available from: https://www.statista.com/statistics/467190/forecast-of-smartphone-users-in-canada/.
11. Government of Canada. High-Speed Access for All: Canada's Connectivity Strategy 2019 [Available from: https://www.ic.gc.ca/eic/site/139.nsf/eng/h_00002.html.
12. Justice Laws Website. Canada Health Act 2021 [Available from: https://laws-lois.justice.gc.ca/eng/acts/c-6/.
13. Gupta S, Price C, Agarwal G, Chan D, Goel S, Boulet LP, et al. The Electronic Asthma Management System (eAMS) improves primary care asthma management. European Respiratory Journal. 2019;53(4).
14. Melnick ER, Dyrbye LN, Sinsky CA, Trockel M, West CP, Nedelec L, et al. The Association Between Perceived Electronic Health Record Usability and Professional Burnout Among US Physicians. Mayo Clin Proc. 2020;95(3):476-87.

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Feature Article

Mobile Health in Asthma

Andrew Kouri, MDCM, FRCPC

Introduction

As smartphones and digital technologies have gradually become integral to our daily lives over the past 20 years, the use of these tools in healthcare has also rapidly expanded. Mobile health (mHealth) technologies are now widely used to collect heath data, provide patient education, promote health behaviour change, and enhance connectivity between healthcare providers and patients.[1] In the US, 60% of adults have downloaded one of the more than 300,000 health and wellness apps currently available, with more than 200 being added daily.[2,3] Investment into digital health is equally booming, with the global mHealth app market valued at $12.4B in 2018, up from $4.4B in 2016.[2,3] The COVID-19 pandemic has accelerated this growth even further, as the widespread move to remote care and monitoring has put a spotlight on healthcare's "digital revolution".[4]

In this review, I will conceptualize the mHealth digital revolution as it pertains to the care of adult patients with asthma, discussing the current evidence for mHealth in asthma, the challenges this growing field must still overcome, and what the future might hold.

What exactly is mHealth?

As with any evolving and innovative field, terminology in the mHealth milieu can occasionally be challenging. Researchers will often use the umbrella terms "digital health" or "electronic health (eHealth)" when discussing mHealth, but these are broader categories that encompass a wide range of health information technologies from electronic health records to telehealth to the Internet and apps.[5] For the purposes of this review, we will focus specifically on the use of mHealth, which the World Health Organization defines as "the provision of health services and information via mobile technologies, such as mobile phones, tablet computers and Personal Digital Assistants (PDAs)"[6]. A more recent definition that better reflects current mobile technology features comes from Dr. Ida Sim, Co-director of Informatics and Research innovation at UCSF's Clinical and Translational Sciences Institute and Director of Digital Health for the Division of General Internal Medicine. In her New England Journal review, Dr. Sim defines mHealth as "the application of sensors, mobile apps, social media, and location-tracking technology to obtain data pertinent to wellness and disease diagnosis, prevention, and management".[7]

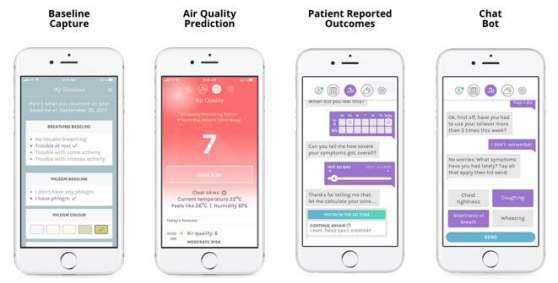
Asthma as a target for mHealth

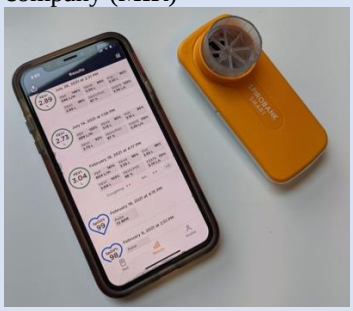
Asthma is one of the most common chronic pulmonary disease in Canada, currently affecting more than 3.8 million Canadians over the age of 1. Worldwide, approximately 26 million disability-adjusted life-years are lost annually due to asthma, and the yearly economic burden caused by asthma in Canada is in the billions of dollars.[8–10] Though effective therapy for asthma is widely available, the majority of patients with asthma in Canada remain uncontrolled.[11–13] Important care gaps at the healthcare practitioner level include inadequate assessment of asthma control, failure to provide patients with asthma education and asthma action plans, underuse of spirometry, and failure to address smoking cessation.[8,11,14–17] At the patient level, major care gaps include insufficient understanding of asthma control, poor adherence to treatments and improper inhaler technique, suboptimal environmental control, and non-use of asthma actions plans and self-management techniques.[8,11,12,16,18] Overall, many of these barriers to optimal care can be framed as failures of knowledge translation between evidence-based recommendations and practice, and also as a lack of effective patient education.[14,19]

mHealth technologies are particularly well suited to help address many of these care gaps in asthma, as they can provide clinicians with novel sources of patient information and encourage collaborative care, and they can empower patients with tailored education and improved self-management tools.[20–22] Applying Dr. Sim's definition to asthma mHealth, we can see that several different categories of mobile interventions may accomplish these goals. To start, there are stand-alone applications that can be used on smartphones or tablets. A recent review found that there were over 500 of these apps available for download on the Apple and Google Play stores. These apps can have a range of functions, including health education, symptom and lung function tracking, environmental alerts, medication reminders, and information sharing.[23] The next category is inhaler-based mobile electronic devices, which often come paired with a mobile app. These devices can monitor inhaler use and adherence, assess technique, and provide reminders for use. Pairing this data with a mobile app also

allows users and their healthcare teams to better track asthma control and understand the context of their inhaler use.[23] The third category is portable home electronic spirometers, which also frequently connect with a mobile app. This new generation of ultra-portable electronic spirometers are intended for home use by patients, and provide reliable measurements of spirometry and peak flow.[24,25] As with inhaler-based devices, pairing their data with mobile apps allows patients to gain insight into their lung function over time and easily share this data with their clinical team.[25] This category could also include other portable electronic devices that measure lung function such as portable oscillometry or FeNO devices, but these are less widely available and not currently suitable for patient self-management applications.[26,27] Likewise, there is an exciting field of research developing around the use of smartphone microphones to generate spirometry measurements, but they currently lack rigorous clinical validation.[28–30] The final category is other mobile electronic devices (apart from inhalers and spirometers) that can record and track vital signs and physical activity, and connect with associated apps. These devices, such as smartwatches that measure oximetry and step count or more sophisticated activity and sleep sensors, are more thoroughly studied for COPD telemonitoring,[31] but may also be useful in patients with asthma seeking to track their overall health status or incorporated into telemonitoring programs.[32] It is also important to mention that there is a rich body of literature around the use of text messaging (SMS) as a mobile intervention in asthma care, but as SMS doesn't rely on the Internet or make use of the full and complex feature sets of smart-devices available today, SMS-only interventions will be excluded from this mHealth review.[33] See Figure 1 for real-world examples (Canadian where possible) of each asthma mHealth category.

Figure 1. Examples of the different categories of asthma mHealth

Category	Example (Canadian examples provided where possible)
Stand-alone apps	Breathe app, developed by the Centre for Global eHealth Innovation at the University Health Network (UHN)  (Image from https://breathebetter.app/asthma/)
Electronic inhalers with connected apps	BreatheSuite MDI inhaler and app, developed in St. John's, Newfoundland  (Image from https://www.breathesuite.com/)

Electronic portable spirometers with connected apps	Spirobank Smart spirometer and app, developed by a multinational company (MIR)  (Image taken by author)
Other electronic sensor devices with connected apps	CloudDx devices and app, developed in Kitchener, Ontario  (Image from https://www.clouddx.com/)

The evidence for mHealth in asthma

The evidence base for mHealth in asthma is still developing, and there remains significant heterogeneity in the definitions of mHealth used across the literature. However, several systematic reviews have been published in the previous 5 years that shed light on the current state of asthma mHealth evidence.

The most recent example is a scoping review by Mosnaim et al., which evaluated "digital heath technology interventions" overall, including generalized reminder and educational interventions, patient-specific noninteractive interventions (i.e. electronic devices without patient feedback or connected apps), and patient-specific interactive interventions (i.e. electronic devices with individualized feedback through connected apps).[34] Among the third category, which most closely aligns with our definition of mHealth, they identified 66 studies, of which 32 described asthma management platforms, 14 described a digital inhaler combined with asthma management platforms, and 14 described telemedicine-based interventions. Most studies were randomized and lasted longer than 3 months. Their descriptive analysis revealed that more studies reported positive effects for medication adherence and asthma control improvement vs. no effect (17 vs. 8, and 31 vs 15, respectively), and an equal number of studies found reductions in healthcare use vs. no effect (14 vs. 14).[34] It is important to note that methodological quality of studies was not assessed.

Another recent and more targeted review by Nguyen et al. sought to evaluate asthma mHealth apps that integrate with inhaler-based sensors.[35] They identified 6 studies that evaluated 2 systems (the Propeller Health platform and the BreatheSmart app) and lasted between 6 and 12 months. Qualitative analysis revealed improvements in maintenance inhaler adherence and decreases in reliever medication use, but no significant change in overall asthma control. Risk of bias was variable across the studies, and no studies reported on asthma exacerbations, asthma-related quality of life, or pulmonary function.[35]

A 2019 systematic review and meta-analysis by Jeminiwa et al. examined the effects of all types of eHealth interventions on medication adherence in asthma.[36] They included 6 mHealth studies: 4 that evaluated electronic inhaler monitoring devices with apps and audiovisual reminders, and 2 studies of text-messaging alone. Studies lasted between 3 and 9 months. Meta-

analysis found a significant effect on medication adherence to inhaled steroids across mHealth studies with electronic inhaler monitoring and self-reports.[36] Significant heterogeneity was again noted between studies.

A 2018 review of portable electronic spirometers for asthma self-management by Carpenter et al. shed light in this mHealth category.[25] They identified 16 commercially available electronic spirometers, 25% of which were FDA-approved and reported accuracy consistent with American Thoracic Society (ATS) standards. All devices could connect with smartphone apps, and cost ranged from $100 to $1000 USD. Unfortunately, no peer-reviewed clinical outcome data was available for analysis at the time of publication.[25]

A 2017 systematic review and meta-analysis by Miller et al. sought to evaluate the effect of "mobile technology interventions" on asthma medication adherence, self-monitoring, and clinical health outcomes.[37] They identified 4 studies using a stand-alone mobile app platform for symptom self-monitoring and asthma action planning, as well as 7 using text-messaging only. Study duration was between 3 and 12 months overall. Meta-analysis of these studies together showed a positive overall effect on medication adherence compared with standard treatment, as well as higher standardized quality of life, lower mean percentage of unscheduled visits, and increased well-controlled asthma levels. No effects on lung function were found.[37] Risk of bias was mostly low or unclear.

Hui et al.'s 2017 systematic review and meta-analysis of "information and communication technology" for asthma identified 3 studies of mobile phone apps (which focused on self-monitoring and asthma action plan provision), 4 of Web apps, 3 of text-messaging only, 1 of an electronic inhaler connected with a Web app, and 1 customized monitoring system connected by telephone line.[38] Study duration was between 3 and 18 months. Meta-analysis, which included 1 mobile app study and 2 Web app studies, demonstrated significant improvement in asthma control using the Asthma Control Questionnaire (ACQ), but the confidence interval did not include the minimum clinically important difference of 0.5. Otherwise, no significant effects were found overall for quality of life and asthma exacerbations.[38] Risk of bias was low or unclear for most studies.

Farzandipour et al.'s 2017 systematic review focused specifically on mobile apps for asthma, excluding mobile devices used only to send text messages, to access Web sites, or make phone calls.[39] They identified 10 studies of stand-alone mHealth apps, with multiple functionalities including self-monitoring, education, reminders, and communication between patients and their healthcare providers. Studies lasted between 2 and 6 months. Descriptive analysis revealed that asthma control, lung function, and quality of life improved significantly in most studies that included these outcomes. Only 40% of the studies were considered of strong methodological quality.[39]

Finally, a 2016 systematic review and meta-analysis from McLean et al. searched for randomized controlled trials of "interactive digital interventions" in asthma, identifying 5 studies including 2 using mobile phone apps, 2 using Web apps, and 1 using interactive phone voice response.[40] Study duration ranged from 2.5 to 12 months. Meta-analysis of 2 of the trials, including one of the mobile phone app studies, showed significant improvement in asthma-related quality of life and asthma control.[40] Studies were all randomized controlled trials but various methodological issues were nonetheless noted.

Overall, the current evidence does suggest a consistent positive effect of asthma mHealth interventions towards medication adherence, asthma-related quality of life, and asthma control. However, there is only limited data in terms of exacerbations, healthcare utilization, and lung function. Heterogeneity across studies, lack of long-term data, and inconsistent definitions of mHealth in each review also make it challenging to draw firm conclusions about the true clinical effectiveness of asthma mHealth.

Challenges to address

Based on the review of evidence presented, one obvious challenge for asthma mHealth moving forward is to establish clear and consistent definitions to facilitate future much needed rigorous research into longer-term clinical effectiveness.[23] However, it can often be difficult to translate conventional effectiveness study designs to digital health technologies, as applications and functionalities are constantly being updated and refined, and technology developers are eager to take their products to market. To address this, innovative regulatory and evaluatory frameworks need to be developed. One example is the US Food & Drug Administration's (FDA) pre-cert program, part of the Digital Health Innovation Action Plan.[41] This program streamlines approval of digital tools through evaluation of software development companies themselves, providing pre-certification to trusted companies with a history of high quality development, combined with ongoing real-world product

performance evaluation.[23,41] Health Canada released a draft guidance document in 2019 outlining a similar plan to regulate digital tools and apps according to a risk-based classification system.[42] Another way to ensure mHealth quality and effectiveness is through the creation and maintenance of official trusted application libraries, like the UK's National Health Service "Apps Library", which currently lists more than 70 "NHS approved" medical apps across a range of conditions.[43] In order to be included in the NHS library, apps must be accessible, high-quality, safe, usable, and supported by published evidence.[3]

A further obstacle for asthma mHealth is the current lack of theory-based research in the development cycle. Recent reviews by Ramsay et al. and Tinschert et al. found that among 23 and 38 publicly available stand-alone asthma self-management apps, a mean of only 4 and 7 validated behaviour change techniques were incorporated into apps, respectively.[44,45] User-centered iterative design methods and theory-based persuasive design and behaviour change principles need to be more deeply incorporated into the mHealth research cycle,[46] as research has shown that chronic respiratory disease interventions that include behaviour change theories in their development are more effective.[47] mHealth also represents an opportunity to further the field of behaviour change science through the real-time collection of rich behavioural data, possibly allowing for future personalization of digital behaviour change interventions.[48]

We must also strive for mHealth interventions that are usable and accessible for all populations with asthma, including those that are traditionally underserved by our healthcare systems. For example, asthma is rising in prevalence in older populations in Canada,[9] and older patients with asthma suffer disproportionately from asthma morbidity and mortality compared to their younger counterparts.[49–51] Though mHealth interventions could potentially address many of the barriers to optimal care in older adults with asthma, little is currently known about the effectiveness of mHealth in this population, as most existing studies have not included patients above the age of 65.[37,40,52] Furthermore, trials that have included older patients with asthma have found decreased acceptance levels of mHealth among older patients, suggesting that older adults may have a negative perception of these digital tools.[53] Beyond concerns related to older adults, effective digital solutions going forward will also need to pay particular attention to language and access barriers, disability, and cultural differences, as all of these may influence equitable use of digital health technologies.[54,55]

As mHealth tools become more ubiquitous in asthma and other health conditions, data privacy and security issues will also need to be considered. For example, in 2017, the NIH was severely affected by the "WannaCry" ransomware attack, which affected over 600 organizations and locked out affected hospitals from their digital systems and medical devices.[56] To mitigate the future possibility and damage from such attacks, the US FDA has incorporated "cyber security by design" principles into their recent Medical Device Safety Action Plan, which compels digital health manufacturers to document the inner workings of their software and discuss potential vulnerabilities a priori through a cybersecurity bill of materials (CBOM).[57]

Other challenges that will also need to be addressed include clear cost and remuneration frameworks pertaining to asthma mHealth use and interpretation, medico-legal liability issues related to the real-time generation of health data, and interoperability challenges with existing electronic health systems.[58,59]

Future possibilities for asthma mHealth

The COVID-19 pandemic was in many ways a lens into the potential future of mHealth in asthma and overall. As clinicians across the world rushed to implement virtual care solutions where possible, mHealth and other digital health solutions became important adjuvants to virtual care, as physical examination and many other essential tests were no longer safe.[4] In asthma, for example, clinicians had to contend with the loss of pulmonary function testing, and mHealth tools like home electronic spirometers and self-management mobile apps were one available avenue to accurately collect physiologic and clinical data remotely.[60] mHealth apps also became central to our management of the pandemic itself, through telemonitoring programs like Covidom in France, which leveraged mobile questionnaires to triage and follow at-risk and COVID-positive patients, as well as to provide real-time evolving patient guidance and education.[61] These expansive programs may provide a model for future virtual care and telemonitoring efforts in asthma and other chronic respiratory diseases.

As mHealth use in asthma grows, the use of apps and connected devices will also generate a completely novel stream of patient-specific digital data. If validated and regulated appropriately, these new "digital biomarkers" may generate new and valuable clinical insights and research opportunities, and may be able to contribute to effective personalization of care.[62]

These potentially massive personalized data streams, if used responsibly, may also be amenable to machine learning and artificial intelligence approaches, further elucidating new clinical and research possibilities.[34]

Conclusion

mHealth in asthma here undoubtedly here to stay, as investment into mHealth continues to grow in line with patient demand. In a national survey in 2020 commissioned by Canada Health Infoway, a large majority of people surveyed wished to use technology to manage their health and believed healthcare technology should be a top priority for government investment.[63] However, despite those numbers, nearly 60% still felt they lacked knowledge about digital health technology and services. This is where we as clinicians and researchers are needed – to inform and guide our patients and public policy makers about the benefits and the risks of mHealth. To start, clinicians should ask their patients with asthma if and how they are currently using mHealth. If they are, we should ensure that they are using safe and effective apps and tools, which meet the criteria of "prescribable mHealth".[64] The Canadian Medical Association has also created a guidance document to help clinicians counsel their patients about mHealth.[65] As stewards of medical education, we must also consider how we will incorporate mHealth into the medical curriculum, as the next generation of clinicians and researchers will require a nuanced understanding of mHealth to better serve their patients and promote greater population digital health.

References

1. Roess A. The Promise, Growth, and Reality of Mobile Health - Another Data-free Zone. N Engl J Med. 2017 Nov 23;377(21):2010–1.
2. MacKinnon GE, Brittain EL. Mobile Health Technologies in Cardiopulmonary Disease. Chest. 2020 Mar 1;157(3):654–64.
3. Mathews SC, McShea MJ, Hanley CL, Ravitz A, Labrique AB, Cohen AB. Digital health: a path to validation. Npj Digit Med. 2019 May 13;2(1):1–9.
4. Keesara S, Jonas A, Schulman K. Covid-19 and Health Care's Digital Revolution. N Engl J Med. 2020 Apr 2;0(0):null.
5. World Health Organization (WHO). Digital health [Internet]. [cited 2021 Aug 9]. Available from: https://www.euro.who.int/en/health-topics/Health-systems/digital-health
6. World Health Organization (WHO). Tuberculosis: Global task force on digital health [Internet]. 2015 [cited 2021 Aug 9]. Available from: http://www.who.int/news-room/q-a-detail/tuberculosis-global-task-force-on-digital-health
7. Sim I. Mobile Devices and Health. N Engl J Med. 2019 Sep 5;381(10):956–68.
8. Boulet L-P, Bourbeau J, Skomro R, Gupta S. Major care gaps in asthma, sleep and chronic obstructive pulmonary disease: A road map for knowledge translation. Can Respir J J Can Thorac Soc. 2013;20(4):265–9.
9. Public Health Agency of Canada. Report from the Canadian Chronic Disease Surveillance System: Asthma and Chronic Obstructive Pulmonary Disease (COPD) in Canada, 2018 [Internet]. aem. 2018 [cited 2019 Apr 5]. Available from: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/asthma-chronic-obstructive-pulmonary-disease-canada-2018.html#a1.2.2
10. Public Health Agency of Canada. Economic Burden of Illness in Canada [Internet]. 2010 [cited 2021 Aug 9]. Available from: https://www.canada.ca/en/public-health/services/chronic-diseases/chronic-disease-knowledge-development-exchange/economic-burden-illness-canada.html
11. Murray S, Labbé S, Kaplan A, Petrasko K, Waserman S. A multi-stakeholder perspective on asthma care in Canada: findings from a mixed methods needs assessment in the treatment and management of asthma in adults. Allergy Asthma Clin Immunol. 2018 Sep 10;14(1):36.
12. Chapman KR, Boulet LP, Rea RM, Franssen E. Suboptimal asthma control: prevalence, detection and consequences in general practice. Eur Respir J. 2008 Feb;31(2):320–5.
13. FitzGerald JM, Boulet L-P, McIvor RA, Zimmerman S, Chapman KR. Asthma control in Canada remains suboptimal: the Reality of Asthma Control (TRAC) study. Can Respir J. 2006 Aug;13(5):253–9.
14. Price C, Agarwal G, Chan D, Goel S, Kaplan AG, Boulet L-P, et al. Large care gaps in primary care management of asthma: a longitudinal practice audit. BMJ Open. 2019 Jan 1;9(1):e022506.
15. Gagné ME, Boulet L-P. Implementation of asthma clinical practice guidelines in primary care: A cross-sectional study based on the Knowledge-to-Action Cycle. J Asthma Off J Assoc Care Asthma. 2018;55(3):310–7.
16. Côté A, Godbout K, Boulet L-P. The management of severe asthma in 2020. Biochem Pharmacol. 2020 Sep 1;179:114112.

17. Djandji F, Lamontagne AJ, Blais L, Bacon SL, Ernst P, Grad R, et al. Enablers and determinants of the provision of written action plans to patients with asthma: a stratified survey of Canadian physicians. NPJ Prim Care Respir Med. 2017 Mar 31;27(1):21.
18. Kaplan A. Treatment Gaps in the Control of Asthma in Canada. Can J Diagn. 2010;39–44.
19. Ehteshami-Afshar S, FitzGerald JM. Asthma patient education, the overlooked aspect of disease management. Can J Respir Crit Care Sleep Med. 2017 Jan 2;1(1):43–5.
20. Poowuttikul P, Seth D. New Concepts and Technological Resources in Patient Education and Asthma Self-Management. Clin Rev Allergy Immunol. 2020 Aug 1;59(1):19–37.
21. Simpson AJ, Honkoop PJ, Kennington E, Snoeck-Stroband JB, Smith I, East J, et al. Perspectives of patients and healthcare professionals on mHealth for asthma self-management. Eur Respir J. 2017 May 1;49(5):1601966.
22. Morrison D, Mair FS, Yardley L, Kirby S, Thomas M. Living with asthma and chronic obstructive airways disease: Using technology to support self-management – An overview. Chron Respir Dis. 2017 Nov 1;14(4):407–19.
23. Himes BE, Leszinsky L, Walsh R, Hepner H, Wu AC. Mobile Health and Inhaler-Based Monitoring Devices for Asthma Management. J Allergy Clin Immunol Pract. 2019 Nov 1;7(8):2535–43.
24. Zhou P, Yang L, Huang Y-X. A Smart Phone Based Handheld Wireless Spirometer with Functions and Precision Comparable to Laboratory Spirometers. Sensors [Internet]. 2019 May 31 [cited 2020 Apr 23];19(11). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6603793/
25. Carpenter DM, Jurdi R, Roberts CA, Hernandez M, Horne R, Chan A. A Review of Portable Electronic Spirometers: Implications for Asthma Self-Management. Curr Allergy Asthma Rep. 2018 Aug 25;18(10):53.
26. Harnan SE, Tappenden P, Essat M, Gomersall T, Minton J, Wong R, et al. Measurement of exhaled nitric oxide concentration in asthma: a systematic review and economic evaluation of NIOX MINO, NIOX VERO and NObreath. Health Technol Assess Winch Engl. 2015 Oct;19(82):1–330.
27. Dandurand RJ, Lavoie J-P, Lands LC, Hantos Z. Comparison of oscillometry devices using active mechanical test loads. ERJ Open Res [Internet]. 2019 Dec 23 [cited 2020 Jun 18];5(4). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6926364/
28. Larson EC, Goel M, Boriello G, Heltshe S, Rosenfeld M, Patel SN. SpiroSmart: using a microphone to measure lung function on a mobile phone. In: Proceedings of the 2012 ACM Conference on Ubiquitous Computing [Internet]. Pittsburgh, Pennsylvania: Association for Computing Machinery; 2012 [cited 2020 Apr 22]. p. 280–9. (UbiComp '12). Available from: http://doi.org/10.1145/2370216.2370261
29. Viswanath V, Garrison J, Patel S. SpiroConfidence: Determining the Validity of Smartphone Based Spirometry Using Machine Learning. In: 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). 2018. p. 5499–502.
30. Chung H, Jeong C, Luhach AK, Nam Y, Lee J. Remote Pulmonary Function Test Monitoring in Cloud Platform via Smartphone Built-in Microphone. Evol Bioinforma. 2019 Jan 1;15:1176934319888904.
31. Ding H, Fatehi F, Maiorana A, Bashi N, Hu W, Edwards I. Digital health for COPD care: the current state of play. J Thorac Dis. 2019 Oct;11(Suppl 17):S2210–20.
32. Kew KM, Cates CJ. Home telemonitoring and remote feedback between clinic visits for asthma. Cochrane Database Syst Rev. 2016 Aug 3;2016(8):CD011714.
33. Kim BY, Lee J. Smart Devices for Older Adults Managing Chronic Disease: A Scoping Review. JMIR MHealth UHealth [Internet]. 2017 May 23 [cited 2019 Apr 16];5(5). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5461419/
34. Mosnaim G, Safioti G, Brown R, DePietro M, Szefler SJ, Lang DM, et al. Digital Health Technology in Asthma: A Comprehensive Scoping Review. J Allergy Clin Immunol Pract. 2021 Jun 1;9(6):2377–98.
35. Nguyen E, Miao B, Pugliese N, Huang D, Sobieraj DM. Systematic Review of mHealth Applications That Interface with Inhaler Sensors in Asthma. J Allergy Clin Immunol Pract. 2021 Feb 1;9(2):844-852.e3.
36. Jeminiwa R, Hohmann L, Qian J, Garza K, Hansen R, Fox BI. Impact of eHealth on medication adherence among patients with asthma: A systematic review and meta-analysis. Respir Med. 2019;149:59–68.
37. Miller L, Schüz B, Walters J, Walters EH. Mobile Technology Interventions for Asthma Self-Management: Systematic Review and Meta-Analysis. JMIR MHealth UHealth. 2017;5(5):e57.
38. Hui CY, Walton R, McKinstry B, Jackson T, Parker R, Pinnock H. The use of mobile applications to support self-management for people with asthma: a systematic review of controlled studies to identify features associated with clinical effectiveness and adherence. J Am Med Inform Assoc. 2017 May 1;24(3):619–32.
39. Farzandipour M, Nabovati E, Sharif R, Arani MH, Anvari S. Patient Self-Management of Asthma Using Mobile Health Applications: A Systematic Review of the Functionalities and Effects. Appl Clin Inform. 2017;8(4):1068–81.

40. McLean G, Murray E, Band R, Moffat KR, Hanlon P, Bruton A, et al. Interactive digital interventions to promote self-management in adults with asthma: systematic review and meta-analysis. BMC Pulm Med. 2016 Dec;16(1):83.
41. Federal Drug Agency. Digital Health Software Precertification (Pre-Cert) Program [Internet]. FDA; 2020 [cited 2021 Apr 5]. Available from: https://www.fda.gov/medical-devices/digital-health-center-excellence/digital-health-software-precertification-pre-cert-program
42. Canada H. Draft Guidance Document - Software as a Medical Device (SaMD) [Internet]. aem. 2019 [cited 2020 Sep 22]. Available from: https://www.canada.ca/en/health-canada/services/drugs-health-products/public-involvement-consultations/medical-devices/software-medical-device-draft-guidance/document.html
43. National Health Service. NHS Apps Library [Internet]. NHS UK. [cited 2021 Aug 10]. Available from: https://www.nhs.uk/apps-library/
44. Ramsey RR, Caromody JK, Voorhees SE, Warning A, Cushing CC, Guilbert TW, et al. A Systematic Evaluation of Asthma Management Apps Examining Behavior Change Techniques. J Allergy Clin Immunol Pract. 2019 Nov 1;7(8):2583–91.
45. Tinschert P, Jakob R, Barata F, Kramer J-N, Kowatsch T. The Potential of Mobile Apps for Improving Asthma Self-Management: A Review of Publicly Available and Well-Adopted Asthma Apps. JMIR MHealth UHealth [Internet]. 2017 Aug 2 [cited 2019 Feb 26];5(8). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5559650/
46. Korpershoek YJG, Hermsen S, Schoonhoven L, Schuurmans MJ, Trappenburg JCA. User-Centered Design of a Mobile Health Intervention to Enhance Exacerbation-Related Self-Management in Patients With Chronic Obstructive Pulmonary Disease (Copilot): Mixed Methods Study. J Med Internet Res [Internet]. 2020 Jun 15 [cited 2020 Sep 17];22(6). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7324997/
47. McCullough AR, Ryan C, Macindoe C, Yii N, Bradley JM, O'Neill B, et al. Behavior change theory, content and delivery of interventions to enhance adherence in chronic respiratory disease: A systematic review. Respir Med. 2016;116:78–84.
48. Michie S, Yardley L, West R, Patrick K, Greaves F. Developing and Evaluating Digital Interventions to Promote Behavior Change in Health and Health Care: Recommendations Resulting From an International Workshop. J Med Internet Res. 2017 Jun 29;19(6):e7126.
49. Bozek A, Jarzab J. Adherence to asthma therapy in elderly patients. J Asthma Off J Assoc Care Asthma. 2010 Mar;47(2):162–5.
50. Federman AD, Wolf MS, Sofianou A, Martynenko M, O'Connor R, Halm EA, et al. Self-management behaviors in older adults with asthma: associations with health literacy. J Am Geriatr Soc. 2014 May;62(5):872–9.
51. To T, Simatovic J, Zhu J, Feldman L, Dell SD, Lougheed MD, et al. Asthma Deaths in a Large Provincial Health System. A 10-Year Population-Based Study. Ann Am Thorac Soc. 2014 Aug 28;11(8):1210–7.
52. Morrison D, Wyke S, Agur K, Cameron EJ, Docking RI, MacKenzie AM, et al. Digital Asthma Self-Management Interventions: A Systematic Review. J Med Internet Res. 2014;16(2):e51.
53. Kouri A, Yamada J, Sale JEM, Straus SE, Gupta S. Primary Care Pre-Visit Electronic Patient Questionnaire for Asthma: Uptake Analysis and Predictor Modeling. J Med Internet Res. 2020 Sep 18;22(9):e19358.
54. Maar MA, Yeates K, Perkins N, Boesch L, Hua-Stewart D, Liu P, et al. A Framework for the Study of Complex mHealth Interventions in Diverse Cultural Settings. JMIR MHealth UHealth. 2017 Apr 20;5(4):e7044.
55. Bhatia S, Jamieson T, Shaw J, Piovesan C, Kelley LT, Falk W. Canada's Virtual Care Revolution: A Framework for Success. C.D. Howe Institute; 2020 Dec p. 24. Report No.: No. 586.
56. Ghafur S, Kristensen S, Honeyford K, Martin G, Darzi A, Aylin P. A retrospective impact analysis of the WannaCry cyberattack on the NHS. NPJ Digit Med [Internet]. 2019 Oct 2 [cited 2020 Sep 23];2. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6775064/
57. Woods B, Coravos A, Corman JD. The Case for a Hippocratic Oath for Connected Medical Devices: Viewpoint. J Med Internet Res. 2019;21(3):e12568.
58. Wu AC. There's an App for That, But Does It Work? J Allergy Clin Immunol Pract. 2019 Nov 1;7(8):2592–3.
59. Lang M, Zawati MH. The app will see you now: mobile health, diagnosis, and the practice of medicine in Quebec and Ontario. J Law Biosci. 2018 May 1;5(1):142–73.
60. Kouri A, Gupta S, Yadollahi A, Ryan CM, Gershon AS, To T, et al. CHEST Reviews: Addressing reduced laboratory-based pulmonary function testing during a pandemic. CHEST [Internet]. 2020 Jul 8 [cited 2020 Jul 8];0(0). Available from: https://journal.chestnet.org/article/S0012-3692(20)31867-5/abstract
61. Yordanov Y, Dechartres A, Lescure X, Apra C, Villie P, Marchand-Arvier J, et al. Covidom, a Telesurveillance Solution for Home Monitoring Patients With COVID-19. J Med Internet Res. 2020 Oct 22;22(10):e20748.

62. Coravos A, Khozin S, Mandl KD. Developing and adopting safe and effective digital biomarkers to improve patient outcomes. Npj Digit Med. 2019 Mar 11;2(1):1–5.
63. Environics Research. Consulting Canadians on the Future of their Health System: A Healthy Dialogue [Internet]. Canada Health Infoway; 2020 Nov [cited 2020 Dec 22]. Available from: https://www.infoway-inforoute.ca/en/component/edocman/resources/reports/3850-a-healthy-dialogue-executive-summary
64. Byambasuren O, Sanders S, Beller E, Glasziou P. Prescribable mHealth apps identified from an overview of systematic reviews. Npj Digit Med. 2018 May 9;1(1):1–12.
65. Guiding principles for physicians recommending mobile health applications to patients [Internet]. Canadian Medical Association (CMA); 2015. Available from: https://policybase.cma.ca/en/permalink/policy11521

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Better Breathing 2022

The **39th annual Better Breathing Conference** will take place from Wednesday January 26 to Friday January 28, 2022 as part of a larger Better Breathing Week. Pre-Conference sessions include Policy Forums on Airways disease asthma, COPD, Lung Cancer, and Infectious Respiratory Disease; the ORCS Research in Action: a Celebration of Achievements; and a TB Gathering. Once again, Better Breathing Week will be delivered virtually.

Many thanks to Dr. Geneviève Digby and the planning committee for their help in developing such an excellent program even in the face of the unprecedented difficulties caused by the pandemic.

Popular traditional programming will return, including the Respirology Year in Review, the venerable André Péloquin clinical case series, and the Resident Case Presentations.

More information, including the program and the link to register are available at **betterbreathing.ca**.

Registration will remain open until Friday January 28, 2022 upon conclusion of the conference. Be sure to register for any sessions you may like to view even if you can't attend as recordings will be made available for 3 months upon conclusion of the conference only to those who've registered to attend.

We look forward to seeing you there!

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The Lung Health Foundation hosts various continuing medical education programs including 3 annual conferences (Better Breathing, Respiratory Health Forum, and TB) and periodic webinars on a wide range of topics related to respiratory lung health, many of which are Mainpro+ certified. For more information or to set up a workshop for your healthcare team or organization please contact pep@lunghealth.ca.

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The Ontario Thoracic Review is the official publication of the Ontario Thoracic Society, a medical section of the Lung Health Foundation.