Methods for Developing, Implementing, and Evaluating a New Artificial Intelligence Guided Mental Health Resource Navigation Chatbot for Canadian Healthcare Workers and Their Families in Two Canadian Provinces During and Following the COVID-19 Pandemic: Cross-Sectional Study

Jasmine M. Noble, Ali Zamani, MohamadAli Gharaat, Dylan Merrick, Nathanial Maeda, Alex Lambe Foster, Isabella Nikolaidis, Rachel Goud, Eleni Stroulia, Vincent I. O. Agyapong, Andrew J. Greenshaw, Simon Lambert, Dave Gallson, Ken Porter, Deb Turner, Osmar Zaiane

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Abstract

Background: One in three Canadians will experience an addiction and/or mental health challenge at some point in their lifetime. Unfortunately, there are multiple barriers in accessing mental health care including system fragmentation, episodic care, long wait times, and insufficient support for health system navigation. Additionally, stigma may further reduce an individual's likelihood to seek support. Digital technologies present new and exciting opportunities to bridge significant gaps in mental health care service provision, reduce barriers pertaining to stigma, and improve health outcomes for patients and mental health system integration and efficiency. Chatbots, i.e., software systems that use artificial intelligence to carry out conversations with people, may be explored to support those in need of information and/or access to services, and present the opportunity to address gaps in traditional, fragmented and/or episodic, mental health system structures, on demand, with personalized attention. The recent Corona Virus (COVID-19) pandemic has even further exacerbated the need for mental health supports among Canadians, and calls attention to the inefficiencies in our system. As healthcare workers and their families are at an even greater risk of mental illness and psychological distress during the COVID-19 pandemic, this technology will be first piloted with a goal to support this vulnerable group.

Objective: This pilot study seeks to evaluate the effectiveness of the Mental Health Intelligent Information Resource Assistant (MIRA), in supporting healthcare workers and their families in the Canadian provinces of Alberta and Nova Scotia with the provision of appropriate information on mental health issues, services, and programs based on personalized need.

Methods: The effectiveness of the technology will be assessed via voluntary follow-up surveys, and analysis of the client interactions and engagement with the chatbot. Client satisfaction with the chatbot will also be assessed.

Results: This project was initiated April 1st, 2021. Ethics approval was granted on August 12th, 2021 by the University of Alberta Health Research Board, and April 21st, 2022 by the Nova Scotia Health Authority Research Ethics Board. Data collection began May 2nd, 2022. Publication of a final report will be sought following the synthesis of analysis June 2022.

Conclusions: Our findings can be incorporated into public policy and planning around mental health system navigation by any/all Canadian mental health care providers - from large public health authorities through to small community-based not-for-profits. This may serve to support the development of an additional touchpoint, or a point of entry, for individuals to access the appropriate services/care, when they need them, wherever they are.

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Protocol

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Abstract

Background:
One in three Canadians will experience an addiction and/or mental health challenge at some point in their lifetime. Unfortunately, there are multiple barriers in accessing mental health care including system fragmentation, episodic care, long wait times, and insufficient support for health system navigation. Additionally, stigma may further reduce an individual's likelihood to seek support. Digital technologies present new and exciting opportunities to bridge significant gaps in mental health care service provision, reduce barriers pertaining to stigma, and improve health outcomes for patients and mental health system integration and efficiency. Chatbots, i.e., software systems that use artificial intelligence to carry out conversations with people, may be explored to support those in need of information and/or access to services, and

present the opportunity to address gaps in traditional, fragmented and/or episodic, mental health system structures, on demand, with personalized attention. The recent Corona Virus (COVID-19) pandemic has even further exacerbated the need for mental health supports among Canadians, and calls attention to the inefficiencies in our system. As healthcare workers and their families are at an even greater risk of mental illness and psychological distress during the COVID-19 pandemic, this technology will be first piloted with a goal to support this vulnerable group.

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Conclusions: Our findings can be incorporated into public policy and planning around mental health system navigation by any/all Canadian mental health care providers - from large public health authorities through to small community-based not-for-profits. This may serve to support the development of an additional touchpoint, or a point of entry, for individuals to access the appropriate services/care, when they need them, wherever they are.

Keywords: eHealth; chatbot; conversational agent; health system navigation; electronic healthcare;

Introduction

Background and Rationale

Mental disorders are the leading cause of disability in Canada, with one in three Canadians experiencing substance use or mental health disorders in their lifetime [1,2]. Unfortunately, there are also significant gaps in care. Based on a 2018 study, 5.3 million Canadians expressed a need for mental health services in a 12-month period [3]. Of those, 48.8% reported their mental health needs were not being met [3]. Of those reporting unmet or only partially met needs, 78.2% identified personal circumstances, including not knowing where to get help and/or affordability, as being a barrier to care [3].

Barriers to seeking support include stigma, denial, concerns over privacy, and/or difficulty connecting effectively with a care provider [4-7]. Additionally, prominent access issues include fragmented or episodic care, lack of support for navigating the healthcare system and connecting with an appropriate provider or specialist, and long wait times to access services [4-10].

Canada's publicly funded health care system is administered and delivered by the Provinces and Territories, through public health authorities or entities operating on a non-profit basis. Hospital and other healthcare services deemed 'medically necessary' must be insured by provincial and territorial plans. Many citizens acquire additional private insurance to pay for unfunded services [11]. Mental health care coverage across Canada varies widely and many available services are not deemed 'medically necessary'; despite mental health being increasingly recognized as fundamental to health. Only mental health services received in hospital settings are covered universally under Canada's public health system. Mental health care in Canada is unique as it is provided by a "meshwork" of local hospitals, community programs, residential care centers, private practices, and more [12]. Adding to this complexity, many organizations are particular to one jurisdiction or specific to a certain type of mental health concern.

Canada's system has been described as a "labyrinth" where individuals may even resort to paying private-sector agents to act on their behalf to find and connect with services, further exacerbating socioeconomic inequalities in access to care [13]. Many Canadians who have received unsatisfactory help for their mental health needs reported 'not knowing where to go' as a primary barrier to care [14]. Testimonies of Ontario-based patients and caregivers highlight feelings of confusion having to navigate this system on their own, resulting in longer delays to care access [15]. Wait times have been as long as two and a half years [14], with many individuals receiving no documented care [10]. The Wait Time Alliance 2014 "Report Card", highlights lack of system coordination and insufficient staff and resources as determinants of long wait times to access mental health services in Canada [15]. Heightened demands for care and lack of navigation towards community services contributes to overcrowding within emergency departments with a 75% increase in mental-health related visits for patients aged 5-24 since 2006/2007 [16]. System integration and system navigation support services between community-based health and social services and formal healthcare providers, has been identified as a key policy issue in Canada and other jurisdictions such as the UK [16-24], where lack of knowledge of service options often poses a barrier to referrals from health providers to community-based services [18,24-27].

The Impact of COVID-19 on Mental Health

In 2019, an outbreak of Corona Virus Disease (COVID-19) (virus name: SARS-CoV-2) resulted in a global pandemic. By early 2022, COVID-19 spread globally with over 334 million known cases, and over 5.5 million deaths [28]. In anticipation of a high volume of serious hospitalizations with technical respiratory needs, Canadians were asked to self-quarantine and/or practice social distancing to reduce the burden to health systems [29]. This intensified the mental health crisis within Canada; according to an Angus Reid Institute poll, 50% of Canadian respondents indicated their mental health had worsened over COVID-19, with 10% indicating that it worsened "a lot" [30]. Multiple public surveys deployed during the pandemic reported respondents' experiences of multiple mental health stressors, such as economic instability, fear of getting sick, and life disruption as a cause of the COVID pandemic, resulting in stress, anxiety and depression [31]. A recent Ontario survey revealed that around 25% of respondents reported unmet mental health needs as a result of the pandemic; moderate to severe anxiety, and symptoms of loneliness and depression [32].

In accord with negative mental health outcomes observed in this and previous epidemics and pandemics [33, 34], it is widely agreed by the international medical community that a wave of

widespread need for mental health related services will result from the pandemic that will persist beyond the acute phase [31]. Within the Canadian context, in consideration of the pre-pandemic prevalence of mental illnesses, such as depression (lifetime prevalence of 5% in Canadian men, and 10% in Canadian women [35]), or insomnia (12-month prevalence ranging from 9.5% to 24% [36-39]), and existing gaps in service delivery, public health practitioners and policy leaders must urgently consider innovative ways to connect a large portion of the Canadian public to appropriate services, in an efficient manner.

In addition to the negative impact on Canadians' mental health, many services have faced disruptions due to adjusting to social-distancing and capacity restrictions; often eliminating face-to-face in lieu of virtual settings [40]. Many countries have developed new online mental health information sites and/or phone support lines to provide coping support [41]. For those facing modest mental health burdens, connection to these online resources can aid in self-management and may provide a bridge before professional support is available [40]. With these changes in offered services and increased online app use, navigation to individual user appropriate, timely and relevant resources is increasingly important.

The Mental Health of Healthcare Workers

Healthcare workers, and their families, are particularly vulnerable during pandemics and, in reflection of anticipated need, are the target participant group for this pilot study. Healthcare workers face an increase of mental health risk factors including anxiety, burn-out, and depression, due to factors such as increased exposure and risk of disease transmission to self or others (e.g., family and friends), and unsafe (e.g., personal protective gear shortages) and/or stressful working conditions [39]. Of concern is the trauma that healthcare workers are witnessing within the workplace, how their ongoing work limits their ability to address their own mental health concerns, and how they may be processing these experiences when they are outside of the workplace with more time to re-process what they are seeing. For example, a recent umbrella review of meta-analyses found that the prevalence of anxiety and depression among healthcare workers was relatively high at 24.94% [40]. A recent survey by the Canadian Centre for Addiction and Mental Health (January 2022), documented an increase in self-reported symptoms of severe anxiety (37% compared to 23.5% in summer 2021) and depression (35.7% compared to 24.8% in summer 2021) for healthcare workers and other frontline workers [32], suggesting mental health problems are being exacerbated with time. Together, these risk factors may lead to healthcare workers resigning from their positions, increasing staff shortages and in-turn pressures on remaining employees [41]. Based on our findings within this pilot group, we aim to further refine, scale, and spread the implementation of our chatbot to be used by Canada's general public.

Opportunities for Health Chatbots

Digital technologies provide an opportunity to bridge service gaps, increase points of access to and knowledge about the mental health care system and existing services, enhance mental health literacy, and permit greater system health and social system integration, which could improve health and social system coordination, efficiency, patient navigation, satisfaction, and overall health outcomes [42]. Additionally, efficiencies realized through use of new technology may lower healthcare costs, enabling resources to be redirected to other areas of priority. Artificial Intelligence (AI) presents the opportunity to bypass barriers inherent to traditional brick and mortar health system structures, to meet individuals in need in a discrete and personalized way, and connect them to services in a timely manner, regardless of where they are. For example, commonly cited factors identified for why individuals choose to access online

services include 24-hour accessibility, ease of accessibility despite geographic location, anonymity, and privacy [43-46]. Although further analysis is required in the context of mental health care, research suggests that patients report greater comfort or preference in disclosing sensitive health information to a computer or technological device, than to a human [47,48]. AI then presents the opportunity to also address social stigma as a barrier to care, which may hinder an individual's drive or motivation to seek access to care.

Chatbots can be defined as computer programs that use AI methods, including natural-language processing and machine learning to simulate conversation with human users. Existing evidence supports the use of health chatbots for empowering users to engage in physical activity and consumption of nutritious food, and for increasing patient access to health information, among other benefits [49-52]. While human-computer interaction technology itself is not new as a concept, evaluative research on the use of applied AI as a tool for bridging gaps in mental health care is limited. More specifically, although chatbots are currently showing promise within a variety of health care settings [53-55], there is limited information on their effectiveness in supporting mental health system navigation [53,56-58]. As such the use of a conversational chatbot for this general purpose is novel. Additionally, existing chatbots are commonly tailored to address one or a limited range of mental health issues [59]. Our conversational chatbot, the Mental Health Intelligent Information Resource Assistant (MIRA), seeks to support a wide range of mental health disorders and considerations.

Most research to date has evaluated constrained client input (options that are provided to the client for input), and research on unconstrained natural language opportunities remains in its infancy [60]. Chatbots in mental health have been characterized and/or criticized as being predominantly rule-based (chatbot led and controlled versus user controlled) and are offered as stand-alone software (versus web-based; complicating ease of client access). MIRA is a web-based, hybrid NLP and decision-tree, user-controlled AI chatbot. In this context, these features are novel in their application, in the mental health space. See Methods section for more details on each of these design elements.

With advances in dialogue management and conversational flexibility, enabled through the establishment of complex neural networks inclusive of sentiment analysis, chatbots within the space of mental health have the opportunity to play an important role in patient care.

Fortunately for emergence of digital health intervention options, the uptake of technology among the general public has been substantive. There are over 3.96 billion Internet users internationally [61]. In Canada, 91% of the population is estimated to be actively using the internet and 85% have a cellphone (65% smartphones specifically) [62-63]. As such, there remain significant opportunities to use existing and widely adopted technological infrastructure to bridge significant gaps in care and improve health outcomes for Canadians.

The MIRA Project

In this paper, our pan-Canadian, multi-disciplinary team of subject matter experts, inclusive of individuals with lived experience, Indigenous Community members, clinicians, psychiatry, and computing science experts, report on the design, implementation, and anticipated evaluation of MIRA, a domain specific AI-enabled chatbot, able to understand common taxonomies in the mental health domain and respond with relevant, appropriate resources aligned with clients' intents and needs. The MIRA chatbot is an informational chatbot only, and does not provide medical advice (i.e., does not diagnose or provide treatment recommendations), nor does it

replace a counsellor or mental health professional. The population group of interest for this pilot are healthcare workers and their families in the Canadian provinces of Alberta and Nova Scotia.

Two additional components have been developed to complement the chatbot's functionality, including a resource management portal (the MIRA Resource Portal), and a Selenium [64] based automated testing framework. MIRA does not search for resource recommendations extracted by the open internet. Instead, MIRA draws recommendations from the MIRA Resource Portal, which not only facilitates the input and expert validation of mental health resources for use by the chatbot, but also automatically monitors validated resources for any changes to a resource after approval and subsequently reports them to the editors. Our Selenium based testing framework uses AI to automatically generate diverse wordings test cases using to assess the chatbot with different dialogue flows using diverse wordings and/or intentional minor spelling errors.

This study will investigate the effectiveness of MIRA in its ability to successfully connect healthcare workers and their families to appropriate information on local mental health issues, services, and programs based on their identified needs. The effectiveness of the technology will be evaluated primarily through data collected via voluntary follow-up surveys and client interactions and engagement with the chatbot. Client satisfaction with the chatbot will also be assessed. We hypothesize that the chat successfully connects users to appropriate health resources (e.g., mental health educational resources, Mood Disorders Society of Canada (MDSC) peer support program, posttraumatic stress disorder training, online peer support, etc.) (see Outcome Evaluation for more details).

Methods

The subsections below describe how the chatbot was developed, implemented, and how it will be subsequently evaluated.

Chatbot Development

A Multidisciplinary Team

In recognition of the complex nature of developing and implementing accepted and effective state-of-the-art computing science technologies seeking to support mental health and wellness within the public health domain, a multidisciplinary team is required.

The MIRA Operational Team (inclusive of senior leadership, fellows, students, and support staff), and voluntary Expert Advisory Committee are inclusive of computing science, and psychiatric expertise, health care workers, and family members and individuals with lived experience. In order to develop a new technology to be accessible to all Canadians, that does not perpetuate the systemic racism inherent within the public health system, MIRA is being co-created with the Indigenous Community, and is inclusive of an ethnically and culturally diverse team leading and supporting its development, from tip to tail. See Multimedia Appendix 1 for a graphical description of the multidisciplinary approach.

Developing MIRA

MIRA was built via Rasa Open Source, an open-source conversational AI platform [65], as team members had familiarity with the platform, it was considered advantageous for the implementation of advanced natural language understanding, for its flexibility and ease of integration, and because it was deemed most customizable by our chatbot team in comparison

to other platforms such as Botkit, BotPress, MindMeld, and/or DeepPavlov [66-69]. Its customization would also allow for the incorporation of progressively more complicated or advanced forms of AI and natural language processing. This is imperative for future iterations of MIRA (beyond this pilot), where the study team intends to program the chatbot to adapt its behaviour differently depending on the geographic and linguistic context of the individual using one chatbot/interface. This approach, using base code from Rasa Open Source and enhancing, adding to, and adapting it based on our needs for this project, allows our team to both pilot a state-of-the-art viable product in a reasonable timeframe to address an urgent public health need , while ensuring that more advanced computing science techniques and advancements can be incorporated incrementally and tested over several years to further enhance chatbot capabilities. This approach builds upon lessons learned from other researchers developing similar technologies in health, where deploying a "working solution" at the time was done at the expense of "…more innovative and potentially better solutions…" [70].

MIRA was built as a web-based chatbot (versus a stand-alone chatbot), to increase accessibility to the chatbot, as no installation of software or applications is needed in order to use the chatbot, and the chatbot can be used on any device regardless of operating systems. This also builds on lessons learned from other research in the field, where stand-alone chatbots were predominantly used [59].

The development of MIRA was guided by a chart-flow diagram via Lucid Chart [71], a web-based collaborative design platform. This conversational-flow diagram was initially developed by a psychiatric expert on our team, then tested and refined by study team members from MDSC, an organization led by individuals with lived experience, inclusive of the categorization of anticipated client "intents", and appropriate chatbot "utterances." Following this preliminary structuring, our computing science team members built the MIRA chatbot to follow the chart-flow diagram as a guide. To further refine the chatbot, the multidisciplinary team was asked to imagine hypothetical questions that could be received by the chatbot. Approximately 200 hypothetical questions were developed (133 distinct questions, along with variations of question types). Questions were subsequently organized into "intents." The chatbot was initially trained on these intents. Where new intents were revealed, the chart-flow diagram was adjusted to include them. Where possible, "Intents" and "utterances" were enhanced using existing open-source libraries on chatbot dialogue. All chatbot "utterances" were reviewed by members of the team from MDSC to ensure the language used was written at an appropriate reading level, clear, considerate, and respectful. The rationale for approaching the chatbot design and training data in this manner was in reflection of the complicated nature of mental health. The chatbot behaviour needed to be tailored to ensure that it behaved in a way that would guide a user to resource recommendations appropriately, effectively, and respectfully. Lucid chart allowed non-computing science team members (e.g., psychiatric and lived experience experts) to communicate necessary chatbot conversational flow behaviours to the computing science team clearly and effectively, including any emergency or urgent related prompts and responses (see more on this below). Open-source use of big-data has been significantly criticized for perpetuating systemic racism and societal inequalities [72]. As such, developing training data using our multi-disciplinary team was important to ensure chatbot behaviour remained respectful and reduced existing issues inherent in big-data. Furthermore, chatbot behaviour was reviewed by members of the team with lived experiences to ensure chatbot responses were trauma informed, to not exacerbate trauma or challenges individuals accessing services may face.

At the request of MDSC, the computing science team incorporated additional conversational functionality, reflective of ELIZA [73], an early natural language processing conversational AI algorithm, to add non-scripted responses. This was to reduce the "transactional" or robotic feel or experience a client had with the chatbot and allow a client to speak freely with the chatbot before asking for assistance in finding specific resources. For the preliminary design, the computing team adjusted ELIZA code to include entity extraction (this adjusted code is referred to as "eEliza," (whereas "e" denotes "enhanced") and can be found in Figure 1). Extracted entities are then used in conversation back to the client (to acknowledge information shared by the client), as well as to refine resource recommendations to be provided later in the interaction. The use of Generative Pre-trained Transformer [74], an open-source AI algorithm that translates input from clients and generates at times human-like output, is currently being explored to further enhance the conversational functionality of the chatbot for this pilot phase.

Of importance is the use of both NLP (via text-based entry) and decision trees (rule-based responses based on use of predetermined "buttons" options) to support response generation. Most chatbots in mental health utilize either one or the other, whereas MIRA uses a hybrid approach to enhance functionality and end user experience by offering them the choice/control to use both interchangeably during their exchange with MIRA. It is our understanding at the time of writing this paper that this approach in itself (using NLP and rule-based responses, and/or allowing users to control the conversation) is a novel application of AI within the mental health field [59].

The chatbot was built to associate various terms or phrases as being of an urgent or serious nature and has been prompted to immediately provide information on emergency services, should this association be triggered. For example, if the client indicates that they are experiencing suicidal thoughts, the chatbot will immediately provide them with emergency contact information, and the Crisis Services Canada phone number, chatline, and texting information. This emergency response was flagged as being of critical importance in supporting individuals experiencing urgent mental health related challenges, by mental health experts on our team and our Expert Advisory Committee. Hypothetical phrases used for baseline training data were developed with the assistance of these members as well.

Following this work, our computing science team members worked on the incorporation of data augmentation, i.e., the use of an AI algorithm that, using existing examples/hypothetical questions, can create new variations of hypothetical questions that could be asked to further refine chatbot functionality, as well as web browser automation via the Selenium platform to test chatbot functionality, to mimic anticipated and unanticipated client questions, responses and behaviours. Over 20 different data augmentation algorithms were used, including contextual word embeddings, random character errors, and synonym augmentations. Stanford's CoreNLP, an open-source natural language processing tool, will be used to further enhance entity extraction [75].

The two main purposes of MIRA are to provide individuals with 1) information/education on substance use and mental health illnesses generally (simple educational information including general definitions, descriptions of symptoms, etc. written at a lay audience level), and 2) information on services and programs in Canada, or, if voluntarily provided, in the specific city/ village, region, or province of the identified end user. Level of specificity of information, services, and/or programs provided is dependent on the level information voluntarily shared by the client. For example, the client may ask for a definition for "mood disorders" or,

alternatively, may ask for an in-person group therapy program for individuals managing major depressive disorder, in Edmonton, Alberta. The programming of these two components required different approaches, detailed below.

The education resource component of the chatbot was developed first by identifying common mental health ailments or challenges. A list of psychiatric disorders was extracted from the Diagnostic and Statistical Manual of Psychiatry Disorders (DSM-5) by a psychiatric expert on the team, who then, extracted common language used online by reputable organizations (known government and not-for-profit, government supported), whose websites were tailored to a lay audience, and linked clinical and common language. This linking was helpful to both train the chatbot on relationships between lexicons used in the psychiatric field between audiences, but also to serve as a preliminary list of common ailments. Following the development of these lists, volunteers at the MDSC supported the collection of online resources that provided the following information on each specific ailment: definition of the disorder or ailment; list of associated symptoms; a description of common associated treatments. These online resources and their relevant informational data were individually logged in the MIRA portal (MIRA Portal details outlined below), and subject to review via a 30-member Expert Advisory Committee.

The services and programs resources component was developed by first logging a resource list provided on the Mood Disorders Society of Canada website. The act of logging was conducted by MDSC volunteers. Following this, government websites were reviewed by team members and volunteers for additional resource lists. Where lists of recommended resources were provided, volunteers were asked to log said resources. These online resources were also subject to review via a 30-member Expert Advisory Committee. The MIRA portal currently has over 750 fully vetted resources.

Testing MIRA

The MIRA core team collaboratively determined a quality threshold for release of a minimum viable chatbot prototype, based on a variety of performance metrics. Performance measures, including accuracy of intent recognition and entity extraction, as well as average rending time, were used by the computing science team to monitor progress of chatbot training and refinement. Where needed the team then strategically addressed particular elements of the chatbot that they felt may enhance measures reporting lower than acceptable metrics.

The chatbot was in Alpha testing from December 2021 to February 2022. The chatbot was then Beta tested by members of our 30-member, multidisciplinary expert advisory committee, from February 7th, 2022, through to May 1st, 2022. Comments were be logged and changes made to the chatbot in real-time. Testing was be enhanced using automation via Selenium, a web-browser automation tool, to repeatedly test anticipated end-user behaviour, and log programming bugs and errors.

The chatbot was launched to the pilot population on May 2nd, 2022. Data collection is anticipated from May 2nd, 2022 to May 2nd, 2023. The publication of a preliminary synthesis of results will be sought Spring/Summer 2022, followed by a more comprehensive evaluation in Spring 2023.

Interacting with MIRA

Once the client clicks the MIRA URL (www.MyMIRA.ca), they are directed to a webpage with

the MIRA chatbot interface. MIRA begins by welcoming the client and asks them for their consent to use anonymized data from the conversation to evaluate and improve its services, with a link to a pop-up with consent information (see Multimedia Appendix 2). If the client provides consent, the chatbot then asks a short series of demographic related questions (employment type, location, end user (e.g., for client or for someone else; if “someone else” then age of end user is also collected) (see Multimedia Appendix 3). Following these preliminary questions, the chatbot asks in an open-ended manner (ex. “How can I help you?”) and provides some examples of questions that could be asked in the form of button options (e.g., I want to find programs and services; I want to learn coping skills) (see Multimedia Appendix 4). If a client asks to “chat” with MIRA, and/or begins expressing feelings opposed to an obvious request for information, eEliza programming will be prompted (see Multimedia Appendix 5). The www.MyMIRA.ca website, MIRA Chatbot, and MIRA Resource Portal (renamed the MIRA Resource Library for the May 2nd launch) was tested to be compatible on multiple electronic devices including tablets, smart phones, and desktop computers, as well as multiple browser applications including Safari and Chrome.

The MIRA Portal

The internet may contain information with inaccurate content, bias, and insufficient evidence [76,77]. This is why MIRA does not draw resource recommendations via the open internet and instead provides resource recommendations drawn from the MIRA Resource Portal. The MIRA Resource Portal is a resource repository, in which MDSC volunteers have catalogued and annotated with meta-data of over 750 resources to-date. These resources were then assessed for quality via a 30-member Expert Advisory Committee, using an approach reflecting the academic peer-review process. More specifically, resources are assigned to Committee members by an Editor (the Study Coordinator). Each resource is subject to review by at least 2 different reviewers. Reviewers are guided by an evaluation matrix developed using a hybrid of items that were drawn from existing validated tools [76,78,79]. Factors assessed included 1) readability, 2) accessibility, and 3) quality [76,78,79]. This “hybrid” approach was taken, as our definition of “resource” was broad (see “resource types” description below), and included many types of resources (e.g., phone number, website links, videos, audio recordings, images, apps etc.), and as such, to our knowledge no validated tool existed at the time of developing this paper. To date over 1,600 resource reviews have been conducted, resulting in 750 resources that have been fully vetted and approved by the Expert Advisory Committee, and are now accessible by the chatbot.

For the purposes of this study, “resource” is defined as evidence-supported, relevant, reliable information that would satisfy an end user of the virtual assistant (chatbot) in retrieving general mental health information and/or connecting with the appropriate mental health services for their identified need and circumstance. A recommended resource can be provided at the end of a dialogue as the final outcome, or anytime during the exchange.

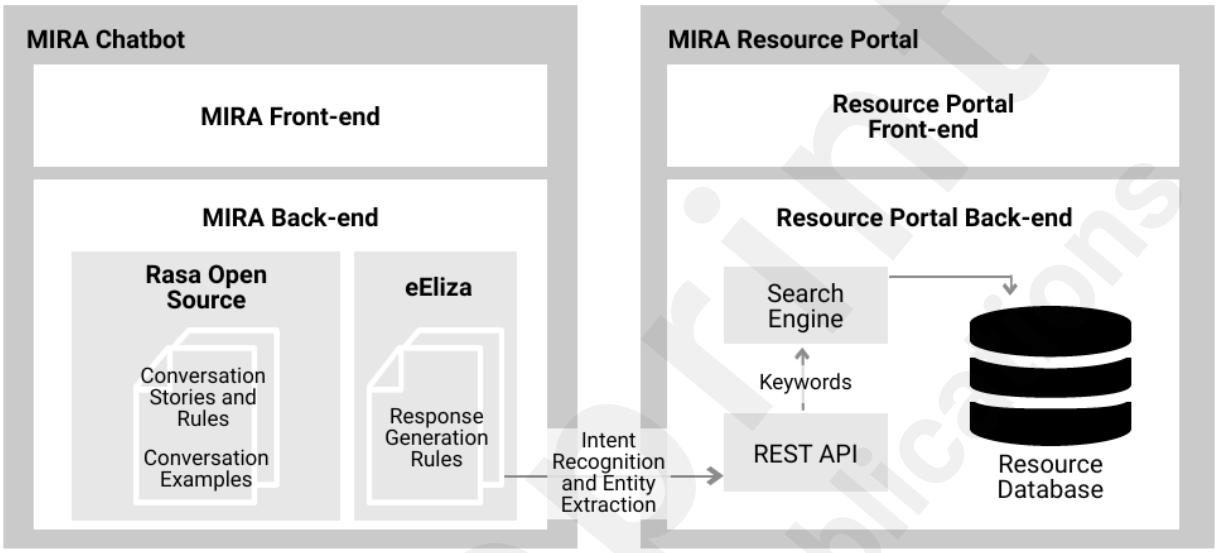
Resource types:

- Health system navigation: Information that connects clients with interactive assistance and services - includes a textual description of the resource AND any of the following elements of a typical "contact" record: email address, phone number, physical address of in-person service, hours of operation, url if website
- Informational/Education Reference: includes a textual description of the resource AND any of the following: website URL, URL to an audio/video/image/PDF attachment
- Simple Answer: just a textual description, that can be provided as answer to a direct

factual question

If a resource received a mixed review, it was then subject to review by a third reviewer (a tiebreaker who is also a member of the Expert Advisory Committee). Reviews were made anonymous to everyone with the exception of the Editor who is responsible for assigning resources to allow reviewers to be candid, and all reviewers are asked to acknowledge any conflicts of interest prior to being permitted to review a resource. See Figure 1 for an architectural diagram of the MIRA chatbot and portal system.

Figure 1: Architectural Diagram of the MIRA Chatbot and Resource Portal System



Participants

For the purposes of this project, the definition of the target sample is broadened to capture all health-related personnel, and their respective families, that may be impacted by heightened mental health burden in light of the on-going pandemic. Additionally, direct and/or vicarious trauma or psychological distress in a healthcare environment is not limited to medical staff [80,81]. Therefore, 'healthcare worker' will be defined as:

- "Any health professionals and any staff member, contract worker, student/trainee, registered volunteer, or other essential caregiver currently working in a healthcare organization, including workers that are not providing direct patient care and are frequently in the patient environment. This includes cleaning staff, food services staff, information technology staff, security, research staff, and other administrative staff.
- Workers providing healthcare service or direct patient service in a congregate, residential or community setting outside of a healthcare organization (e.g., nurse providing patient care in a school, worker performing personal support services in an assisted living facility, medical first responder in the community, peer worker in a shelter)" [82].

The definition of healthcare worker varies considerably by health authority and/or administrator. As such the following numbers are used to determine a general goal post for a target sample size, recognizing that the data sources (Alberta Health Services and Nova Scotia Health Authority) may have differing inclusion criteria for what is categorized as healthcare worker. There are approximately 240,000 front-line AHS healthcare workers in Alberta [83],

and 23,400 in Nova Scotia [84]. To include “family members” into sample size calculations, 2011 Statistics Canada estimates on the average number of individuals in a household were used (2.5 per household) [85]. With a confidence interval of 95% and 3% margin of error, the sample size target for Alberta is estimated to be 1066 and 1048 for Nova Scotia. More specifically, this sample size refers to the number of participants that consent to use the chatbot. This study will seek to slightly oversample from each Province (Alberta n=1100; Nova Scotia n=1100). In reflection of the general experiences of other researchers with participation rates for online surveys (34-43% [86-90]), we will aim to collect between 374 to 473 partial and complete baseline surveys, and 110 partial and complete follow-up surveys per province. To the knowledge of authors at the time of writing this paper, this study is the first study evaluating the use of conversational agents or chatbots to support mental health system navigation, as such effect size is unknown at the time of the design phase of the study, and power analysis will need to be conducted as the study team actively gathers data to ensure our sample size is adequate. As such the sample size is subject to re-estimation during the course of this study.

Participant recruitment will be conducted through snowball sampling via word of mouth, social media advertisements, physical advertisements (study posters and study information posted on physical bulletin boards in hospital staff rooms as well as in newsletters to staff where possible), and by referral via our network and partners (including medical professional organizations). After consenting to take part in the study via an online consent form, participants will be asked if they would like to participate in voluntary follow-up surveys following use of the chatbot. Regardless of their response, they will then be able to immediately engage with the chatbot. Inclusion criteria are an age of over 18 years at the start of the study; a healthcare worker or a family member of a healthcare worker; located in Alberta or Nova Scotia; the ability to speak and read English; access to the internet. The chatbot will be developed with the options of adding French and other languages of peoples geographically located within the settlement of Canada in future iterations of the chatbot (e.g., Cree, Inuktitut, Ojibway, etc.). Exclusion criteria include individuals under the age of 18 years of age; individuals in provinces outside of Alberta and Nova Scotia; those with limited comprehension of English; and, without internet access. However, if a client tries to access this service in order to support an individual under the age of 18 years old and/or outside of the two provinces indicated, the chatbot will include cross-Canadian resources that could support them.

Procedures

This project was initiated April 1st, 2021. Data collection began May 2nd, 2022 and will continue to May 2nd, 2023. Publication of preliminary results will be sought following the synthesis of data in Spring/Summer 2022. A final report will be developed Spring 2023.

Healthcare workers from the provinces of Nova Scotia and Alberta will be invited to use the chatbot service. Family members of healthcare workers will also be welcome to participate in the study. Participant recruitment will be conducted via snowball sampling, through word of mouth, social media advertisements, physical advertisements, and by referral via our network and partners (including medical professional organizations). Potential participants will be asked to provide informed consent prior to receiving services from the virtual assistant. Although participants will be encouraged to register their email address so that the study team can send them voluntary follow-up surveys to evaluate program performance (more on surveys below), registration will be voluntary. Regardless of registration, participants will be provided with access to MIRA following the provision of consent.

Should a participant register their email address, they will be provided with two voluntary surveys: one at baseline (immediately following use of the chatbot), and a second at 24 hours following the initial use of the chatbot. Surveys will collect demographic information (e.g., year of birth, gender identity, visible minority status), ask participants whether or not they followed through with a recommended resource and the perceived appropriateness of that resource (e.g., “Were the resource(s) that MIRA recommended to you during your conversation appropriate?" “After your conversation with the MIRA, did you follow-up/connect with the resource(s) that the chatbot recommended?”), and assess baseline mental and physical health via the Clinical Outcomes Routine Evaluation System (CORE-10) – a validated brief 10-item assessment and outcome measurement tool used to assess conditions including anxiety, depression, physical problems, and risk to self [91]. Select items from Embodied Conversational Agent (ECA) Trust Questionnaire (ETQ) (e.g., Did you feel that MIRA was competent? (4 point Likert scale from not at all (0) to completely (3)), and Acceptability E-scale (AES) (e.g., How much do you agree with the following statements? MIRA gave me information that was relevant to my concern. (5 point Likert scale from “strongly agree” to “strongly disagree”)), are used to assess client satisfaction and acceptability, including perceived usability, benevolence, credibility, and trustworthiness [92].

In addition to the voluntary survey, data will be extracted in aggregate of the general use of the technology to assess effectiveness and engagement, including topics most frequently raised, average time spent on service, number of resources provided in an average conversation, number of client interactions with links, top most frequent recommendations by the chatbot to clients, number of resources recommended by the chatbot in an average conversation, average number of objections raised by clients in conversations, and intent identification and entity extraction accuracy. This use of aggregate data in this manner will be flagged in the consent form preceding use of the virtual assistant. Participation on the platform will remain anonymous, with the exception of the satisfaction surveys (voluntary), which may be temporarily linked via email address in order to track survey responses at different time intervals (baseline and 24 hours). Following linkages, emails are permanently deleted and replaced with a randomized participant number to further protect anonymity. Transcripts between clients and the chatbot will be used anonymously to further train and refine the chatbot. Transcripts do not contain any identifiable information and will only be used to improve chatbot functionality. The use of transcripts by the chatbot to serve as a form of “memory” from which the chatbot will learn and teach itself to perform in a more refined manner, is outlined in the consent form provided to participants. To further protect anonymity, the chatbot has been programmed to remove any personally identifiable information from transcripts prior to saving them (e.g., if a name is provided, it is omitted from the saved transcript).

There is no standardized approach to evaluate chatbots within the field of health [60,93]. In order to determine which variables to collect for analysis, our team aggregated findings from several academic studies and reviews that described the technical characteristics, applications, and evaluation measures of chatbots in the field of health [60,93]. In reflection of the findings of these studies, where applicable for the purposes of our study, we chose items from validated tools, and/or items used to evaluate other chatbots (e.g., CORE-10, ECA ETQ, AES, as well as classifier performance measures such as accuracy, precision, etc.) to permit cross-comparability where possible between this and existing research, and to support efforts to align evaluative measures within the field [60,93-96].

Data analysis

The effectiveness of the technology will be assessed primarily through data collected via voluntary follow-up surveys and client interactions and engagement with the chatbot. As use of the chatbot is anonymous, it is not possible to conduct direct follow-up via electronic medical records to confirm the utilization of any particular services. As such, the research team will primarily rely on information volunteered by clients via the follow-up surveys and chatbot analytics, in order to assess whether clients successfully connected with recommended resources (by asking them directly).

Outcome Evaluation

The primary outcome measure will be an analysis of participant responses to follow-up survey questions on successful connection to resources recommended by the chatbot and the perceived appropriateness of the resources recommended. More specifically, we ask the participants the following questions:

> "Was/were the resource(s) the MIRA chatbot recommended to you during your conversation appropriate?"
> Response options: yes; no; other, please specify
>
> "After your conversation with the MIRA chatbot, did you follow-up/connect with the resource(s) that MIRA recommended?"
> Response options: yes; no; other, please specify; I prefer not to answer
>
> If "no," then the respondent is asked subsequent question "why not?"

Assessment of whether the chatbot successfully "connected" the respondent to appropriate resources will be the number of respondents to who answered "yes" to both these questions. Further consideration will be given to "no" or "other, please specify" responses, where additional detail is shared by the client, to assess rationale for a failed connection (e.g., personal choice not to connect; could not successfully reach resource after attempting to do so; etc.). In reflection of previous reports that approximately 24-49% of Canadians do not feel their mental health needs are being adequately met [3,32], we have set a minimum threshold for successful connection to appropriate resources to be over 50%.

Secondary outcome measures will be analysis of mental and physical wellbeing (CORE-10) at time of use and 24 hours following use, client satisfaction and acceptability (including perceived usability, benevolence, credibility, and trustworthiness), inter-group variation, drop-off/engagement rates, general chatbot utilization patterns, and exploration of why this intervention may or may not have been supportive or helpful for particular groups.

Chatbot performance will also be evaluated based on additional technical measures identified in reflection of other evaluative works within the field of chatbots in health to allow for the cross-comparability of findings [97-101] including an analysis of intent classification accuracy scores, entity recognition accuracy scores, client URL engagement, chatbot rending and response speed, conversational completes, task completion rates measured via binary responses to questions such as "is this what you were looking for"? and "is there anything else I can help you with?", star rating by clients at the end of a conversation, client objections, and prompt interruptions.

Ethics and Data Privacy

Ethics approval was granted on August 12th, 2021 by the University of Alberta Health Research Board, and April 21st, 2022 by the Nova Scotia Health Authority Research Ethics Board. All data and computer code will be password protected and stored on a secure server at the University of Alberta in Canada.

Data Availability

The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Results

On April 1st, 2021, this project was initiated by partners Mood Disorders Society of Canada, the University of Alberta, Dalhousie University, the University of Saskatchewan, the International Indigenous Health Research and Training Centre, the APEC Digital Hub for Mental Health, AI4Society, the Alberta Machine Intelligence Institute. A Mitacs Accelerate grant to support student involvement in this project was successfully awarded August 11th, 2021, with a secondary award granted March 23, 2022 to support research activities for this project into Spring 2024. For this study, ethics approval was sought and granted by the University of Alberta Health Research Board (case number: Pro00109148), and the Nova Scotia Health Authority Research Ethics Board (case number: 1027474), on August 12th, 2021 and April 21st, 2022 respectively. On May 2nd, 2022, data collection began, and is anticipated to continue up until May 2nd, 2023. Spring/Summer 2022, preliminary results will be published, with a more comprehensive evaluation with a larger data set to be completed by Spring 2023.

Discussion

The world is undergoing a period of significant growth in technological innovation. Starting with the Internet, technological networks and systems have emerged as so complex and disruptive that they have transformed not only our governing and economic structures, but also of our perception of self, community, and day to day life. With 8 million global deaths attributed annually to mental illness [12], there is urgency to identify effective and timely service options that reduce and eliminate barriers, including through health system navigation, as well as investigate innovations where technology may present constructive novel solutions.

In this paper, we describe our experience to date with the development of MIRA, a chatbot designed to guide clients that experience mental-health challenges to appropriate information and services available to them. Our development process includes a broad team of stakeholders and experts (in mental health and computing science) and addresses a number of challenges that one should consider in order to develop a realistic and practical solution.

This paper also describes our anticipated methodology to evaluate MIRA, including its ability to connect healthcare workers and their families to relevant high-quality mental health services and information. As noted, we hypothesize that the chatbot will effectively connect clients with appropriate information on mental health issues, services, and programs, based on personal need. If proven effective, in the spirit of the Canadian universal health care system, it will be offered free of charge to the Canadian public. To our knowledge, there have been no similar studies in this field. If successful, this innovation has the potential to offer significant benefit to the Canadian public and to demonstrate a solution that can be adopted by other international healthcare systems.

Future Directions:

There are several considerations that could be given for future research, some of which our team seeks to touch upon in future works related to this study, outlined below.

Research evaluating health chatbots is commonly criticized for being inconsistent in terms of outcome measures, which hinder opportunities for cross-comparability with other evaluations. As such, through the careful review of previous works and the publication of our protocol, we hope to help support a movement towards consistency, by using evaluative measures consistent with those reported in systematic and scoping reviews of chatbots in mental health, where possible and appropriate [97-101]. Further consideration should be given by other researchers towards the development of a standardized approach to evaluate chatbots within the field of health.

Discussions around the development and implementation of ethical AI and in prioritizing health equity throughout the lifecycle of an AI system are of critical importance. AI has been criticized for being "no more than human behaviour reflected back to us" [102]). Inherent in this argument is the ability of AI to "reflect the biases present in our collective conscience" [72]. Discourse on guidelines to rectify and prioritize health equity in the development lifecycle of an AI system [103], as well as around ethical AI application generally is becoming more prolific. This project uses a multi-disciplinary core team and advisory committee, inclusive of members of the Indigenous Community and other communities of colour, Individuals with Lived Experience, and other expertise. This co-creation of a mental health chatbot (inclusive of efforts to action the First Nations Principles of Ownership, Control, Access, and Possession), with the support of an advisory group to support usability testing and the development of a controlled training "ground truth" data set is novel and presents an interesting and rich opportunity to conduct an analysis and exploration of mental health equity in the digital space, through a lens of different existing and potential end users. Researchers should be encouraged to continue to explore these topics further in the context of applied AI design and implementation, in order to support health equity and racial justice.

This study will also explore other areas of interest such as the analysis of Health Information-Seeking Behaviour (HISB). HISB is a coping strategy individuals use involving the gathering of information about a health topic in response to a recent diagnosis or for other health related reasons such as general health promotion. The personal and contextual considerations of HISB have not been adequately explored. More specifically, further analysis is needed into the cultural, contextual, and demographic influences which may play a role in HISB [101,104]. As the perceived level of quality of information accessed can influence individuals "intention to seek further [information]", additional considerations must be made to quality review and assurance of any resources recommended by the chatbot. As such, resources that the chatbot recommends must be vetted by experts, including health professionals and individuals with lived experience [101,105,106]. Our team has sought to address this through development and use of the MIRA Resource Portal, and vetting supported by an Expert Advisory Committee inclusive of a diverse set of voices. Further analysis on the topic of HISB is thus possible as a result of this work.

Although deep learning models currently have the ability to conduct language processing tasks such as tagging, text classification, machine translation, and question answering, existing, state-of-the-art models are criticized for lacking "explainability" - more specifically being able to describe how the algorithm came to a particular result or action, which is considered a key

pillar in discourse around ethical AI development [107-109]. This, and future studies, must seek to improve methods of explainable natural language processing.

Another direction for future consideration is the incorporation of emotional intelligence into dialogue generation, to better imitate human conversational patterns and appropriately respond to emotional input. Existing neural dialogue systems, such as sequence-to-sequence, have been criticized for being limited in response length, and/or for producing generic or non-committal versus empathetic or emotionally intelligent output [110,111]. Future studies should explore the integration of empathetic response generation that appropriately categorizes a client's current emotional state based on their input utterance, considers a desired target emotion to guide clients towards, and subsequently generates an emotional intelligent response back to clients incorporating these considerations [110,111]. Multi-label emotion mining may be considered to support said categorization [112]. Our team will seek to improve the emotional intelligence of future iterations of MIRA, following this pilot, through the further enhancement of "eEliza."

Limitations

There are several limitations anticipated of note we consider unavoidable. First, digital interventions are not accessible to all Canadians, and there are barriers to their use including: technical issues with connectivity; lack access to the electrical and/or technological infrastructure due to cost, service provision, and natural disasters; and, distrust of technology in use of data and/or protection of anonymity [11].

Second, consistent adaptation and refinement is inherent in innovations using AI, as the technology is programmed to remember interactions with clients and will evolve or learn. Additionally, there will be a number of technological bugs or errors in the programming code for the chatbot that will become apparent as it is being piloted. As such, it is anticipated that the technological device itself will require ongoing adaptation with implementation. Any changes observed or made by the study team will be carefully documented and made available upon request.

There is potential for selection bias as participant recruitment includes use of snowball sampling or chain-referral sampling, using the research team's network and/or referrals through affiliated-organizations (listed with the authors of this publication) to help encourage participant recruitment. Additionally, individuals who are more familiar or comfortable with technology may be more likely to participate in this study. To reduce this form of bias, the study team plans to use multiple methods of participant recruitment including printing hard copies of the study poster for use on bulletin boards in staff rooms in hospitals, as well as asking hospital operations staff, with approval from respective health authorities, to share information about the study with their staff widely.

There is a risk of response bias. As such, our team will seek to oversample in each province, ensure the anonymity of the survey is clear to users by outlining anonymity at in the welcome message of the chatbot as well as consent documentation, primarily use validated tools and/or items extracted from validated tools to assess baseline mental and physical health, as well as user satisfaction and acceptability, including perceived usability, benevolence, credibility, and trustworthiness (i.e., the CORE-10, ECA, ETQ, AES), and ensure Likert scale questions include a neutral response option. Data will then be weighted where possible according to Statistics Canada Census Profile data.

Acknowledgements

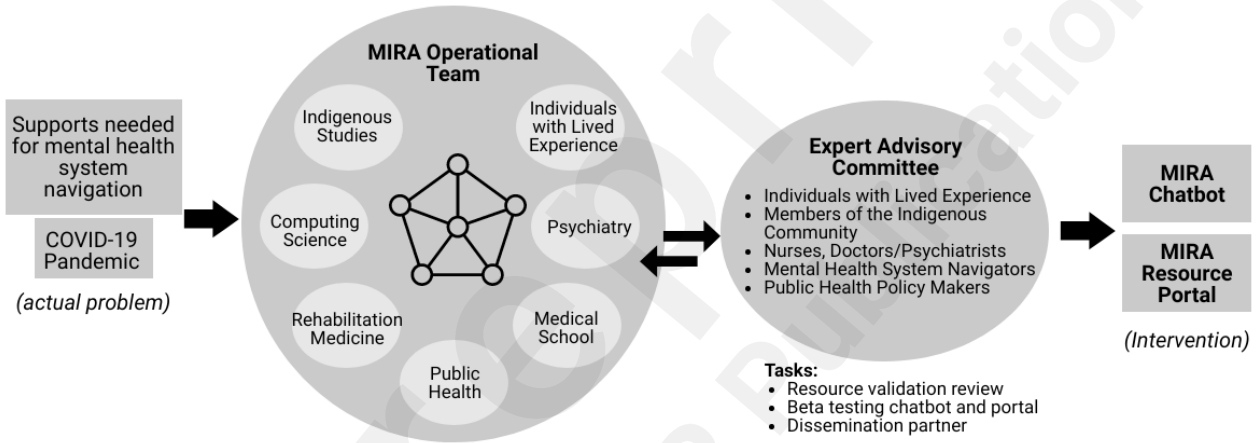
This study received funding to support student involvement through the Mood Disorders Society of Canada and the Mathematics of Information Technology and Complex Systems (MITACS) Accelerate grant. Additionally, Dr. Osmar Zaiane is supported by the Amii Fellow Program and the Canada CIFAR AI Chair Program. This study includes multiple partnerships, including support via a committee of experts titled the Expert Advisory Committee, as well as MDSC volunteers. Authors would like to give thanks to these members for volunteering their time to validate resources that the chatbot will ultimately draw from, as well as insight provided in the beta testing of the chatbot itself.

Conflicts of Interest

There are no conflicts of interest to note.

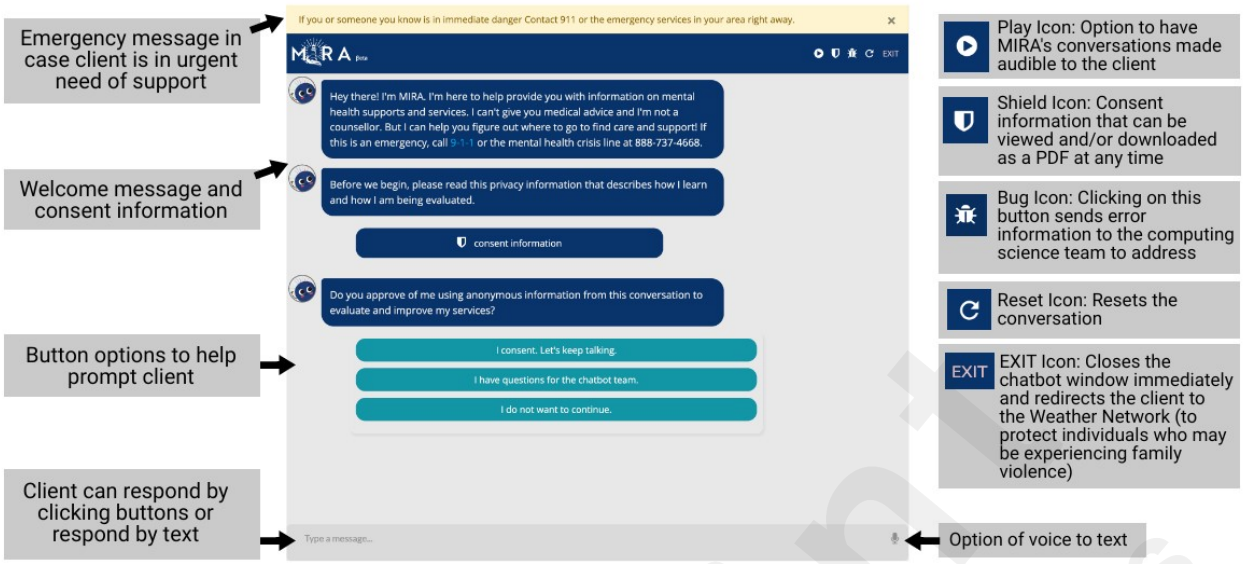
Multimedia Appendix 1

A multidisciplinary approach to mental health chatbot development



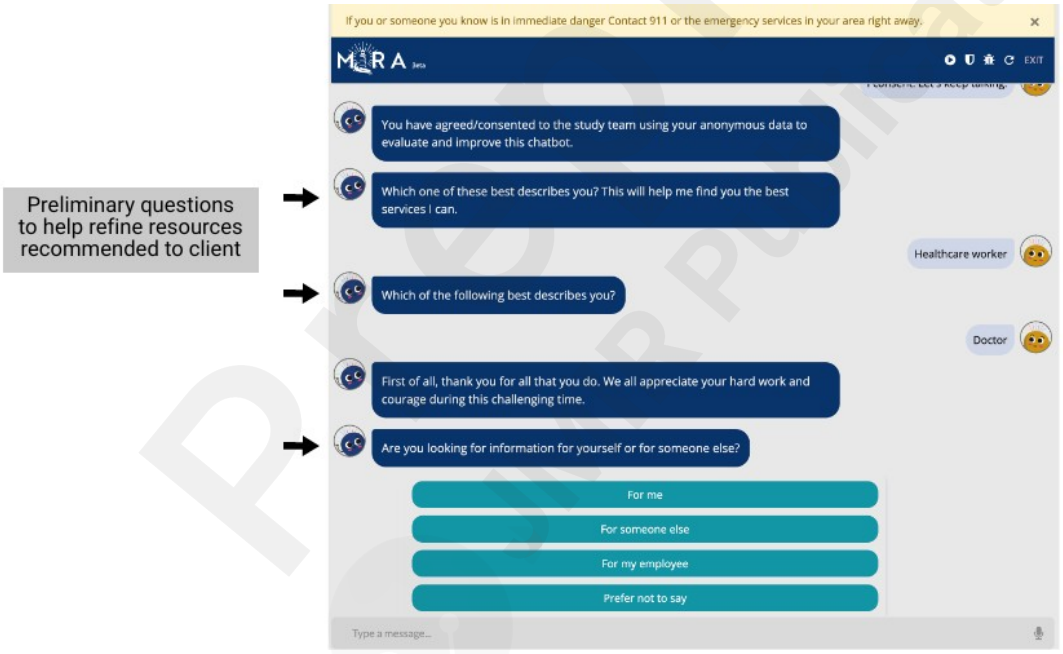
Multimedia Appendix 2

Chatbot story board - Screen shots of chatbot interface with details on chatbot functions and features



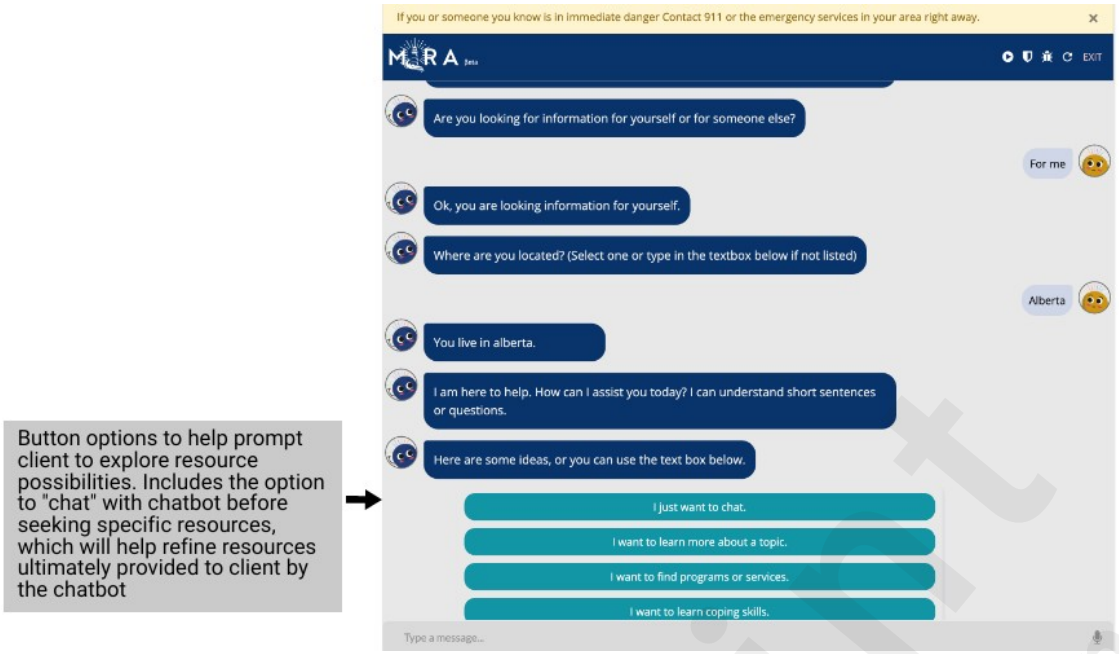
Multimedia Appendix 3

Chatbot story board - Screen shots of chatbot interface with details on chatbot functions and features



Multimedia Appendix 4

Chatbot story board - Screen shots of chatbot interface with details on chatbot functions and features.



Multimedia Appendix 5

Chatbot story board - Screen shots of chatbot interface in eEliza

Abbreviations

AES: Acceptability E-scale
AI: Artificial Intelligence
CIFAR: Canadian Institute for Advanced Research
CORE-10: Clinical Outcomes Routine Evaluation System
COVID-19: Corona Virus Disease
ECA: Embodied Conversational Agent
ETQ: Embodied Conversational Agent Trust Questionnaire
HISB: Health Information-Seeking Behaviour
MDSC: Mood Disorders Society of Canada
MI: Machine Intelligence
MIRA: Mental Health Intelligent Information Resource Assistant

ML: Machine Learning

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Supplementary Files

Untitled.
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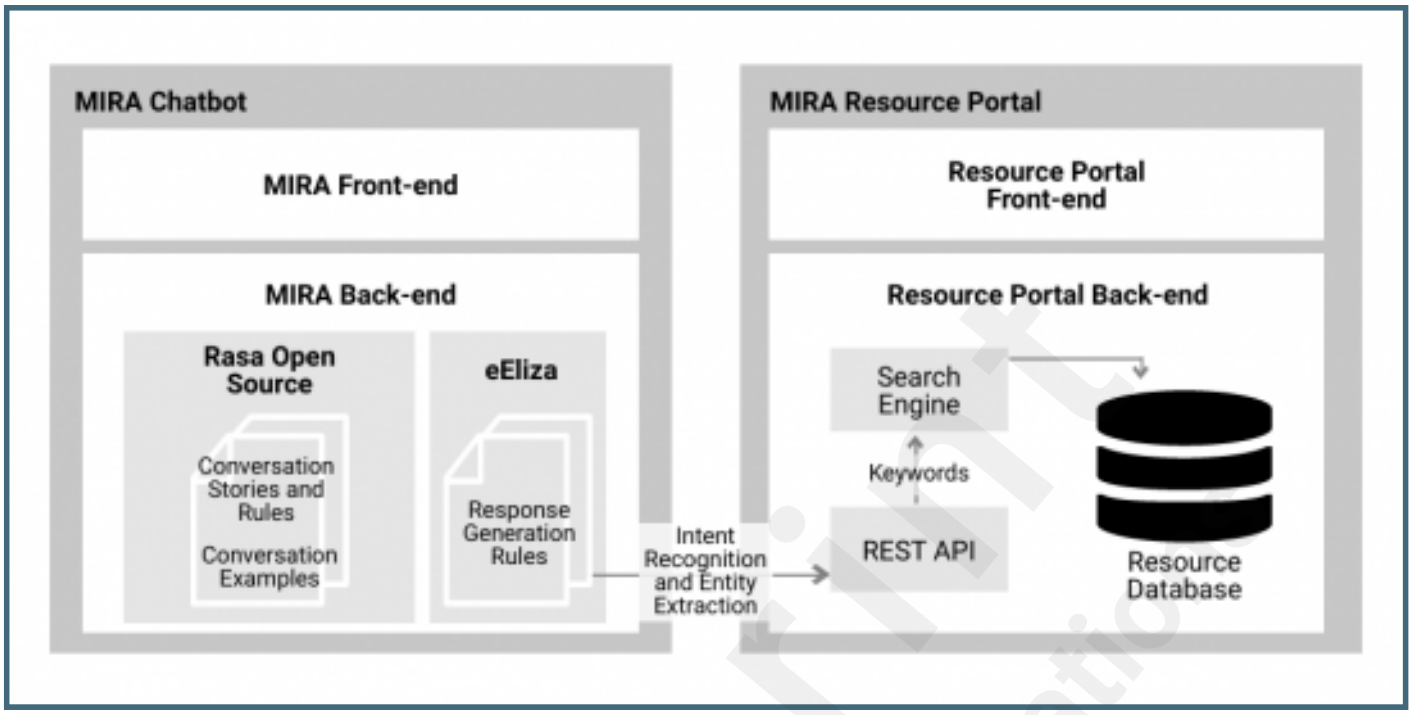
Figures

Architectural Diagram of the MIRA Chatbot and Resource Portal System.



Multimedia Appendixes

A multidisciplinary approach to mental health chatbot development.
URL: http://asset.jmir.pub/assets/df4bc2a3992fc213d5bfb7bb9934ca90.png

Chatbot story board - Screen shots of chatbot interface with details on chatbot functions and features.
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Chatbot story board - Screen shots of chatbot interface with details on chatbot functions and features.
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Chatbot story board - Screen shots of chatbot interface with details on chatbot functions and features.
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Chatbot story board - Screen shots of chatbot interface in eEliza.
URL: http://asset.jmir.pub/assets/8d98ac41e50d180b07d23f7d60b07b2d.png