THE RESPONSE OF MOBILE APPLICATIONS TO CRISIS IN CANADA

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree of Master of Science – eHealth

DESCRIPTIVE NOTE

Master of Science (2020)

(eHealth)

McMaster University

Hamilton, Ontario

Title: The Response of Mobile Applications to Crisis in Canada

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Number of Pages: 117

ABSTRACT

When a crisis strikes, technology allows information to move quickly. By leveraging mobile technology, mobile applications (apps) can serve as a reliable way to ensure rapid communication. This thesis evaluated mobile apps created for two crises: the COVID-19 pandemic and the Indigenous Mental Health crisis. Through the completion of two independent scoping reviews on each topic, apps were collected, analyzed and assessed in a double-blind nature, including results from both grey and scientific literature searches. The results of these scoping reviews were compiled to create an overall report on the capability of these apps to address each crisis respectively. The results indicate that while apps can be quickly developed and made available on application stores in order to help mount a rapid response to crises, many do not fit the needs of users and none can completely cater to a crisis within one app. Further research is required to provide evidence of effectiveness, acceptability and usability of these apps. Innovation and collaboration between key stakeholders, government, health care organizations and application developers will be essential to address the identified gaps and facilitate the creation of successful apps for use in either crisis.

ACKNOWLEDGMENTS

I would like to provide my deepest appreciation to my supervisor, Dr. Cynthia Lokker and my thesis committee, Dr. Christine Wekerle, Dr. Anne Niec, and Dr. Alex Drossos. Without your tireless efforts to support me, this thesis would not have been possible. It has been a privilege to work with all of you. My deepest thanks goes to Dr. Cynthia Lokker for always making time to talk about my countless ideas on my thesis and other research projects in my field and Dr. Christine Wekerle for helping me shape my ideas.

I would like to thank everyone who assisted me in my scoping reviews including Savanah Smith, Sarmini Balakumar, Katherine Toy, Dr. Dawn Martin Hill, Dr. Beverly Jacobs, Dr. Kristen Thomasen, Alessia D'Elia, Giulia Coletta, Bronwyn Novak and Ashley Avarino. I would also like to thank the librarians Ms. Tamara Navarro, and Ms. Janice Linton who double checked my search strategies and helped me learn to build one on my own.

Lastly, I dedicate my thesis to my loving family, boyfriend, Josh, and dog, Smokey.

ABBREVIATIONS

apps: applications

BIPOC: Black, Indigenous and People of Colour

BMC: BioMed Central

CDC: Centre for Disease Control and Prevention

COVID-19: 2019 novel Coronavirus disease

CRCC: Canadian Research Coordinating Committee

FAQ: Frequently Asked Questions

mHealth: mobile health

PRISMA-ScR: PRISMA for Scoping Reviews

SSHRC: Social Sciences and Humanities Research Council

SMS: Short Message Service

SARS: Severe Acute Respiratory Syndrome

WHO: World Health Organization

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CHAPTER 1: GENERAL BACKGROUND

General Background

Crisis is defined as a time of intense difficulty, trouble or danger. This thesis focuses on two major crises of the 20th century: The Indigenous Mental Health crisis and the Severe Acute Respiratory Syndrome Coronavirus 2 (COVID-19) pandemic, with a specific narrowing to Canadian communities. While it is difficult to anticipate the onset of crisis, crisis planning and management is important as it helps develop routes of action, identifies major challenges that arise, and gathers information from similar cases. It is important to place emphasis on the stark differences of the two crises covered in this thesis: most importantly, the Indigenous Mental Health crisis has roots of colonialism, abuse and intergenerational trauma. In contrast, the COVID-19 outbreak focuses on an infectious disease and addresses a physical health pandemic that spread worldwide due to the contagious nature of the virus. The differences between these two crises are not to be ignored, the main goal of this paper is to describe and report the way mobile apps have been designed and leveraged to respond to these crises. The nature of the applications generated in response to both crises provide important lessons for the way that mobile application development can be harnessed to better address the needs of end users and support wide-scale public health responses.

mHealth

Mobile health (mHealth) applications are software tools that can be installed on mobile devices, generally smartphones. With the increasing use of technology, apps have proven to be capable of broadly disseminating health knowledge and resources (1-5). As a

suitable and powerful tool, apps can be used as a means for engagement, to facilitate treatment, and to maintain gains after treatment has ended in a more affordable and accessible format. In both crises, apps have been leveraged to provide information in a manner that will relieve pressure on the healthcare systems. Very quickly, apps for COVID-19 have been designed to facilitate self-assessment at home, track statistics and provide current updates (6). Whereas apps for Indigenous Mental Health have been designed for knowledge translation, and community resources. However, Indigenous Mental Health apps have had a slower progression, though prevalent for longer than COVID-19. While some apps do exist for Indigenous Mental Health, 3 times the number currently exist for COVID-19 specific to Canada.

The Indigenous Mental Health Pandemic

For over a century, Indigenous children in Canada were removed from their families and home dwellings, forcibly taken to Residential Schools where they were housed and educated under the authority of the Government of Canada in hopes of cultural assimilation to the dominant culture (7-9). Considered a cultural genocide, Residential Schooling has caused devastating effects in the First Nations, Inuit and Métis communities of Canada, with intergenerational trauma causing descendants of Residential School Survivors to share the same burdens as their ancestors without having attended the schools themselves (7-9). These effects include personal trauma and compromised family structure, with a loss of language, culture and teaching of tradition from one generation to another (7-9). In alignment with this trauma, the Indigenous Mental Health crisis was acknowledged and appealed for in the Truth and Reconciliation Commission of Canada:

Calls to Action stating "we call upon the federal government, in consultation with Aboriginal peoples, to establish measurable goals to identify and close the gaps in health outcomes between Aboriginal and non-Aboriginal communities, and to publish annual progress reports and assess long-term trends. Such efforts would focus on indicators such as: infant mortality, maternal health, suicide, mental health, addictions, life expectancy, birth rates, infant and child health issues, chronic diseases, illness and injury incidence, and the availability of appropriate health services." (10-12)

The COVID-19 Outbreak

An outbreak of the 2019 novel Coronavirus diseases (COVID-19) that began in Wuhan, China has now escalated to a worldwide pandemic (13). Individuals infected with COVID-19 experience mild to moderate respiratory illnesses, but often recover without requiring special treatment (14). Symptoms of COVID-19 can include fever, cough, difficulty breathing and pneumonia in both lungs (13). Older adults and those with underlying health disorders and medical problems such as cardiovascular and respiratory diseases, diabetes and cancer are more likely to have a more severe form of illness (14). COVID-19 spreads most commonly by human-to-human transmission through droplets of saliva or discharge from coughs and sneezes (14). Around the globe, recommendations of social distancing for all citizens and self-isolation for those experiencing COVID-19 related symptoms have been implemented, with some regions resorting to government enforcement to uphold social distancing measures and prevent community transmission. Given what is known about transmission rates of coronaviruses, the COVID-19 pandemic

may quickly overwhelm healthcare systems, leaving severely infected patients with deteriorating pulmonary conditions and no known effective forms of treatment (15).

In the case of each crisis, users need to be cognisant of the information being provided by critically appraising apps before downloading and using them. There are currently no studies that assess the content of existing apps for either COVID-19 or Indigenous Mental Health available in Canada. This thesis presents two scoping reviews that explore the following domains related to COVID-19 and Indigenous mental health:

(1) identify available mobile apps;

(2) characterize the focus or goals of the apps;

(3) describe the apps in terms of accessibility, target age group, notification features, account capability, feedback surveys, language style and connectivity;

(4) describe the app in terms of specialized features (for example- Indigenous symbols, teaching, and language);

(5) discuss the limitations of the available literature; and

(6) present areas for future research.

As mobile apps are continuing to grow in popularity among the general public, so does the opportunity to increase and evaluate the quality of care and access to evidence-based treatments provided through apps. In order to address these domains, scoping reviews were selected as an appropriate method to assemble what we know on the use of apps within these two crisis scenarios.

Scoping review methodology

Scoping reviews are defined as a synthesis of research that aims to "map the literature of a particular topic or research area" while providing an opportunity to identify key concepts, gaps in research and varying types and sources of information (16, 17). With little information available on how to undertake a scoping review, in 2002, Arksey and O'Malley developed a framework to guide the procedure (16,17). Based on their classification, scoping reviews are commonly undertaken in the following situations:

- When a review is rapid and may not fully describe details, but still produces information in fields where it is difficult to visualize the range of material available.
- To determine the value of undertaking a full systematic review – providing ample evidence beyond an initial scoping review.
- To summarize and disseminate research findings to a variety of populations including policy makers, practitioners, and consumers.
- To identify research gaps in the existing literature especially in areas where little to no research has been conducted (16, 17).

The framework for scoping reviews diverges from some of the procedures followed in systematic reviews but remains consistent such that the process should be documented in a manner to be reproducible by others, upholding the reliability of findings and maintaining methodological rigour (16, 17). Scoping reviews adopt a method whereby studies relevant to the topic are included regardless of study design. At the outset, it encourages researchers not to place limitations on search terms or identifying and selecting relevant studies. The process is not considered to be linear but rather iterative, requiring

each researcher to engage with the individual stages in a flexible manner. The stages of the framework are summarized as:

- Stage 1: Identifying the research question
- Stage 2: Identifying relevant studies
- Stage 3: Study selection
- Stage 4: Charting the data
- Stage 5: Collating, summarizing and reporting the results
- Optional stage: consultation exercise (16, 17)

Both scoping reviews presented here also adhered to the PRISMA extension for scoping reviews (18), a checklist of 20 essential reporting items and 2 optional items to cover when conducting a scoping review (18). The use of PRISMA-ScR ensured transparent reporting of information, consistent with reporting common to systematic reviews and meta-analyses (17). The scoping reviews are presented within Chapter 2 and Chapter 3, with a holistic discussion section that compares both reviews in Chapter 4.

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CHAPTER 2: Mental Health Mobile Applications developed for Indigenous Communities in Canada: A Scoping Review

Mental Health Mobile Applications developed for Indigenous Communities in Canada: A Scoping Review

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Abstract

Background: For over a century, Indigenous children were removed from their families and forcibly placed in Residential Schooling. Residential Schooling forced cultural assimilation and resulted in cultural genocide which has caused intergenerational trauma to survivors, and their families. This intergenerational trauma has caused post-traumatic stress disorder, compromised family structures and resulted in losses of language, culture and teachings from one generation to another. In alignment with this trauma, the Indigenous Mental Health pandemic was called to action in the Truth and Reconciliation Commission of Canada. Today, Indigenous populations are characterized with increased prevalence of psychiatric disorder and distress, being nearly twice the level of non-Indigenous communities. Mobile applications for mental health support have been found to be an effective way of providing support in an easy-to-access and low-cost manner. In recent years, increasing numbers of mental health applications have become available for the general population however, very few have been developed for Indigenous communities in Canada. This review seeks to assess the mental health applications developed for Indigenous communities in Canada.

Objective: To review the nature and scope of mental health related mobile apps developed for Indigenous communities in Canada.

Design: A scoping review with searches of EMBASE, CINAHL, MEDLINE, psycINFO, the grey literature, and the two largest app stores, Google Play and Apple's App store, for details on mobile apps designed for mental health. Descriptions of the apps were analyzed thematically and summarized; gaps were identified.

Results: After deduplication, a total of 100 potential apps were found through the search strategy. Three apps and one abstract met inclusion criteria. Two of the apps were available for Apple & Android phones, and one for Android smartphones only. The apps were identified through the grey literature; none were through peer-reviewed literature. The apps were all developed after 2016 and by commercial or private individuals, available in English, and contained at least one image or symbol related to Indigenous culture. Two comprised tools to connect Indigenous youth to counsellors and networks, and the last included a combination of mental health reporting and connection to networks.

Conclusions: While the need for mental health support in Indigenous communities has long been recognized, there is a limited availability of mental health apps specifically tailored for Indigenous persons. A user-centered, collaborative, interdisciplinary approach is required to increase the number of evidence-based and culturally appropriate apps. Such a team-based approach should combine research expertise, clinical and traditional practitioners from the Indigenous community, community members, and app developers, to bring together the skill sets and insight required for the creation of relevant mental health apps to support Indigenous communities. Information gathered from the creation of these apps can inform practice and policy for future apps and mental health support.

Keywords: technology, mental health, Indigenous, First Nations, mobile apps

Background

For over a century, Indigenous children were removed from their families and home dwellings, and forcibly taken to residential schools where they were housed and educated under the authority of the Government of Canada in hopes of cultural assimilation to dominant culture (1-3). Considered to be a cultural genocide, residential school has caused devastating effects in the First Nations communities of Canada, with intergenerational trauma causing descendants of residential school survivors to share the same burdens as their ancestors without having attended the schools themselves (1-3). These effects include personal trauma and compromised family structure, with a loss of language, culture and teaching of tradition from one generation to another (1-3). In alignment with this trauma, the Indigenous Mental Health pandemic was called to action in the Truth and Reconciliation Commission of Canada: Calls to Action stating "we call upon the federal government, in consultation with Aboriginal peoples, to establish measurable goals to identify and close the gaps in health outcomes between Aboriginal and non-Aboriginal communities, and to publish annual progress reports and assess long-term trends. Such efforts would focus on indicators such as: infant mortality, maternal health, suicide, mental health, addictions, life expectancy, birth rates, infant and child health issues, chronic diseases, illness and injury incidence, and the availability of appropriate health services" (4-5).

Today, there are approximately 370 million Indigenous Peoples globally, making up 5% of the worldwide population (6-8). In Canada, there are approximately 1.7 million people who identify as Indigenous, comprising 4.9% of the Canadian population alone (6-

8). The Indigenous community in Canada is made up of First Nations, Métis and Inuit populations. Since 2006, the Indigenous community in Canada has grown by 42.5%, more than four times the growth rate of the non-Indigenous population (6-8). Statistics Canada has projected that in the next 20 years, the Indigenous population will grow to more than 2.5 million people (8).

Life expectancy in the Indigenous population is shorter than in the non-Indigenous population, in a large part is due to increased infant mortality and deaths of young people by accident and suicide (9). Epidemiological studies have highlighted that high rates of suicide, substance use disorders, and violence are a direct consequence of colonialism, where Indian Residential Schools and other atrocious government policies resulted in disruption of traditional lifestyles and overwhelming trauma (11-14). The impacts of Residential Schools have echoed through generations, with the last school in Canada closing in 1996 (15). While the Truth and Reconciliation Commission of Canada, created in 2008, works to advocate for the compensation of Indigenous survivors of Residential Schools and facilitates reconciliation among Survivors, their families and settler Canadians, however, this trauma cannot be erased (15-19). Reported prevalence of psychiatric disorders in this community is likely lower than the true prevalence as many Indigenous peoples do not seek or receive psychiatric treatment (16). Of those who do seek treatment for mental health, research has shown that the prevalence of psychiatric conditions is nearly twice the level of neighbouring non-Indigenous communities (20-21). Suicide is one of the most dramatic indicators of distress, with elevated rates in First Nation, Inuit and Métis communities, particularly among youth (9,10).

To date, mental health services have not been able to meet the needs of Indigenous communities and those living in rural and remote (i.e., fly in) communities face additional barriers to access (22). In areas where mental health services are available, few professionals have training to specifically support Indigenous communities (9). In remote or rural areas, there are even fewer material resources and social service or health care providers assume multiple roles, which can lead to burnout due to overwork, the stressful nature of the job, and lack of adequate support (11, 22). In areas where health care providers are available, mental health training for Indigenous communities can be limited, lacking cultural competence and knowledgeable mental health care providers. Research has suggested that Westernized interventions could be utilized in these areas if they incorporate culturally based intervention strategies and recognize historical trauma by providing examples on how participating in Traditional activities helped Indian Residential School survivors recover from historical trauma in all treatment programs (23 - 25). Other challenges for accessing mental health services still remain and include stigma, discrimination, maintaining anonymity due to limited choice of healthcare providers and counsellors (23 – 26). Given this scenario of insufficient support, mobile health apps for mental wellness in Indigenous communities have been a recent consideration to address the gap between mental health service need and availability.

Mobile health (mHealth) applications (apps) are software tools that run on smartphones. They have the potential to broadly disseminate mental health knowledge and available resources (27-29). As a suitable and powerful tool, apps can be used as a means for engagement, to facilitate treatment, and maintain gains after treatment has ended in a

more affordable format (30-33). Individuals who are at high risk for developing mental health problems have been shown to have difficulty accessing mental health services and support (24, 34-36), face barriers towards reimbursement, and have difficulty locating health care providers who will accept a specific form of coverage (34-36). In addition, attitudes and beliefs surrounding treatment can also serve as a barrier, especially for multicultural populations (36). As mobile apps are continuing to grow in popularity among the general public, so does the potential to increase the quality of care and access to evidence-based treatments through apps. By creating culturally appropriate mobile apps for Indigenous communities, we can begin to move to a hybrid model of mental health care that can provide treatment, monitoring and adherence, health promotion and educational resources.

The objective of this review is to examine the current literature and the digital landscape on mental health apps specifically available for Indigenous communities in Canada. Through thematic analysis and descriptive summaries, we investigated the available apps and highlighted potential considerations and generalizable ideas for future apps. Strengths, limitations, gaps in literature, and suggestions for the future were analyzed and included.

Purpose

This study aims to:

1. Identify available mental health apps for Indigenous communities located in Canada
2. Characterize the focus or goals of the apps

3. Describe the app in terms of Indigenous related features (symbols, water teachings, language, Indigenous ways of knowing, Medicine Wheel, etc.) and general app characteristics (notifications, account capability, speed, etc.)

Methodology

The Arksey and O'Malley framework was utilized with supplements for methodological improvements for scoping reviews (37, 38). Our methods also align with the PRISMA extension for Scoping Reviews (PRISMA-ScR) (39).

Stage 1: Identifying the Research Question

The research question was: What are the available mental health mobile apps (apps) developed for Indigenous communities in Canada? Secondary research questions were (a) What do these mobile health apps target?; (b) Have these apps been evaluated?; and (c) Where are these apps available? We defined "mental health" as apps promoting improvement to emotional well-being and psychological improvement without the presence of other health disorders (e.g., apps targeted specifically to patients with diabetes). We kept this definition in line with the Indigenous Mental Health and Healing Model which highlights that the well-being of Indigenous Mental Health is intersectional between community, cultural identity, holistic approach and interdependence (108).

Stage 2: Identifying Relevant Studies and Apps

Searches for relevant apps were conducted in clinical databases, grey literature, and mobile app stores (Apple App Store, and GooglePlay). Electronic databases EMBASE, CINAHL, MEDLINE, and PsycINFO, from inception to August 2019 were searched. The

search strategy (see Appendix 2 - A) was developed with advice from a science librarian and aimed to capture articles that included mobile apps for Canadian Indigenous communities. The search results were then sorted to identify those specifically targeting mental health. Searches of the app stores were conducted using a variety of Indigenous and Aboriginal specific terms such as “Indigenous”, “First Nations”, “Mental Health”, “Canadian”, “Native”, and “Aboriginal”, etc. A complete list of this string can be found in Appendix 2 - A.

Stage 3: Study and app selection

Citations retrieved from the search strategy were imported into Rayyan, an online systematic review program, to review titles and abstracts for inclusion or exclusion. Two authors (N.N and S.B) first completed a practice screen of 10 articles by deciding whether or not to include articles based on the following questions: (1) Does this article include Indigenous communities? and (2) Does the article refer to or include Mental mHealth Apps? If both screeners responded “yes” to both questions, the full text of the article was pushed forward to the next stage of reviewed full review screening. If there was a discrepancy between the reviewers , articles were reviewed and discussed to achieve consensus. Both screeners independently and blindly screened the title and abstracts, then reviewed unblinded for any discrepancies. For apps identified on the GooglePlay or Apple Store, identified apps were screened in duplicate using the same inclusion and exclusion criteria as for the scientific literature. Any discrepancies in agreement were reviewed and discussed to achieve consensus.

The inclusion criteria included citations pertaining to Indigenous communities in Canada and mental health apps compatible with mobile smartphones. The exclusion criteria were mobile apps that targeted persons with disorders other than a mental health disorder (e.g., diabetes) even if they included a mental health component (e.g., resiliency), Indigenous communities not in Canada, and/or apps not related to mental health.

Stage 4: Charting the data and Stage 5: Collating, summarizing and reporting the results

The following data was extracted from included papers, abstracts and apps. Two reviewers (N.N and S.B.) piloted data extraction, and then reviewed the data together. For searches of the app stores three reviewers (N.N, K.T and S.B.) reviewed inclusion decisions collectively and extracted data independently based on pre-determined criteria. All extracted data was verified by a second author (N.N, K.T, S.B). Data elements included whether the app had been created incorporating or accounting for the Indigenous community; and app features such as age rating, notification features, account capability, feedback surveys, speed, security and privacy; Indigenous-specific elements such as cultural symbols, Indigenous language availability, Indigenous teachings, and Indigenous resources ; and inclusion of mental health topics such as resiliency, social and emotional wellness, anxiety and depression. Details were summarized into tables such as summary of apps (Table 1), research studies on mHealth tools (Table 2), app specific features (Table 3) and Indigenous (Table 4) and mental health (Table 5) related features. This information was further analyzed and can be observed within the results and discussion below.

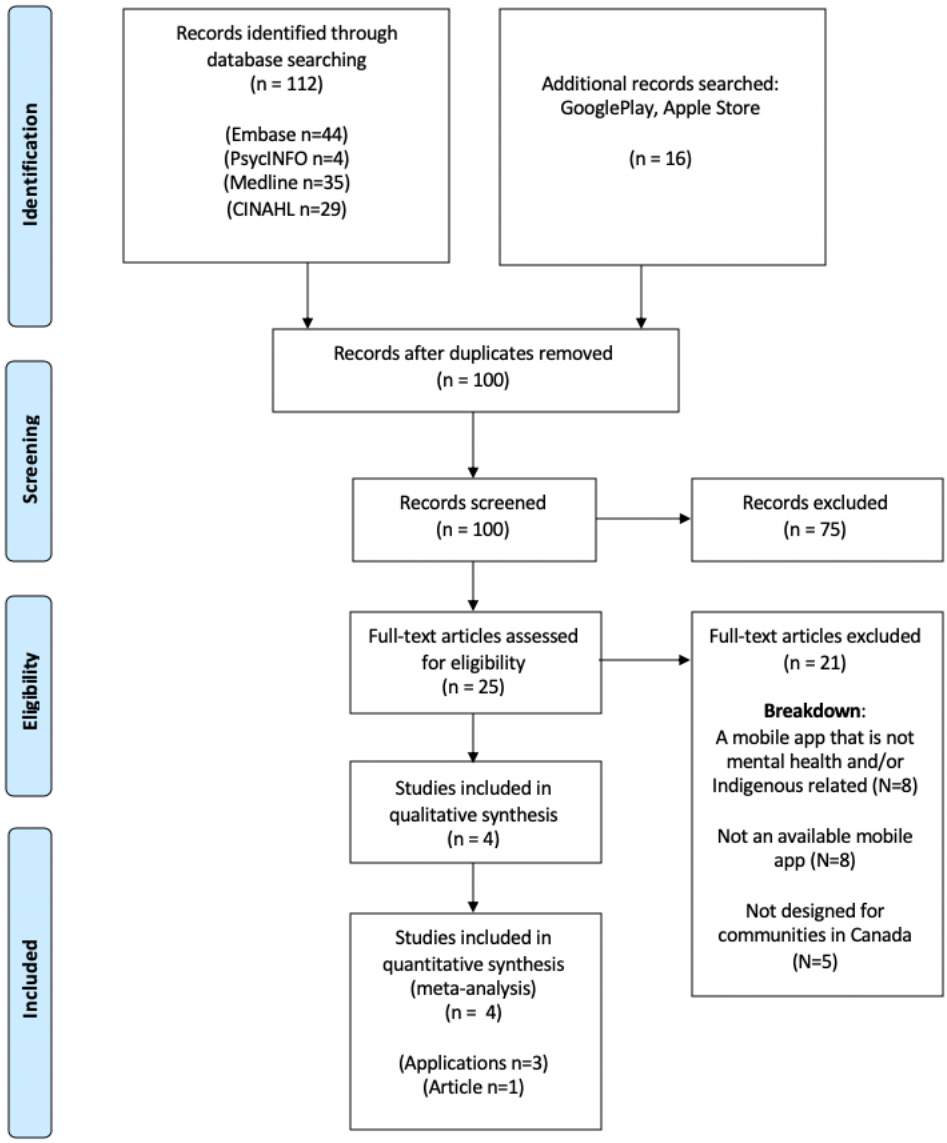

Figure 1: Prisma Flow diagram of study and app selection.

Results

Of the 100 articles and apps identified through our search strategies, three apps from the app stores (Table 1) and one article, a conference abstract, from the literature databases met our inclusion criteria (Table 2). The primary reason for exclusion was not

applying to either an Indigenous or mental health context. All four of the included items were published between 2016-2019.

Results

Table 1. Summary of apps included in this study.

APPLICATION NAME	DEVELOPER	DESCRIPTION
INDIGENOUSFRIENDS (40)	Alejandro Mayoral-Banos	Created for a Master's level thesis (12), the mobile app provides a supportive space for Native Youth with access to Indigenous counselling, social networking, and information about resources and events in Canada.
FIRSTRESPONSE: MATAWA LC APP (41)	QWAN Technologies	App users contact peer support workers trained to assist in connecting users to the tools and resources provided or recommended by their organization.
IT'S MY LIFE (42)	Push Interactions Inc	App uses 9 areas to explore what is important to the growth and development of First Nations Youth to set goals and achieve wellness.

Table 2. Included research studies on mHealth for indigenous communities

REFERENCE	**KRISTMAN & GILBEAU, 2018 (43)**
TYPE OF PUBLICATION	Conference Abstract reporting development of an app prototype in a hackathon environment, with a team comprised of the principle investigator, knowledge user, and individuals with lived experience, technical, design and programming expertise.

POPULATION	Indigenous workers experiencing stress
APP DESCRIPTION	e-Mental health app based on the medicine wheel and Indigenous cultural teachings

App Characteristics

Based on app store descriptions from GooglePlay and the Apple App Store, the three apps were classified as "social networking," "utility" or "lifestyle." App specific features are summarized in Table 3. Of the three apps, the age ratings varied with IndigenousFriends (40) catering to 12+, FirstResponse (41) 17+ and It's My Life (42) being 4+. All of the apps had account capability (means to set up an account with an email and password), were relatively quick in speed (without any lags between screens - a subjective measurement), and none had notification customization features within the app (hiding notifications, notification frequency, specific notifications only). IndigenousFriends (40) and It's My Life (42) both had feedback surveys for users and had recently been updated. IndigenousFriends (40) also had map features, allowing users to locate nearby Indigenous resources, tutorials, and an option for French language. There was no cost associated with the three apps; each is completely free to the user.

Table 3. Specific features associated with each app.

INDIGENOUS RELATED FEATURES (Y FOR YES, N FOR NO)	**MOBILE APPS (N=3)**

	INDIGENOUS FRIENDS (40)	FIRSTRESPONSE: MATAWALC (41)	IT'S MY LIFE (42)
AGE RATING	12+	17+	4+
ACCOUNT CREATION-	Y	Y	Y
NOTIFICATION FREQUENCY OPTIONS	N	N	N
MAP FEATURES	Y	N	N
FEEDBACK SURVEYS	Y	N	Y
TUTORIAL FEATURES	Y	N	N
GOOD IMAGE RESOLUTION	N	N	Y
QUICK SPEED	Y	Y	Y
SECURITY & PRIVACY FEATURES	N	Y	N
LANGUAGE FEATURE (FRENCH ONLY)	Y	N	N
RECENT UPDATES	Y	N	Y

REQUIRES INTERNET CONNECTION	Y	Y	N

Indigenous specific features (Table 4) associated with the mobile apps varied. None of the apps had an option for Indigenous language. IndigenousFriends (40), FirstResponse (41) and It's My Life (42) had Indigenous related symbols and images, utilizing medicine wheels, eagles, feathers, and dream catchers. IndigenousFriends (40) included 3 symbols, It's My Life (42) included 2 symbols, and FirstResponse (41) had 1 symbol. None of the apps included Indigenous teachings of love, respect, courage, wisdom, humility, honesty or truth. IndigenousFriends (40) and FirstResponse (41) included information on Indigenous related events in the community with FirstResponse (41) targeting high school events, and IndigenousFriends (40) catering to university students of York and St. Paul's Universities in Canada. Lastly, all apps included Indigenous-specific resources such as events in the area, scholarships, upcoming movies, and popular articles such as the origin of First Nation monies (e.g. where money that supports Indigenous communities comes from).

Table 4. Indigenous related features associated with each app.

INDIGENOUS RELATED FEATURES (Y FOR YES, N FOR NO)	**MOBILE APPS (N=3)**		
	INDIGENOUS FRIENDS (40)	FIRSTRESPONSE: MATAWALC (41)	IT'S MY LIFE (42)

INDIGENOUS LANGUAGE	Not included	Not included	Not included
INDIGENOUS RELATED SYMBOLS AND IMAGES	Y	Y	Y
INDIGENOUS TEACHINGS	N	N	N
INFORMATION ON INDIGENOUS RELATED EVENTS IN THE COMMUNITY	Y	Y	N
INDIGENOUS RESOURCES	Y	Y	Y

IndigenousFriends (40) and FirstResponse (41) had little mental health related information, and any information was only available by links to external websites that required web access. IndigenousFriends (40) included information and articles related to emotional wellness, suicide and grieving. FirstResponse (41) had information and articles related to anxiety, depression, and schizophrenia. It's My Life (42) had information related to a wide range of mental health topics including resiliency, social and emotional wellness, anxiety, depression, schizophrenia, eating disorders, grieving, obsessive compulsive disorders, and more found in Table 5. All of the articles and information available on It's My Life (42) were directly components of the app, and accessible without internet access.

Table 5. Specific mental health topics and features included in the apps.

MENTAL HEALTH RELATED FEATURES (Y FOR YES, N FOR NO)	**MOBILE APPS (N=3)**		
	INDIGENOUS FRIENDS (40)	FIRSTRESPONSE: MATAWALC (41)	IT'S MY LIFE (42)
RESILIENCY	N	N	Y
SOCIAL WELLNESS	N	N	Y
EMOTIONAL WELLNESS	Y*	N	Y
ANXIETY	N	Y*	Y
DEPRESSION	N	Y*	Y
SCHIZOPHRENIA	N	Y*	Y
EATING DISORDERS	N	N	Y
GRIEVING	N	N	Y
OBSESSIVE COMPULSIVE DISORDERS	N	N	Y

POST TRAUMATIC DISORDERS	N	N	Y
SUICIDE	Y*	N	Y
GRIEVING	Y*	N	Y

*The topic is not found on the app itself but through a link to a website which requires internet service and access.

Discussion

This scoping review highlights the current status of mobile apps in the context of Indigenous communities and mental health. No evaluations of existing Indigenous mental health apps in Canada were found in the published peer-reviewed literature and three mobile apps were retrieved from searches of the app stores. The app described in the included abstract is currently being exclusively used for research and is in the process of further development and could not be included for full review in this paper as it was not available to the authors (43). . In contrast, Radovic (2016) found over 208 readily available smartphone apps for mental health and/or support for the non-Indigenous population (44), vastly more than the number of those developed for Canadian Indigenous communities. This low yield of research activity and mobile app availability reflects the lack of mental health programming and support for Indigenous communities despite higher levels of mental health disorders (10). While no peer reviewed research was found for mobile apps as an intervention reporting health relevant outcome, a master's level thesis that informed

the creation of "IndigenousFriends" was identified and highlights the specific steps taken to make the app Indigenous focused (45).

Language

Of the mental health apps developed for Indigenous communities in Canada, all were in English, without the option of Indigenous language. IndigenousFriends (40) stated that while Indigenous languages were first considered, they were eventually not included, to avoid confusion among Indigenous users belonging to different nations and speaking different languages and dialects (45). Thus, selecting any language for an app could be problematic. However, a culture's conceptual understanding of the world is articulated through its own language, making language a crucial part of identity (46, 47). Indigenous health consists of a combination of: spiritual, mental, emotional and physical well-being with any disruption being seen as a loss of health (48). Spiritual health has been hallmarked by intergenerational trauma with deep grief being caused through taking away of language and culture, imposed by residential schooling (48, 49). Since spiritual health contributes to the overall combination of health, damage through colonization, residential schools and more can perpetrate through intergenerational trauma and impact overall health greatly (48, 49). A study by Hallett et al. (2007) found lower suicide rates for youth from Indigenous communities in British Columbia; communities that were 50% conversationally fluent had 16% fewer suicides than Indigenous communities with lower fluency (49). Language remained a consistent correlated factor for suicide rates even when all other factors were adjusted for in the analysis (50). Future apps should consider making these apps available

in multiple Indigenous languages, so that language preference can be selected by users to promote cultural alignment.

Symbols

Symbols are considered the basic unit of culture, being able to convey a message without further explanation or language (51). FirstResponse (41) included a single symbol of a feather as the main icon of the app. Feathers are a common symbol of Indigenous culture observed in goose-feather blankets, mittens and moccasins, symbolic of Indigenous knowledge and bush skills (52). Feathers represent trust, honor, strength, wisdom and power, and are often given as a gift from a high official. It's My Life (42) contained some generic images such as blueberries, medical equipment, housing, as well as a dream catcher and medicine wheel, but this was a brief transition page as the app loaded and not a permanent screen. In contrast, IndigenousFriends (40) contained symbols of the medicine wheel based on Anishinabe tradition that depicts four colours representing the dimensions of human beings, and a Tipi, a sacred place that should be cared for by the whole community (45). The app was developed in keeping with the Tipi tradition, considering the app as a sacred space to be cared for by the community. This approach was a deliberate effort to include understanding and teachings of the Indigenous peoples. The name, IndigenousFriends (40), came from focus group sessions that suggested the simplicity was easier to remember, and its reflection of its inclusivity of all Indigenous groups (not a specific Indigenous nation) (45).

While symbols are important to convey culture and unite a community, many of these apps could have been created to be generalizable to all Indigenous populations in

Canada. It could be potentially harmful to use symbols conveying to one Indigenous clan due to misinterpretation and conflicting meanings (53). For example, crests are commonly property to the Indigenous clan who own them who may defend their ownership over these crests to prevent infringement of trademarking. It is important for app developers to consider making similar re-iterations of apps with appropriate symbols for each Indigenous community using the app.

Privacy and Security

Quality of care and willingness to share information could be affected by a sense that shared information is not being protected or that it can be easily accessed by others. Privacy breaches themselves can take an emotional toll which can negatively affect mental health. Currently laws for privacy and security in mHealth apps do not exist or are outdated. The Health Insurance Portability and Accountability act was designed in 1996, before the term mHealth existed (54 - 56). While there have been updates to the Health Information Privacy Rule, the last update was in 2002 and is not considered to be up to date (54 - 56). These laws need to be adapted to including mHealth and the mobile app industry (56). Of the three apps (40, 41, 42) included in this review only FirstResponse (41) contained a privacy policy statement directly on the app. The privacy policy outlined information collection and use, log data, communications, cookies, security, and changes that have come into effect since the app has been available. Interestingly, the app reports potential use of information by third party services such as Google Analytics, and the ability to use identifiable information within the app to contact you. Users of these apps should look into the privacy policies to ensure they understand where and how their information can be

used. Research has reported that lack of privacy is a leading reason to cause users to stop utilizing apps (54-57). In order to satisfy privacy, mobile apps should contain privacy policy statements if they collect information (54-57). Research has found that in mobile apps for depression, most privacy policies were only available after users entered data, forcing users into sharing their information (56). And while some apps have privacy policy statements, many privacy policies within apps are unacceptable and present a risk of privacy evasion (reference). While mHealth apps have the potential to be resources to extend health care, they must be safe, secure and responsible. Apps created for any community should integrate privacy policies to ensure users of their protection and rights of their information (57).

Mental Health Efficacy

Characteristics of high efficacy mental health apps are those with high user engagement, simple user interface and experience, transdiagnostic capabilities, and self-monitoring features (58 - 60). Of the apps included in this review, all apps had a simple interface with purposeful page layouts, consistency between screens, and common elements such as menus, and buttons. Only IndigenousFriends (40) fulfilled the other domains of high patient engagement and self-monitoring features. Upon account creation, which requires Indigenous status and postsecondary school attendance, IndigenousFriends (40) included features of public directories, chat capability, forums, mentorship (connected through SMS, and phone calls) and an “I Need Help Now” feature. The chat capability, forums and mentorship were supported by mentors, either Elders and/or Traditional Knowledge Keepers and/or Aboriginal Faculty members. The plan for the “I Need Help

Now" feature, if tapped, would ask for confirmation with a pop-up and geo-location tagging, and then notify a mentor who could offer timely assistance. At the time of evaluation, the forums and mentorship were available, but the "I Need Help Now" feature was not yet activated. However, it is reasonable that "I Need Help Now" was not yet activated if one considers the network and support training required to support this feature. If a user were to request help but no one were able to respond, this could be tragic. Additionally, none of the apps had transdiagnostic capabilities, defined as treating symptoms across comorbid disorders (example: anxiety and depression) (58 - 60). In addition, all of the apps appeared to compile a number of resources, and none focussed on mental health alone. For example, It's My Life (40) included information on housing, relationships, financial literacy and mental health. IndigenousFriends (40) and FirstResponse (41) used pre-existing platforms to share mental health resources such as websites, and phone numbers. In contrast, It's My Life (42), contained a mix of platforms, one was information related to mental health directly on the app and others were pre-existing information from websites. It's My Life (42), had no references for information directly on the app, raising questions of reliability when website links were not provided. In contrast, IndigenousFriends (40) and FirstResponse (41) included several sources and provided references for information (either through links or proper citations).

Notifications

All of the available apps lacked notification abilities, and all appeared to be of low quality with few regular updates. IndigenousFriends highlighted that while notifications and geo-location were initially of value, the functionality was not built in the app (45).

Notifications are considered helpful in engagement and participation of users, and geolocation can help localize someone in distress who is seeking assistance (61).

Age Group & Targeted Populations

The apps were designed to engage Indigenous persons of varying ages; young adults of university age (IndigenousFriends (40)), children and caregivers (FirstResponse (41)), and any age (It's My Life (42)). However, although age ratings were provided for each app on the app stores, after reviewing the apps it appears that the age recommendations from app stores do not match who the content is intended for. For example, It's My Life (42), has a recommendation of 4+ which seems to be inaccurate as the app discusses topics beyond this age group such as housing, finances, and employment. Furthermore, It's My Life (42), nor any of the other apps, had parental/guardian consent.

App Co-Creation

Co-creation refers to any act of collective creativity (62). For apps, this involves user-input and collaboration to build an app that is fit to the need. The included abstract from our search results, Kristman (2018), is utilizing app co-creation by including the opinions of those who will be using the app. It is not clear whether the other apps included in this review utilized co-creation (43).

Kristman (2018), and colleagues, are working towards increasing the number of mental health apps available for Indigenous communities (43). This is the only publication describing the development of a culturally relevant e-Mental Health resource for Indigenous employees and managers to better equip them to manage workplace stress (43). While the app has yet to be complete, the researcher is actively engaging in qualitative data

collection. This is expected to be the first Indigenous mental health app supported by a research study that directly links health-relevant outcomes to a mobile app (43).

Gaps in Research

There are gaps in knowledge about the feasibility of mobile apps, especially those regarding mental health. While there have been review papers, which examine the use of mobile mental health apps in general settings (63-65), there have been none to highlight the use of mental health apps in an Indigenous community. These studies examine usability (63-65), but it remains unknown whether these apps would be utilized in everyday lives. In particular, the lack of evidence for mental health apps for Indigenous communities in Canada, indicate that future research is required, especially on user engagement with apps, and the potential impacts that apps can have (both in Indigenous and other populations).

Limitations

Scoping reviews are not considered to be exhaustive, but rather intended to map literature in a field of interest quickly, in order to identify gaps in current research (37-39). Although we searched four databases, two app stores and other grey literature sources, it is likely that other relevant publications were not included. We also only included articles in English, which may have excluded relevant articles in other languages. Given our target population, it may be safe to assume that articles in Indigenous languages may have benefited from inclusion. In addition, research studies may also be undiscoverable due to data sovereignty and protection Indigenous communities hold.

eHealth Terminology

While the term eHealth is well-recognized today, a precise consensus of definition has still not been determined, with 51 definitions uniquely available (66). While these 51 definitions were identified in 2005 (66) these numbers may no longer be valid however no study has provided an update since. Therefore, "eHealth" ambiguously refers to technology as a tool to enable services, functions and processes that are related to health (66). This ambiguity in definition has been objectively studied in several systematic reviews. Thus, we recognize that researchers may use extensions of this definition resulting in nomenclature that result in research fragmentation.

App Utility

The nature of technology does not allow for a clear understanding on app utility. When research is not conducted behind a mobile app, is unclear if apps are found useful, or highly utilized. Without the use of standardized measurement instruments, it is difficult to conduct a randomized controlled trial of mobile app interventions that is considered to meet the standard of health care research (i.e., reliable and valid). Since mobile apps are however user-driven and increasingly utilized in today's society, it is not considered ethical to deem apps as experiments without the proper consent. Data obtained from app stores such as number of downloads and user reviews can also be a misrepresentation of user information being falsified or unrepresentative of user's perceptions (67, 68). Therefore, data obtained from app stores such as downloads or user reviews should be properly examined with research before being utilized to examine app utility (67, 68) .

Future Research

Mobile apps developed for Indigenous communities can be considered a way to connect services to those in need of support. Advancing mobile technologies can contribute to improving patient-centred care for our increasing technology-based society. Developing tools for mental health problems with Indigenous communities requires special consideration especially regarding stigmas related to mental health and Indigenous communities. Thus, more research on mobile apps with Indigenous communities is required to determine the effectiveness of the apps in improving mental health or identifying the conditions they can be utilized for. In addition, research has reported that colonialism and trauma are much more significant causes of distress and that treatment should address these concerns rather than focusing specifically on mental health and/or substance use (69, 16). Thus, additional research should come in the form of evidence-seeking research that is grounded in the principles of co-creation. Co-creation of community mental health tools will allow the right tools to be created for the community that requires them.

Conclusion

For mental health support in Indigenous communities, our search found three apps that are available for download through the app store, and another app that may be designed and in production in the near future. Despite the limited number of apps and lack of research, mental health apps still present a unique solution for remote Indigenous communities, allowing services to be accessible in any location. Such apps can improve patient care, especially when tailored to the requirements and necessities of the communities they serve. However, research and evidence in this area is limited and sparse.

More research is required to create mental health apps that are relevant and specific to Indigenous communities, but this research should be done in a collaborative way, guided by the self-determined needs of individuals from these communities. As health-related apps continue to increase in number on the app store, studies providing evidence of their effectiveness and professional understanding is called for, to increase the successful utilization by the population of interest.

Acknowledgments

The authors would like to thank Tamara Navarro at the Health Information Research Unit for McMaster University for their help with the search strategy. The authors would also like to thank the librarians from the University of Alberta who provided the search strategy criteria and additional support to refine the strategy.

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CHAPTER 3: Mobile Applications for COVID-19: A Scoping Review

Mobile Apps for COVID-19: A Scoping Review

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Abstract

The rapid outbreak of Coronavirus disease (COVID-19) originating in Wuhan, China, and the subsequent declaration of a state of "pandemic" on March 11, 2020 has necessitated a widespread global response to manage and control the transmission, spread and impact of COVID-19. Mobile technology has been leveraged in a number of ways to control the spread of COVID-19, including to support knowledge translation. Mobile applications are accessible, acceptable, easily adopted, and have the ability to support social distancing efforts. The following review assesses the mobile applications available as of (date) to address COVID-19, and seeks existing studies in the literature that evaluate such applications. 36 studies, 72 websites and 312 mobile-based applications were identified through searches. 14 applications met the inclusion criteria and were analyzed. Additional eHealth tools identified through the search strategy were considered for supplemental analysis (including online dashboards and applications not available through application stores). This review provides a brief assessment of the goals of applications addressing COVID-19 early in the pandemic, the types of approaches being used by these applications, and draws conclusions on the needs not being met by such application-based interventions. Innovation and collaboration between government, healthcare organizations and application developers is needed to address the identified gaps and facilitate the successful harnessing of mobile applications in the management of COVID-19.

Keywords

Covid-19, Coronavirus, Mobile applications (apps), eHealth, Treatment, Symptoms, Assessment, Management

Background

An outbreak of 2019 novel Coronavirus disease (COVID-19) that began in Wuhan, China has now escalated to a worldwide pandemic [1]. Individuals infected with COVID-19 experience mild to moderate respiratory illnesses, but often recover without requiring special treatment [2]. Symptoms of COVID-19 can include fever, cough, difficulty breathing and pneumonia in both lungs [1]. Older adults and those with underlying health disorders and medical problems such as cardiovascular and respiratory diseases, diabetes and cancer are more likely to have a more severe form of illness [2]. COVID-19 spreads most commonly by human-to-human transmission through droplets of saliva or discharge from coughs and sneezes [2]. Around the globe, recommendations of social distancing for all citizens and self-isolation for those experiencing COVID-19 related symptoms have been implemented, with some regions resorting to government enforcement to uphold social distancing measures and prevent community transmission. Given what is known about transmission rates of coronaviruses, the COVID-19 pandemic may quickly overwhelm healthcare systems, leaving severely infected patients with deteriorating pulmonary conditions and no known effective forms of treatment [3].

Mobile health (mHealth) applications (apps) are software tools that can be installed on mobile devices, generally smartphones. With the increasing use of technology, apps have proven to be capable of broadly disseminating health knowledge and resources [4–8]. In an attempt to "flatten the curve" of the increasing number of COVID-19 cases, numerous apps have been created for COVID-19 to provide information to all civilians and subsequently relieve the pressure on healthcare systems. Apps have been designed to facilitate self-assessment at home, track statistics, and provide current updates. As the

number of COVID-19 apps continues to grow rapidly, users need to be cognisant of the information being provided by critically appraising apps before downloading. Fraudulent COVID-19 apps have been installing ransomware and spyware onto devices, resulting in Apple, Google and Amazon starting to block non-official Coronavirus apps from app stores, and denying any apps not from a "recognized institution" [9,10]. There are currently no studies that qualitatively assess the content of existing apps regarding COVID-19, despite reliance on these as part of a toolbox of strategies to support social distancing and personal decision-making to reduce the potential impact on overwhelmed clinical services. This review examines the current landscape of mobile apps available for COVID-19, providing a brief assessment of the goals of the apps and the approaches they use; we consider the potential of such app-based interventions for supporting pandemic efforts.

Purpose

The following study aims to:

(1) identify available mobile apps for COVID-19;

(2) characterize the focus or goals of the apps; and

(3) describe the apps in terms of accessibility, target age group, notification features, account capability, feedback surveys, language style and connectivity.

Methodology

The Arksey and O'Malley framework was utilized with supplements for methodological improvements for scoping reviews [11–13]. Our methods also align with the PRISMA extension for Scoping Reviews (PRISMA-ScR) [14].

Stage 1: Identifying the Research Question

The research question was: What mobile apps for COVID-19 are available to date? Secondary research questions included, (a) What are the goals and features of the mobile health apps?; (b) Have these apps been studied?; and (c) Where are these apps available?

Stage 2: Identifying Relevant Studies and Apps

Searches for relevant apps were conducted in clinical databases, grey literature (websites) and mobile app stores (Apple Store, and GooglePlay). Electronic databases including EMBASE, MEDLINE, and PsycINFO, were searched from inception to April 5th, 2020. The search strategy (Table 1) was developed with advice from a science librarian and aimed to capture articles that included mobile apps for COVID-19. The search results were then reviewed to identify articles specifically targeting COVID-19. Searches of grey literature, described in Table 1, were completed through the Google Search Engine using key words “Coronavirus”, “COVID-19”, “Covid”, “SARS-CoV-2”, “Corona Virus”, and “Corona” crossed with specific terms such as “app”, “apps”, “application” and “applications”. Google Search Engine results were screened; only results pages recommended by Google as relevant were included in our search. Searches of the app stores, described in Table 1, were conducted using 6 key terms (i.e. Coronavirus, COVID-19, Covid, SARS-CoV-2, Corona Virus, Corona) to search for iPhone and Android apps in the Apple App Store and Google Play Store, respectively. These terms were included to capture any apps relevant to Coronavirus treatment, assessment, and diagnosis. The only

restriction placed on apps was that they must be available in an app store and written in the English language (all other languages were excluded).

Table 1. Key Search Terms for Web of Science, PubMed and Embase.

Database	Search Terms
Web of Science	(mHealth or m-Health or mobile app* or cell* phone* or handheld device* or smartphone* or personal digital assist* or mobile device* or tablet* or iPhone or iPad) *AND* TOPIC: (Coronavirus* OR Coronavirus disease* OR Coronavirus infection* OR SARS-CoV-2 OR (wuhan and coronavirus))
Pubmed	(((2019-nCoV OR 2019nCoV OR COVID-19 OR SARS-CoV-2 OR ((wuhan AND coronavirus) AND 2019/12[PDAT] : 2030[PDAT]))))) AND ((m-health OR health OR mobile app* OR cell* phone* OR handheld device OR smartphone* OR personal digital assist* OR mobile device* OR tablet* OR iphone OR ipad))
Embase	(m-Health.mp. OR mHealth.mp. OR mobile app*.mp. OR mobile device*.mp. OR cell* phone*.mp. OR personal digital assist*.mp. OR handheld device.mp. OR iPhone.mp. OR smartphone*.mp. OR mobile device*.mp. OR tablet*.mp. OR iPad.mp.) *AND* ((wuhan AND coronavirus) Corona*.mp. OR Coronavirus*.mp. OR SARS-CoV-2.mp. OR SARS coronavirus/ OR COVID-19.mp.)
Google Search Engine	Coronavirus, COVID-19, Covid, SARS-CoV-2, Corona Virus, Corona crossed with App, Application, Apps, Applications each. *For example: Coronavirus, Coronavirus App, Coronavirus Application, Coronavirus Apps, Coronavirus Applications.*
GooglePlay and Apple Application stores	Coronavirus, COVID-19, Covid, SARS-CoV-2, Corona Virus, and Corona

Stage 3: Study and app selection

Articles and apps identified through the search strategies were screened according to the following inclusion and exclusion criteria. The inclusion criteria included any citations pertaining to COVID-19 and apps on mobile phones from 2019-present. The exclusion criteria were mobile apps that: (1) targeted persons with any disease other than COVID-19

(e.g., diabetes) even if they referred to other diseases within the coronavirus family of diseases (e.g., Severe Acute Respiratory Syndrome or SARS); (2) discuss the transmission, the management of symptoms, or the recommended treatment of conditions/diseases/illnesses other than COVID-19; and (3) apps not related to COVID-19. Any apps that were prototypes, not complete, or not available in an application store were excluded due to the potential for spyware, malware, and viruses that can be transmitted through mobile app when downloaded from sources other than the app stores.

Citations retrieved from each search strategy were imported into an Excel spreadsheet, in order to review titles and abstracts for inclusion or exclusion. Two authors (NN and AD) first completed a calibration screen of 10 articles, deciding whether to include articles based on the following questions: (1) Does this article target COVID-19? and (2) Does the article refer to or include COVID-19 apps? If both screeners responded "yes" to both questions, the full text of the article was included in the full-text review screening (phase 2). If there was a discrepancy between the reviewers or decisions on any article, these articles were reviewed by a third reviewer (GC) and discussed to achieve consensus. Both screeners independently and blindly screened the titles and abstracts, then reviewed unblinded for any discrepancies. For GooglePlay or Apple Store search results, identified apps were screened in duplicate using the same inclusion and exclusion criteria as for the scientific literature. Any discrepancies in agreement were reviewed with a third reviewer (GC) and discussed to achieve consensus.

Stage 4: Charting the data

The following data were extracted from included articles, abstracts, and apps. Two reviewers (NN and AD) piloted data extraction, and then reviewed the data together. For searches of the app stores two reviewers (NN and AD) reviewed inclusion decisions collectively and extracted data independently based on pre-determined criteria. All extracted data were verified by the other author (NN and AD). Mobile apps were examined for app features such as age rating, notification features, account capability, feedback surveys, and language style (Table 2). Features of the app that were specific to COVID-19 were extracted (Table 3). Grey literature searches using the Google Search engine were conducted to capture apps discussed in articles or news items; these searches identified apps, but also identified other eHealth tools, such as websites and dashboards. These items were examined for COVID-19 specific characteristics, and the results can be found in a supplementary table as these items did not meet criteria for the main analysis (Appendix A).

Stage 5: Collating, summarizing and reporting the result

Extracted information about articles and apps were summarized and assessed to identify themes and gaps. General and COVID-19 specific characteristics were assessed for each app (Table 2 and 3, respectively), and descriptions of each app were generated (Table 4).

Results

Summary of Search Results

Searches of EMBASE, Web of Science, and PubMed databases identified 34 articles. Of these 34 articles, 0 met inclusion criteria for the full-text review phase. Searches of grey literature yielded 72 web-based sites and popular articles; only 2 apps were found to be relevant and were identified through a popular article [15]. Searches of app stores identified 166 mobile apps. After de-duplication, 123 original apps were screened for inclusion. 14 apps met inclusion criteria and were eligible for data extraction. Major reasons for exclusions of apps were: 18.5% (N= 22) apps were related to business ventures (example: a Pizza shop called Pizzeria Corona), 6.72% (N=8) were related to education (example: releasing COVID-19 related announcements), and 13.4% (N=16) were related to entertainment (for example, games). Other reasons for exclusion included fitness apps (N=1), general apps that provided COVID-19 updates (N=6) (e.g. apps that provided users with updates to services related to COVID-19 but whose focus was not COVID-19), lifestyle apps (eg. Corona Community application) (N=9), apps discussing a different condition (N=2), navigation apps (N=1), apps not available in English (N=38), social networking apps (N=3) and research-related apps (N=3).

App Characteristics

The general characteristics of the 14 apps are summarized in Table 2; all were free or had a free option, 71% (n=10) targeted a general audience including individuals with symptoms of COVID-19, 7% (n=1) were designed specifically for medical professionals, and 14% (n=2) were designed for general and medical professionals. The majority of apps were co-created with government organizations, followed by independent commercial organizations. Of the 14 apps, 35% (n=5) were rated 4.0-4.9 (out of 5) by users with 7%

(n=1) receiving 5.0, 21% (n=3) receiving 3.9 or below and 35% (n=5) having no available ratings. 14% (n=2) had over 1000 reviews and 42% (n=6) had no reviews, while the remaining 42% (n=6) apps had between 1-99 reviews. The apps included live updates; 14% (n=2) had the ability to notify health care providers and 71% (n=10) had news updates/statistics. Many apps were created in collaboration with >1 country, with 42% (n=6) of the included apps being created in North America. COVID-19 specific characteristics were integrated into the apps and summarized (Table 2). The apps had features for symptom management (28%, n=4) and symptom assessment (57%, n=8), and included resources such as the location of testing centres (42%, n=6), preventative measures (35%, n=5), regional/federal guidelines (14%, n=2), specific instructions for those at greatest risk (14%, n=2), and physical distancing (21%, n=3). Of the 14 apps, 28% (n=4) had a coronavirus "tracking feature", three had a live chat room feature, and 14% (n=2) had training resources for clinicians. A summary of the described features of these apps can be found in Table 2 and Table 3. The main purposes of each app are provided in Table 4.

Table 2. General Application Characteristics, N=14, N (%).

Cost	
Free	13 (93%)
Free & paid options	1 (7%)
Paid	0 (0%)
Age Groups [a]	
Not specified	0 (0%)
Adults	4 (28%)
Children and adults	1 (7%)
Youth and adults	3 (21%)
Adult and older adults	1 (7%)
Older Adults	0 (0%)
All age groups	5 (35%)

Audience	
General public	10(71%)
Medical community	1 (7%)
General public & medical community	2 (14%)
General public & primary care provider	1 (7%)
Primary care provider for COVID-19 patients	0 (0%)
Creator	
Commercial	3 (21%)
Commercial & Government organization	2 (14%)
Government organization	8 (57%)
Academic organization	0 (0%)
Student	1 (7%)
User Rating (out of 5)	
0-0.9	1 (7%)
1-2	1 (7%)
2.1-2.9	0 (0%)
3.0-3.9	1 (7%)
4.0-4.9	5 (35%)
5.0	1 (7%)
Unavailable	5 (35%)
Number of Reviews	
1-10	2 (14%)
10-99	4 (28%)
100-999	0 (0%)
1000+	2 (14%)
No reviews	6 (42%)
Language style used[b]	
Lay (consumer friendly)	9 (64%)
Medical	1 (7%)
Lay & Medical	4 (35%)
Notification Capability	10 (71%)
Live Updates	
Notifies health care provider	2 (14%)
News updates/statistics	10 (71%)
Neither	2 (7%)
Tracking Capability	
Only when app is open	2 (14%)
Always	2 (7%)
Ability to be always or only on when using app	1 (7%)
No tracking	9 (64%)
Anonymity	
De-identified	1 (7%)
Anonymous	8 (57%)

Account Capability	**8 (57%)**
Connectivity with outside tools	
Apple Health kit	1 (7%)
Fitbit	1 (7%)
Pulse Oximeter	1 (7%)
Application Store Availability	
Apple App Store	12(86%)
GooglePlay & Apple App Store	2 (14%)
GooglePlay	0 (0%)
Country of origin	
United States of America (USA)	3[b](21%)
Canada	3[b] (21%)
Ireland	1 (7%)
England	1 (7%)
Singapore	1 (7%)
Pakistan	1 (7%)
Punjab	1 (7%)
Australia	1 (7%)
Mumbai	1 (7%)
United Arab Emirates	1 (7%)
Feedback survey	5 (35%)

[a] Age Groups. Children: <18 years of age, Youth: 18-24, Adults: 25-64, Older Adults: 65+.
[b] One app was a joint development between the United States of America and Canada; this app has been added to both countries within this category.

Table 3. COVID-19 Specific Characteristics of Application, N=14, N (%)

Symptom management	**4 (28%)**
Symptom assessment	**8 (57%)**
Resource information in app	
Testing centres	6 (42%)
Preventative measures	5 (35%)
Regional/federal guidelines	2 (14%)
Those at higher risk	2 (14%)
Physical distancing	3 (21%)
Source of information supporting app	
Not specified	2 (14%)
Research evidence	0 (0%)
Professional experience	2 (14%)
Personal experiences or stories	0 (0%)

National guidelines	2 (14%)
Coronavirus tracking feature	**4 (28%)**
Live chat room	**3 (21%)**
Training resources for clinicians	**2 (14%)**
Frequently Asked Questions (FAQ) forum	**5 (35%)**

Table 4. Reported purposes of COVID-19 applications

Mobile Application	Reported Purpose
HealthLynked COVID-19 Tracker [16]	Improving healthcare for everyone by connecting patients, doctors and health care data around the world.
HSE COVID-19 [17]	A monitoring app for patients who have mild to moderate symptoms and are in self-isolation. An alternative to visiting the hospital, ability to be monitored remotely.
BC Covid-19 Support [18]	Developed by the BC Ministry of Health in partnership with Thrive Health, the app provides latest updates and recommendations from trusted experts. Helps to coordinate the provincial response to COVID-19.
PatientSphere for COVID19 [19]	Created to allow patients to control their medical data and monetize the information (sharing with researchers).
Trace Together [20]	Community driven contact tracing app to help stop the spread of COVID-19.
Osler Covid Learning Centre [21]	Resource app that is designed to support nurses, doctors, paramedics and allied health professionals to learn and refresh their skills/knowledge, providing podcasts, videos, and training modules.
Canada COVID-19 [22]	Developed by the BC Ministry of Health in partnership with Thrive Health, this app was expanded for all Canadians. This app helps to determine care plans and next steps if any symptoms appear, providing personalized recommendations based on personal risk factors. This app gives updates on the COVID-19 situation in Canada, and important news from the Ministry of Health, in accordance to current guidelines.
COVID-19! [23]	This app gives basic information on COVID-19, how to prevent it, and how to defend against it. Provides up-to-date information about the world. Features a map with the occurrence of COVID-19 which allows you to view specific information about a location of interest.
COVID-19 Gov PK [24]	This app includes dashboards for information on cases by state in Pakistan. This app provides pop-up notifications to remind individuals of personal hygiene. Chatbot services and awareness videos are provided in order to limit spread of COVID-19.

COVA Punjab [25]	Provides preventative care information, emergency and hotline details. This app has been developed by the Government of Punjab to provide government advisories, a dashboard to track the evolving COVID-19 situation for Punjab, India and the world. This app includes a symptom checker for self-screening, raises awareness, and provides information on travelling instructions, prevention products, and healthcare resources. The app includes a FAQ section and call support.
Coronavirus Australia [26]	Provides up to date information and advice for Coronavirus and preventing its spread. Quick snap-shots of the current status of Australia. Symptom-checking functionality for oneself or others. This app includes relevant contact information and updates from the Australian government. Push notifications are provided for urgent updates.
BMC Combat Covid19 [27]	Notes location and provides information to track health status to the Municipal Corporation of Greater Mumbai.
CoronaFACTS [28]	Informational service informed by physicians, providing information on coronavirus globally. This app incorporates an interactive map to show the evolving situation, and global newsfeeds that can be filtered in order to find country-specific data.
TraceCOVID [29]	Allows users to detect other devices in close proximity with the same app installed and share proximity data with it. If one of the users of the app becomes infected with COVID-19, official authorities will request the infected user to upload the list close contacts stored on his or her device obtained through the app.

Discussion

While this scoping review found that rapidly increasing numbers of mobile apps are being created for the evolving COVID-19 outbreak, it is no surprise that evidence-based assessments of these apps do not currently exist. The rapid growth of the commercial market and need for COVID-19 apps has outpaced a standard of improvement for content and functionality of these mobile apps, resulting in an overaccumulation of COVID-19 apps with little evidence of effectiveness despite their availability for public use.

All 14 of the mobile apps appeared to have a singular focus, being either symptom management/assessment, news updates/statistic tracker, or an information sharing/training app; none comprehensively include a full range of features.

Current capabilities for sharing news, statistics, and live updates of COVID-19 through the included apps limit user customization, meaning that the app may share information that is irrelevant to the user's geographic location or provide notification that are not relevant regardless of whether the user wants them. 71% have live news and statistics communicated through the app, nearly all of which impart global, rather than local or user-selected information. Several of the apps included some type of territorial filtering but remained broad; for example, *Canada COVID-19* allowed for province filtering, but does not support specific data for certain cities and towns [22]. *BC COVID-19* is specific with features and content for British Columbians but still remains broad in terms of city filtering, remaining as a general tool for the entire province [18]. While many of the apps (77%) had the ability to convey news and statistics, these apps did not frequently provide notifications to users for live updates. Mobile app notifications can be a useful tool when used at the appropriate frequency with a concise message [30]. It is important for future apps related to COVID-19 to consider personalized notification features to increase app interaction and dissemination of desired content.

Apps can be successful in improving symptom management and tracking, specifically apps that allowed clinicians to provide input [31]. One app, *HSE COVID-19*, had the capability to document users' in-home isolation and synchronize activity data with Apple's Health Kit, Fitbit, and a pulse oximeter [17]. These results were then shared with

clinicians who remotely monitor patients. Measuring a patient's oxygen saturation, symptoms and activity allows clinicians to review a patient's condition in self-isolation, while ultimately avoiding a hospital visit until absolutely necessary, therefore reducing the risk of spreading or contracting the virus by reducing the number of unnecessary visits. This feature may be beneficial for future app developers to consider. Of interest is the fact that only two of the six included apps had feedback surveys, despite research which indicates feedback is a valuable resource for quality improvement of mobile apps [32].

One of the apps, *Coronavirus Australia*, had the ability to document registered isolation [26]. The Government of Australia used this information to better understand the experience of those in isolation, to create a safeguard for isolated individuals, and to allow public health to conduct appropriate analysis and research. Personal information collected such as name, age, and geographical location were to allow for the government to obtain timely and accurate infection rates. No personal information was disclosed to parties overseas, and was instead stored on servers within Australia. While this app did not allow tracking of the participant in isolation to be shared with other individuals on the app, it allowed public health to stay updated on the patient's current status through documentation of symptoms and to confirm that isolation was followed with people remaining in the same geographical location as that selected as their location of isolation. Analysts interpreting this data should do so cautiously, as the correct tracking would require for the subject to carry their mobile device with them at all times, and therefore this function may lead to inaccurate mapping.

Only one of the included apps, *OSLER Covid Learning Centre*, was strictly a resource app for supporting health care providers at William Osler Hospital in Brampton, Ontario [21]. The app hosted a learning centre focused on COVID-19 related topics such as techniques on non-invasive ventilation and co-ventilation of multiple patients. The app shared updated World Health Organization (WHO) situation reports, the Cochrane library collection for critical care management and infection control, and videos and podcasts related to COVID-19. The use of apps for education of hospital staff has the potential to share information in an innovative and engaging format that enables users to learn at their own speed [33] and is a good approach in an evolving situation. Given the current recommendation of self-isolation and social distancing, a mobile app would allow for health care providers in various fields (for example, home nurses, personal support workers, and mobile phlebotomists) to convene on health topics and changes to protocol without potentially perpetuating the spread of COVID-19.

Social media is a popular source for news consumption, with users claiming the value of sharing news in real-time and exposure to a wider range of topics [34,35]. Popular mobile apps such as WhatsApp, TikTok, Facebook, Instagram, and Twitter have been sharing COVID-19 knowledge by creating Information Centres available through their apps. These Information Centres include updates from health organizations, tips on self-isolation, and resources for sharing with loved ones. The information shared on each of these platforms can be specific to the geographical location of the user and reflects information from the recognized Health Organization serving their area. Canadian Facebook users can review COVID-19 information shared by the Government of Canada,

found on Canada.ca/coronavirus. WhatsApp has been commissioned by the WHO to begin facilitating information sharing on COVID-19; users can send messages to a number specific to their area to subscribe for COVID-19 updates, reports and statistics in real-time [36]. The strategies used by popular social media support the growing perspective that social media platforms are central to the way people experience news [34,35].

Many pre-existing apps have also begun including COVID-19 related features, modifying their apps to fit the needs of their users during the pandemic. Headspace, a self-help app used for tackling problems such as anxiety, relationships and sleeplessness, began offering free guided meditations and exercises to all employers and employees to compassionately support teams through the stress and anxiety of COVID-19 [37].

While the development and use of apps could be critical in circulating information and minimizing the spread of disease by encouraging virtual engagement with clinical services, caution must be exercised when selecting which apps to download. Disguising themselves as sources of information on the COVID-19 outbreak, some apps are installing malware and demanding special access once downloaded [15]. To address these fraudulent apps, and to curb the sharing of inaccurate information, the Apple Store and Google Play Store seem to be obscuring searches for “coronavirus”, “covid-19” and other similar keywords [9,10]. Such searches have yielded “no results found” messages or have returned options from reputable sources such as the Centre for Disease Control and Prevention (CDC) app. Without any clinical validation of apps, users should be wary of sources of any COVID-19 information. Apps affiliated with ministries of health, government

organizations, and academic institutions should be prioritized when searching for reliable mobile sources of information for COVID-19.

Further research should also evaluate web-based apps and online dashboards for tracking COVID-19. A number of dashboards are currently available which allow consumers to view the evolving global trajectory of COVID-19 by including confirmed and recovered cases, and deaths [38–43]. Many of these dashboards transform these data into charts and interactive maps to help consumers visualize these statistics and the distribution of cases. With the functionality to group country data and customize filters, these dashboards provide users the opportunity to put these data into a more local and personal context [38–43]. A majority of the dashboards identified through Google Search Engine include those which cite their data from the Coronavirus COVID-19 Global Cases dashboard supported by the Center for Systems Science and Engineering at Johns Hopkins University [39], which itself cites the WHO, the CDC, the European Centre for Disease Prevention and Control, and other federal organizations worldwide. Dashboards have been proven to support the fight against infectious diseases by collating location to events in relationship to disease spread [44]. One hallmark example is the Cholera outbreak in Soho, London. In 1858, John Snow was able to complete hand-spatial analysis to determine that pumps supplying water were the source of Cholera outbreaks [45]. By analyzing the distribution of disease, dashboards have the potential to present the patterns of spread of COVID-19 in ways that may help minimize transmission. While dashboards, and websites were not targeted for inclusion within this paper, it is important to highlight all of the

information sources available on mobile devices regarding the advancing COVID-19 crisis to illustrate the current environment of this field.

While this review did not include apps that were not available on an app store or in a language other than English, an app developed in Hangzhou City, Zhejiang, China [46] is worth highlighting. This health status app displays colours of either green, yellow, or red to indicate the current health status of the user [46]. The colours are allocated based on information reported by the individual, including their current health status, travel history, and previous exposure to highly affected areas such as Wuhan, China. Those with a red or yellow code are required to undergo quarantine, while anyone with assigned green can continue going to work. These unified health code systems are promoted throughout China and checked frequently on public transportation and by safety officers to ensure compliance with quarantine regulations to maintain the safety of other civilians [46]. While such a strategy could look promising in maintaining quarantine regulations, it is important to consider that these codes are sensitive to users' input, and that these answers require no medical verification [46].

Lastly, the SARS-2003 outbreak had public health recommendations similar to those now being practiced for COVID-19, including wearing face masks and social distancing [47]. Two unique citations obtained through a grey literature search provided insight on apps modelled on the SARS-2003 outbreak (Table 6, Appendix B). One of the strategies implemented in Singapore during the SARS-2003 outbreak involved electronic tracking of individuals entering public hospitals. Staff and visitors were required to wear credit-card sized radio frequency identification (RFID) cards, and these records were saved

by the hospital for 20 days [48]. If an individual became infected, health officials would examine who had been in contact with them based on RFID tracking records [48]. Today, mobile apps in South Korea, such as Corona 100m, have used this strategy through Bluetooth technology [49]. Participants no longer require credit-card sized recognition cards but can anonymously be tracked through their mobile devices. The information is anonymous to users of the apps; that is, users are able to see where de-identified individuals with COVID-19 have been while government health officials and mobile developers are able to identify who each user is. Further, when a patient is recognized as infected with COVID-19, the Ministry of Health and Welfare in South Korea examines the apps to ensure that the patient stays in quarantine and follows rules of contact [50]. In addition, *TraceCovid* [29], one of the included apps in this study, implemented similar strategies utilizing Bluetooth frequencies to identify individuals who has crossed paths. All users who have downloaded the app have their paths and contact with other individuals traced and are able to share this information with Government authority if identified as COVID-19 positive. However, apps for the COVID-19 outbreak largely fail to consider the eHealth technologies that were implemented during the SARS-2003 outbreak. SARS-2003 apps wirelessly transmitted symptoms to health or infectious disease centres and allowed for remote monitoring of patients, communicating through Short Message Service (SMS) notifications on nearby SARS exposure for users who choose to share their phone location [47]. Given the 17-year gap, apps created for COVID-19 should look to past successes and failures of SARS-2003, creating apps that are multifaceted and able to combine all features of tracking, notification, statistics, updates, and symptom management.

mHealth apps remain an affordable, portable, and cost-effective strategy in delivering healthcare [51]. They also constitute an excellent platform for data collection. Some apps, such as *Corona-care* [52] allows healthcare workers to access and track patient symptoms remotely, while also collecting longitudinal data for research institutions. This app is accessible to patients who may have COVID-19 and have been seen by a clinician regarding their condition. Another application called *Castor COVID-19* [53] was developed for research purposes to collect population level data on COVID-19 by asking participants to report symptoms daily. As these apps can only be downloaded in a research context, they were not included for data extraction, but they were still described within the discussion to highlight the mobile app landscape during COVID-19. While helpful in supporting research efforts and in collecting data for healthcare purposes, it is important to consider privacy, security and additional expenses to the users of these apps, as well as the effects of these factors on adoption rates. In continuous location tracking apps, similar to *TraceCovid* [29] and *Corona100m* [54], users agree to share information by consenting to a location tracking request [15]. Up to $1/5^{th}$ of cell phone users have turned off location tracking features on their phone, citing worries of privacy invasion [40,50]. Overtime, users have been found to become comfortable sharing private information with larger corporations when a long-term business relationship between users and services providers has been established [55]. Given that many apps created for COVID-19 are created by government organizations, users may be more comfortable sharing private information. However, privacy issues can remain constrained regardless of the business relationship, with users choosing not to sharing location when in a sensitive area they prefer not to be

disclosed, such as place of work or home address. Security concerns pose another adoption constraint, worrying users of potential attacks through malware infection such as viruses [56]. It has been suggested that all mobile apps available on application stores be created in accordance with standard guidelines to ensure that security procedures are put into place [57]. While the evolving pandemic of COVID-19 moved quickly, developers should still be held to a high standard when creating apps to ensure privacy and security measures are undertaken. The overall quality, security and privacy concerns, and additional costs related to the applications should also be taken into account. For example, apps with location tracking function in the background present a challenge in terms of data usage and internet access. When developing apps, data consumption and the reliance upon internet access should be considered in order to reduce user monetary burden and maximize the level of access to pertinent information. The application development process could address such concerns though involvement of end-users in order to incorporate the consumer perspective adequately.

Limitations

This scoping review has several limitations. Firstly, the review of the grey literature was limited to a search of app stores and websites, and did not capture dissertations, unpublished reports, or conference abstracts, though the availability and abundance of such material is unlikely given the recency of the onset of the COVID-19 pandemic. Further, the apps included from clinical databases were those in published trials or articles concerning mobile apps for COVID-19. A second limitation of this review is the breadth of the eHealth tools analyzed. While there are other tools available to the public with

respect to this pandemic, this review focused exclusively on mobile apps. Thirdly, applications which covered a multitude of health concerns in addition to COVID-19 were not included in this analysis, as the aim of the study was to assess apps designed specifically for addressing COVID-19 rather than apps designed to respond to pandemics generally. For example, some apps provided information on a variety of health topics, such as heart disease, diabetes, and made extensions to also cover COVID-19 as a result of the current crisis. Additionally, this analysis is limited by the accuracy of the features reported by the application developers; that is, this analysis captures the capabilities reported by the app developer and does not reflect whether these features are accurate. Reasonable measures to confirm the accuracy of reported functions were taken by all reviewers, however, it is possible that features such as "sending symptom data" to the relevant health or regulatory bodies may not have full functionality. Finally, this review systematically excluded grey literature and published work that was not in the English language, meaning that some apps for COVID-19, notably those developed in countries hit earlier with the virus, are not included. In turn, this investigation is biased toward apps designed by English-speaking nations or developers.

Conclusions

The impetus to create apps to provide mobile support in the wake of the COVID-19 pandemic has resulted in the development of different types of apps and eHealth solutions. However, further expansion is needed to create apps which host multiple helpful features in one place, supported by reliable statistics and updates. Strengthening of partnerships between academic and research institutions, healthcare, and government is

needed in order to create apps that will serve to improve the quality of the information accessed by the public and bridge the gaps in healthcare widened by the current pandemic. This scoping review identifies the areas currently being addressed by apps for COVID-19 but also highlights a number of opportunities for improvement and innovation. Collaboration between key stakeholders will not only provide vital platforms to respond to the current crisis but also stimulate the development of infrastructure for future health challenges.

List of Abbreviations

apps: applications

CDC: Centre for Disease Control and Prevention

COVID-19: 2019 novel Coronavirus disease

FAQ: Frequently Asked Questions

mHealth: mobile health

PRISMA-ScR: PRISMA for Scoping Reviews

SMS: Short Message Service

SARS: Severe Acute Respiratory Syndrome

WHO: World Health Organization

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

All authors consent for publication.

Competing Interests

No competing financial interests exist. All authors declare no conflicts of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Author Contributions

NN and AD conceived the study, participated in its design and all review steps. GC drafted the results section and corresponding text. NN, AD contributed to the literature synthesis and led the writing of the final manuscript. NA, CL, and NW provided critical revision of the manuscript. All authors read and approved of the final manuscript.

Acknowledgements

We would like to thank Ms. Tamara Navarro for their expertise and support in the conception and development of the search strategies

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Appendix 1

Appendix 1 - A

Table 5. COVID-19 specific features of website applications and dashboards. While these websites and dashboards were not included in our analysis, it is important to highlight mobile technologies available for COVID-19 to date, and further explored in the discussion. Applications which include a specific feature are denoted by an "X" in the appropriate column. *Symptom management & sharing is defined as documenting and sharing symptoms with healthcare professionals, and family members.

Features	Description	Targeted Country	Live tracking	News updates	Statistic counter	Symptoms screening	Symptom management & sharing*	Information on next steps	Information assessment centres	Emergency contacts
Application										
Apple's COVID-19 Screening Tool	Allows users to screen themselves for COVID-19 symptoms and receive notifications from the Centre for Disease Control and Prevention	Worldwide				X		X		
CoronaVirus App	An interactive map that allows tracking of the spread of	Worldwide	X	X	X					

	COVID-19, view stats, and check affected regions in real time.									
Covid-19 (Coronavirus) Update	Web-based application that allows user to check global statistics, latest news, and complete self-assessment.	Canada	X	X	X	X				X
Project Baseline	Web-based application that allows user to create an account, complete COVID-19 self-assessment, get tested and receive results through the application.	USA (California)				X	X	X	X	
COVID near you	Web-based application that allows users to contribute to the health status and tracking of COVID-19 daily. By inputting personal symptoms, duration, quarantine/isolation status, exposure to COVID-19, zip-code, and birthdate, participants contribute to general knowledge to build a distribution map. The application also tracks COVID-19 activity	USA		X	X		X			

	in the US and highlights the number of cases in the past 2 weeks in the US.									
Tracking Coronavirus Covid-19	This application provides global information on number of confirmed cases and deaths, daily. This web-based application includes interactive mapping to visualize the global distribution of the COVID-19 outbreak.	Worldwide				X				
Dashboards										
COVID-19 Tracker Dashboard	This application provides a dashboard of confirmed and recovered cases by country, and total numbers of deaths, and critical cases. Visualization of countries with the most cases, deaths and recoveries are provided.	Worldwide			X					
COVID-19 Global Cases	This application provides a dashboard of global information on number of confirmed, active and recovered cases, as well as number of deaths, daily. This web-based application	Worldwide			X					

	includes interactive mapping to visualize the global distribution of the COVID-19 outbreak.									
Coronavirus dashboard	This application provides a dashboard of global information on number of confirmed, active and recovered cases, as well as number of deaths, daily. Provides charts and tables demonstrating trends in each type of case over time.	Worldwide			X			X		
Covid-19 Dashboard	This application provides global information on number of confirmed and recovered cases, as well as number of deaths, daily. Includes filtering options for grouping data by multiple countries.	Worldwide			X					

Appendix 1 - B

Table 6. Two unique references obtained through grey literature search of Google
These applications were not available for download within Canada, and a thematic description could only be provided.

Application	Description
FluPhone (58)	Created by the University of Cambridge and University of Liverpool following the SARS epidemic in 2003, the mobile app is currently being investigated to determine how many people come into contact with each other through their mobile devices. The app tracks interactions using Bluetooth technology, to understand how individuals can be exposed to disease and contribute to spread.
Corona100m (54)	Mobile app that notifies individuals in South Korea on where COVID-19 patients have been and how close they currently are, when within a 100m radius. This central tracking app is based on SARS applications that emerged following the 2003 outbreak, and utilizes Bluetooth technology.

Appendix 2

Appendix 2- A: Search Strategies for Ovid (MEDLINE), PsychINFO and CINAHL.

Database: Ovid MEDLINE(R) <1996 to August 16, 2019>
Search Strategy:

1 m-Health.mp. (325)
2 mHealth.mp. (1755)
3 mobile app*.mp. (5097)
4 cell* phone*.mp. (9094)
5 handheld device.mp. (286)
6 smartphone*.mp. (6035)
7 personal digital assist*.mp. (894)
8 mobile device*.mp. (1736)
9 tablet*.mp. (37566)
10 iPhone.mp. (514)
11 iPad.mp. (881)
12 (exp Indians, North American/ or exp Inuits/ or exp Health Services, Indigenous/ or exp Ethnopharmacology/ or Athapaskan.mp. or Saulteaux.mp. or Wakashan.mp. or Cree.mp. or Dene.mp. or Inuit.mp. or Inuk.mp. or Inuvialuit*.mp. or Haida.mp. or Ktunaxa.mp. or Tsimshian.mp. or Gitsxan.mp. or Nisga'a.mp. or Haisla.mp. or Heiltsuk.mp. or Oweenkeno.mp. or Kwakwaka'wakw.mp. or Nuu chah nulth.mp. or Tsilhqot'in.mp. or Dakelh.mp. or Wet'suwet'en.mp. or Sekani.mp. or Dunne-za.mp. or Dene.mp. or Tahltan.mp. or Kaska.mp. or Tagish.mp. or Tutchone.mp. or Nuxalk.mp. or Salish.mp. or Stl'atlimc.mp. or Nlaka'pamux.mp. or Okanagan.mp. or Sec wepmc.mp. or Tlingit.mp. or Anishinaabe.mp. or Blackfoot.mp. or Nakoda.mp. or Tasttine.mp. or Tsuu T'inia.mp. or Gwich'in.mp. or Han.mp. or Tagish.mp. or Tutchone.mp. or Algonquin.mp. or Nipissing.mp. or Ojibwa.mp. or Potawatomi.mp. or Innu.mp. or Maliseet.mp. or Mi'kmaq.mp. or Micmac.mp. or Passamaquoddy.mp. or Haudenosaunee.mp. or Cayuga.mp. or Mohawk.mp. or Oneida.mp. or Onodaga.mp. or Seneca.mp. or Tuscarora.mp. or Wyandot.mp. or Aboriginal*.mp. or Indigenous*.mp. or Metis.mp. or red road.mp. or "on reserve".mp. or off-reserve.mp. or First Nation.mp. or First Nations.mp. or Amerindian.mp. or (urban adj3 (Indian* or Native* or Aboriginal*)).mp. or ethnomedicine.mp. or country food*.mp. or residential school*.mp. or ((exp Medicine, Traditional/ or traditional medicine*.mp.) not Chinese.mp.) or exp Shamanism/ or shaman*.mp. or traditional heal*.mp. or traditional food*.mp. or medicine man.mp. or medicine woman.mp. or autochtone*.mp. or (Native* adj1 (man or men or women or woman or boy* or girl* or adolescent* or youth or youths or person* or adult or people* or Indian* or Nation or tribe* or tribal or band or bands)).mp.) and (exp Canada/ or (Canad* or British Columbia or Columbie Britannique or Alberta or Saskatchewan or Manitoba or Ontario or Quebec or Nova Scotia or New Brunswick or Newfoundland or Labrador or Prince Edward Island or Yukon Territory or NWT or Northwest Territories or Nunavut or Nunavik or Nunatsiavut or NunatuKavut)).mp. (4861)
13 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 (56751)
14 12 and 13 (12)

Database: Embase <1974 to 2019 August 16>
Search Strategy:

1 (((Indigenous People/ or American Indian/ or First Nation/ or Metis/ or Eskimo/ or Inuit/ or Indigenous Health Services/ or exp Ethnopharmacology/ or Athapaskan.mp. or Saulteaux.mp. or Wakashan.mp. or Cree.mp. or Dene.mp. or Inuit.mp. or Inuk.mp. or Inuvialuit*.mp. or Haida.mp. or Ktunaxa.mp. or Tsimshian.mp. or Gitsxan.mp. or Nisga'a.mp. or Haisla.mp. or Heiltsuk.mp. or Oweenkeno.mp. or Kwakwaka'wakw.mp. or Nuu chah nulth.mp. or Tsilhqot'in.mp. or Dakelh.mp. or Wet'suwet'en.mp. or Sekani.mp. or Dunne-za.mp. or Dene.mp. or Tahltan.mp. or Kaska.mp. or Tagish.mp. or Tutchone.mp. or Nuxalk.mp. or Salish.mp. or Stl'atlimc.mp. or Nlaka'pamux.mp. or Okanagan.mp. or Sec wepmc.mp. or Tlingit.mp. or Anishinaabe.mp. or Blackfoot.mp. or Nakoda.mp. or Tasttine.mp. or Tsuu T'inia.mp. or Gwich'in.mp. or Hannot Chinese.mp. or Tagish.mp. or Tutchone.mp. or Algonquin.mp. or Nipissing.mp. or Ojibwa.mp. or Potawatomi.mp. or Innu.mp. or Maliseet.mp. or Mi'kmaq.mp. or Micmac.mp. or Passamaquoddy.mp. or Haudenosaunee.mp. or Cayuga.mp. or Mohawk.mp. or Oneida.mp. or Onodaga.mp. or Seneca.mp. or Tuscarora.mp. or Wyandot.mp. or Aboriginal*.mp. or Indigenous*.mp. or Metis.mp. or red road.mp. or "on reserve".mp. or off-reserve.mp. or First Nation.mp. or First Nations.mp. or Amerindian.mp. or (urban adj3 (Indian* or Native* or Aboriginal*)).mp. or ethnomedicine.mp. or country food*.mp. or residential school*.mp. or ((exp Medicine, Traditional/ or traditional medicine*.mp.) not Chinese.mp.) or exp Shamanism/ or shaman*.mp. or traditional heal*.mp. or traditional food*.mp. or medicine man.mp. or medicine woman.mp. or autochtone*.mp. or (Native* adj1 (american or man or men or women or woman or boy* or girl* or adolescent* or youth or youths or person* or adult or people* or Indian* or Nation or tribe* or tribal or band or bands)).mp.) and (exp Canada/ or (Canad* or British Columbia or Columbie Britannique or Alberta or Saskatchewan or Manitoba or Ontario or Quebec or Nova Scotia or New Brunswick or Newfoundland or Labrador or Prince Edward Island or Yukon Territory or NWT or Northwest Territories or Nunavut or Nunavik or Nunatsiavut or NunatuKavut)).mp.) or Canadian Aboriginal/) not oriental medicine/ (7977)
2 m-Health.mp. (626)
3 mHealth.mp. (3184)
4 mobile app*.mp. (9701)
5 mobile device*.mp. (3577)
6 cell* phone*.mp. (4779)
7 personal digital assist*.mp. (2037)
8 handheld device.mp. (596)
9 iPhone.mp. (1540)
10 smartphone*.mp. (14288)
11 mobile device*.mp. (3577)
12 tablet*.mp. (96383)

13 iPad.mp. (2524)
14 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 (127515)
15 1 and 14 (32)

Database: PsychINFO <1974 to 2019 August 16>
Search Strategy:

1 Indians, North American/ (0)
2 Inuits/ (0)
3 Indigenous/ (5325)
4 Ethnopharmacology/ (0)
5 Athapaskan.mp. (19)
6 Saulteaux.mp. (21)
7 Wakashan.mp. (0)
8 Cree.mp. (348)
9 Dene.mp. (46)
10 Inuit.mp. (720)
11 (Inuk or Inuvialuit* or Haida or Ktunaxa or Tsimshian or Gitsxan or Nisga'a or Haisla or Heiltsuk or Oweenkeno or Kwakwaka'wakw or Nuu chah nulth or Tsilhqot'in or Dakelh or Wet'suwet'en or Sekani or Dunne-za or Dene or Tahltan or Kaska or Tagish or Tutchone or Nuxalk or Salish or Stl'atlimc or Nlaka'pamux or Okanagan or Sec wepmc or Tlingit or Anishinaabe or Blackfoot or Nakoda or Tasttine or Tsuu T'inia or Gwich'in or Han or Tagish or Tutchone or Algonquin or Nipissing or Ojibwa or Potawatomi or Innu or Maliseet or Mi'kmaq or Micmac or Passamaquoddy or Haudenosaunee or Cayuga or Mohawk or Oneida or Onodaga or Seneca or Tuscarora or Wyandot or Aboriginal* or Indigenous* or Metis or red road or "on reserve" or off-reserve or First Nation or First Nations or Amerindian).mp. (19029)
12 (urban adj3 (Indian* or Native* or Aboriginal*)).mp. (715)
13 ethnomedicine.mp. (57)
14 country food*.mp. (8)
15 residential school*.mp. (892)
16 (exp Medicine, Traditional/ or traditional medicine*.mp.) not Chinese.mp. (611)
17 exp Shamanism/ or shaman*.mp. (1226)
18 traditional heal*.mp. (1544)
19 (traditional food* or medicine man or medicine woman or autochtone*).mp. (340)
20 (Native* adj1 (man or men or women or woman or boy* or girl* or adolescent* or youth or youths or person* or adult or people* or Indian* or Nation or tribe* or tribal or band or bands)).mp. (1415)
21 (Canad* or British Columbia or Columbie Britannique or Alberta or Saskatchewan or Manitoba or Ontario or Quebec or Nova Scotia or New Brunswick or Newfoundland or Labrador or Prince Edward Island or Yukon Territory or NWT or Northwest Territories or Nunavut or Nunavik or Nunatsiavut or NunatuKavut).mp. [mp=title,

abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh] (60537)
22 20 and 21 (121)
23 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 22 (24244)
24 mHealth.mp. (760)
25 M-Health.mp. (112)
26 mobile app*.mp. (1577)
27 cell* phone*.mp. (2874)
28 handheld device*.mp. (222)
29 smartphone*.mp. (3220)
30 personal digital assist*.mp. (449)
31 mobile device*.mp. (3605)
32 tablet*.mp. (4524)
33 iPhone.mp. (267)
34 iPad.mp. (816)
35 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 (14633)
36 23 and 35 (69)

CHAPTER 4: GENERAL DISCUSSION

The two identified crises are very different and difficult to compare directly. The two scoping reviews can be used to highlight the number and types of mobile apps created as responses to the crises, the time required to create these apps, the overall quality of the apps, and their relevance. Given the disparity in the crises, for the purpose of this thesis, only a thematic analysis of the apps will be discussed.

Key Themes for Each Scoping Review

Both scoping reviews sought to assess the apps created in response to crisis. Utilizing both scientific literature and grey literature searches, all apps were retrieved from the application stores with no available scientific material.

Chapter 2, Mental Health apps for Indigenous Communities in Canada, highlighted the lack of privacy and security in these apps with only 1/3 apps having a privacy policy statement. In addition, the use of symbols within the apps from Chapter 2 indicated an attempt to convey culture however the apps appeared to be generic to Indigenous communities as a whole. However, none of the apps had the ability to toggle language between English and varying Indigenous languages, indicating that these apps can be improved in term of language. App develops in the future should focus on creating apps that can cater to each Indigenous community to promote apps that are considerate of each culture. These apps were limited in diversity, being primarily information sharing vehicles and one being a network connection tool sharing local. This field was also limited in the number of apps with only 4 search findings meeting inclusion criteria. All of these apps

were created by private commercial or individual groups, and none appeared to be government funded or supported.

Chapter 3, Mobile Apps for COVID-19, had a larger variety and number of apps, with search findings yielding 14 apps that met inclusion criteria having various functions such as chatting rooms, training resources, material sharing, symptom assessment, and providing live updates. The apps created for COVID-19 also had capability to be culturally targeted, with apps being created for individual countries, and having the ability to switch languages (from English to French). Generally, the growth of the commercial market outpaced a standard of improvement for content and functionality of these apps, resulting in an overaccumulation of apps in this field.

The COVID-19 pandemic continues to evolve today, and literature and apps are being created in a fast manner.

Similarly, in both reviews, apps for both crises had self-assessment tools, with Covid-19 apps having the tool built into the app and Mental Health apps having internet links that connected the user to outside assessment tools. Apps from both scoping reviews had limited notification control, were mainly free (17/18), catered to the general public, and some had account capability (10/18). One app from each review was student created. Only a few apps for Covid-19 had tracking capability (5/14), and no apps for mental health had any tracking capability. 1 Covid-19 app also had the ability to connect with outside tools such as a Fitbit. All of the apps from both scoping reviews were available on the Apple App store. Both scoping reviews drew conclusions on the needs not being met by application-based interventions and suggested that further innovation and collaboration

between government, healthcare and community individuals should be utilized in creating future apps. Both scoping reviews warranted that research is required to assesses the efficacy and effectiveness of the mobile apps in order to create evidence-based apps that meet the needs of users of the apps.

Number of Apps Developed for Each Crisis

The mental health crisis faced by Indigenous communities is heavily impacted by intergenerational trauma stemming from colonialism, history, identity, politics, language and dislocation (1 - 3). Without a discussion of identity and colonization, mental health in the context of Indigenous communities cannot be discussed (1-3). The first call to action for the mental health crisis of Indigenous communities came in the Truth and Reconciliation Commission of Canada: Calls to Action in 2012, with an updated report released in 2015 (4-6). These calls to action were created through the story sharing of residential school survivors and presented to the commission to redress the legacy of residential schooling and advance the process of Canadian reconciliation. The journey of truth and reconciliation is ongoing and remains far from over. However, apps for Indigenous mental health remain scarce in number, with only 3 apps and 1 abstract available for Indigenous mental health in Canada (7-9)

In contrast, The COVID-19 outbreak began in late December 2019 (10). Within a few weeks, apps for COVID-19 became available on app stores, and external websites for downloads (11-14). The number of apps available grew quickly, with a wide scope including contact tracing, quarantine and self-isolation information, screening for

infection, clinical management, planning and tracking, and medical supplies (11-14). From December 2019 – April 2020, 14 apps were available for COVID-19 in Canada (15-28)

Despite a 5 to 7-year difference in onset between the two crises, it is evident that apps created for Indigenous support are less in number compared to COVID-19, with COVID-19 having three times more apps.

Types of Mobile Apps Created as Responses to Each Crisis

In terms of app diversity, there were multiple types of COVID-19 apps (14) where in contrast, there were only two types of Indigenous mental health apps: those for information resources (I*t's My Life* (9) or *FirstResponse* (8)), and those for social networking, or the combination (*IndigenousFriends* (7)). One similarity between the apps created for both crises is that no singular app was able to comprehensively include the full range of features. For example, no app for COVID-19 was able to include all domains of infection screening, planning, tracking, etc. While some apps included multiple domains such as information resources and social networking, (e.g. *IndigenousFriends* (7) *CanadaCOVID-19 (21)),* it was more common to find apps for both crises containing one domain rather than multiple and none containing all domains. Lack of diversity in mobile apps demonstrates the unequal provision of social services available for Indigenous communities. This unequal division of services has been apparent for more than a century and is still prevalent in the lack of options and number of apps compared to those available for the non-Indigenous communities (29).

Time Required to Create Mobile Apps for Each Crisis

It is apparent that COVID-19 app generation was much quicker compared to Indigenous mental health apps. One example is in the geographic tracking feature of two apps; *IndigenousFriends* (7) including an "I Need Help Now" feature and *Coronavirus Australia* (25) having the ability to register self-isolation. "I Need Help Now" was designed to create an optional geo-location tagging of Indigenous users, and then notify an Indigenous mentor who could offer timely assistance in times of crisis. Unfortunately, *IndigenousFriends* (7) has not yet enabled this feature due to the network and support it may have required. In contrast, *Coronavirus Australia* (25) was able to integrate a similar tracking feature, which proved functional and well supported within months of the pandemic onset. The tracking feature was capable of tracking self-isolation for those who tested positive for COVID-19 and utilized Bluetooth frequency to let other users know when they may have come into contact with a positive COVID-19 citizen. Unlike *IndigenousFriends* (7), *Coronavirus Australia* (25) received support from its country's Public Health offices which analyzed the tracking review feature of the app to communicate with Australian citizens who could have been exposed. Given the technical hurdles that COVID-19 apps have been able to overcome and the ability to generate a larger variety of apps, it seems that these elements could have also been incorporated into Indigenous apps.

Research & Funding for Each Crisis

When compared to research for COVID-19 mobile apps, a lack of research around mental health mobile apps for Indigenous Canadian communities is evident. In our search, only one abstract by Kristman, 2018 (30) and one thesis by Mayoral-Banos, 2016 (31)

existed that analyzed an app for Indigenous communities. The novel COVID-19 crisis, however, has several articles available to date that analyze apps for COVID-19 (11-14). While no studies for either crisis have any research around app testing, utility, acceptability or usage – when comparing the length of time for each crisis, it is surprising that no Indigenous mental health apps in Canada have been trialed with published research. However, research with Indigenous communities follow several principles which involve community engagement, recognition of community's interests, community engagement plan with submission to research ethics boards for review, respect for governing Indigenous authorities, and an ultimate emphasis of understanding Indigenous communities where research will be conducted (32). Beyond principles, discussion of intellectual property and dissemination of research require further discussion and complete review by Indigenous communities at large (32). It is possible that the general principles involving Indigenous research could have impacted the movement of this research. Alternatively, the research may have occurred but is currently owned by Indigenous communities and only being disseminated at their own wishes (32). In addition, the lack of high-quality apps available for Indigenous communities may reflect a larger systemic issue of less funding available for Indigenous research and education preventing Indigenous research from moving forward. Only recently in 2017, the Canadian Research Coordinating Committee (CRCC) brought together many of the presidents of Canada's research granting agencies to create a national dialogue with Indigenous communities in order to promote interdisciplinary Indigenous research and research training rooted in reconciliation and co-development (33). Through these discussions, Indigenous People expressed the need for long-term

research relationships built on trust, respect and mutual interests (33). The Indigenous community emphasized that these relationships take time and cannot be accomplished without involving the entire community. As well, lack of funding for Indigenous student's also presented barriers to schooling (33). Through this same dialogue, Indigenous communities highlighted that many Indigenous students face additional challenges beyond finances that involved current academic models competing with ancestral values, leaving students and young researchers torn between their identities (33). The funding provided by the CRCC and Canada's research granting agencies includes $3.8 million from the Social Sciences and Humanities Research Council (SSHRC), 116 grants valued at $50,000 for a total value of $5.6 million and $824 million over 10 years for Indigenous post-secondary education (33). While funding is now available, it may be too soon to assess if the increased funding for research is meeting the need of the community. However, this increased funding may allow in the future for advances in research completed through co-creation by Indigenous communities. Similarly, COVID-19 had several funds developed to support research including the Ontario COVID-19 Rapid Research Fund where 49 Covid-19 research projects were funded valued at $54.2M dollars (34). Interestingly, although there is less research funding dollars available for COVID-19 compared to the Indigenous Mental Health crisis, more research has been conducted in a short period of time. The key players involved in development of COVID-19 research range University Professionals, large organizations such as Apple and large governmental bodies such as the White House and the Government of Canada (34, 35). While, Indigenous Mental Health research is left to Indigenous researchers. Research for COVID-19 continues to grow in

number with a large stream of apps and articles appearing even today, as the whole world continues to focus on the COVID-19 pandemic.

Social Media Response to Each Crisis

When used to promote health and wellbeing, social media platforms can be a powerful tool to encourage ideas and convey important information to the general public. For the COVID-19 pandemic, many popular social media apps encourage health and well-being while conveying important information. Apps such as TikTok, Facebook, Instagram and Twitter created information centres to convey COVID-19 related information to their users (36, 37). The information shared on these platforms were geographic specific and reflected information from the recognized Health Organization in their area (36, 37). In contrast, for the Indigenous mental health crisis, there has not yet been a response from popular social media platforms similar to those used for COVID-19. For Indigenous communities, social media can be a place to remind those of trauma, and abuse for Indigenous communities (38 – 40). Around the world, Indigenous communities are enthusiastic towards social media use but there remains a shortage of research that examines racial discrimination and traumatic events on these platforms (41- 43). The effects of racism are often normalized on social media platforms and have a detrimental impact on Indigenous communities and their use of media (41 – 49). Case studies have illustrated shared images of Indigenous abuse on the cover of the Vancouver Sun (49), and cartoons depicting racist jokes aimed at Indigenous communities (45). These case study examples did not go unnoticed by Indigenous communities, with mass expressions of pain shared by Indigenous social media users (47). Flocking to twitter, Indigenous people shed

light on colonial history, intergenerational trauma, and re-traumatization that can happen through social media (47). Despite Indigenous defense, these racist examples remain overwhelming, having serious impacts on individual's wellbeing. In fact, research has reported that online hate and harassment, such as that experienced by Indigenous communities, can lead to depression, anxiety, and in some cases suicide (50, 51). Although the rise of social media in today's day and age is undeniable, it is also undeniable that racism, trauma and discrimination remain on these platforms for Indigenous communities exposing them to sadness and further trauma in unexpected and unique ways. Future mobile apps created for the Indigenous community should be mindful of potential for discrimination and bullying on these platforms and should monitor the apps closely to remove any hateful or hurtful postings.

COVID-19 App for Indigenous Community

Research has reported that a key contributing factor for illness from COVID-19 is the presence of an underlying health condition. Black, Indigenous and people of colours are reported to be 1.5 - 2.0x more likely than white people to develop chronic health conditions (43, 52, 53). In addition to the higher rate of underlying disease, Indigenous communities also face discrimination in accessing health care services. Many health centres in these communities are ill-equipped, understaffed, and do not have access to personal protective equipment required (for both staff and community members) (54). The mental health impact caused by COVID-19 in these communities has not even begun to be uncovered. Data shows that COVID-19 is impacting Indigenous communities harshly, and it is expected that the numbers are worse than reported (55). Many health departments

categorize Native Americans and Indigenous peoples as "others" in their reports, suggesting that the prevalence and severity of COVID-19 in these communities may be underreported (42, 55). The examination of Indigenous communities and COVID-19 remains underserved. One app created by the Government of Canada, *Canada Covid-19* (21), included statistics on all Canadian provinces within the application but failed to report Indigenous statistics. How can one COVID-19 app be considered to cater to the entire Canadian population when it fails to directly account for 4.4% of the Canadian population (56)?

To date, no app has been created to communicate COVID-19 information to the Indigenous Canadian communities in Canada. While the Canadian government has taken steps to address these concerns through the form of funding for PPE and government bursaries for those unemployed, larger and bigger movements are required. The Government of Canada needs to create solutions to address the needs of the Indigenous community in a way that respects their wishes, and rights while accounting for systemic colonial approaches that have harmed them in the past. In the least, the Government of Canada needs to create the same resources and tools for the Indigenous population, as those created for the non-Indigenous population, specifically around creating an app that can help communicate COVID-19 information.

Past Examples for Each Crisis

Lastly, it is important to note that both crises had previous examples of apps to build from. For the COVID-19 pandemic, the SARS-2003 outbreak had public health recommendations similar to those being practised currently for COVID-19, such as

wearing a face mask and social distancing (57-59). The SARS-2003 outbreak also had apps that were generated to help control spread and increase information (57-59). The apps created for the SARS-2003 outbreak were utilized by some apps developed for COVID-19 and served as examples of successes and failures of strategies for apps dealing with a similar pandemic. The Indigenous mental health crisis also has an example that is occurring simultaneously, which can be defined as the non-Indigenous mental health crisis. Identified as a global pandemic by the World Health Organization, mental illness is defined as the leading cause of disability worldwide (60). In Canada specifically, it is reported that 6.7 million are affected and that one in every two Canadians have or will have mental illness by the time they are 40 years of age (51, 60). For the non-Indigenous population, mental health apps have been extensively examined with focus groups, case studies, usability testing and accuracy – even creating frameworks for evaluating mobile mental health apps (61-65). Although there is the presence of systematic reviews and meta-analyses on smartphone apps for mental health, there is no report that any of the Indigenous mental health apps included in this manuscript have used these as examples to build off of for their own communities (61-65). In both crises it is crucial that current apps are created based on the successes and failures of other apps, in order to promote the creation of apps that are better than the ones previously created.

Limitations

This thesis has several limitations. The review of grey literature for both scoping reviews were limited to search of apps stores and websites. The COVID-19 scoping review specifically did not capture dissertations, unpublished reports, conference abstracts or

poster presentations, although the presence of such material is unlikely given the recency of the pandemic onset. Another limitation is the extent to which eHealth tools were analyzed; also given the flurry of publications related to COVID-19, newer apps have since been released. eHealth tools are vast in number with respect to both crises (e.g., websites) however, these reviews focused exclusively on mobile apps available on app stores. Thirdly, apps which covered a multitude of health concerns (for example: a Diabetes app that also had a mental health component) were not included for analysis, as the aim of the studies were to assess apps specific to COVID-19 or Indigenous mental health alone. However, an app that assesses Indigenous mental health alone may not be possible as Indigenous world views involve thinking of health and wellness on a in conjunction rather than in isolation. Additionally, the analysis may be limited in its accuracy, as app features were taken for face value based on what is reported by developers and researchers. While reasonable measures were taken to confirm information was true and accurate, there is always a chance of data manipulation or incorrect features being described in app store descriptions or within apps themselves. Finally, both reviews excluded apps that were not available in the English language as translation was not obtainable. There is a chance that apps were available in languages that were not targeted by English search strings that are relevant to the topics discussed in this manuscript. Therefore, it can be observed that the investigation through this thesis is partial towards English-speaking apps.

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CHAPTER 5: GENERAL CONCLUSION

mHealth tools remain affordable, portable and cost-effective as a strategy in delivering healthcare. As technology continues to become increasingly utilized, the necessity to create apps to provide mobile support in times of crisis is apparent. Further expansion is needed to create apps that host multiple helpful features in one place and to cater to all communities or create apps for each community specifically. Research on these apps to improve quality and provide information on usability and acceptability are necessary to ensure evidence-based apps are being created. In addition, co-creation of apps with community members, key stakeholders, academic and research institutions could allow for apps that improve the use and quality of information being included. This thesis identifies that while apps are currently in place for two crises – the COVID-19 pandemic and the Indigenous Mental Health crisis, there are a number of opportunities for improvement and innovation.