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Towards data-driven tele-medicine intelligence: community-based mental healthcare paradigm shift for smart aging amid COVID-19 pandemic

Lan Cheng^{1*}, WK Chan², Yi Peng³ and Harry Qin⁴

Abstract

Purpose: Telemedicine are experiencing an unprecedented boom globally since the beginning of the COVID-19 pandemic. As the most vulnerable groups amid COVID-19, the digital delivery of healthcare poses great challenges to the elderly population, caregiver, health service providers, and health policy makers. To bridge the service delivery gaps between the telemedicine demand side and supply side, explore evidence-based approach for integrated care, address challenges for aging policy, and build foundation for the development of data-driven and community-based telemedicine, our R&D team applied translational research to design and develop telemedicine "SMART" for enhancing elderly mental health wellbeing amid COVID-19. Our aim is to investigate the preparedness mechanisms of mental health disease including response, intervention, and connection these three healthcare delivery pipelines with the collection, consolidation, and synergy of heath parameters and social determinants, using data analytics approach to achieve Evidence-Based Medicine (EBM).

Methods: A mix of quantitative and qualitative research design for scientifically rigorous consultation and analysis was conducted from Jan 2020 to June 2021 in Hong Kong. An exploratory and descriptive qualitative design was used in this study. The data were collected through focus group discussions conducted from elderly and their caregivers living in 10 main districts of Hong Kong. Our research pilot tested "SMART" targeting for elderly with mental health improvement needs. Baseline questionnaire with 110 tele-medicine product users includes questions on demographic information, self-rated mental health digital adoption. The follow-up five focus group discussions with 57 users (elderly and their caregivers) further explore the social determinants of telemedicine transformation and help propose the integrated telemedicine paradigm shift framework establishment, development, and enhancement.

Results: Grounded on the baseline needs assessment and feedbacks collected, it is evident that multi-dimensional health information from the four various streams (community, clinic, home, remote) and customized digital health solutions are playing a key role in addressing elderly mental health digital service needs and bridging digital divide. The designed tele-medicine product lines up health service provider (supplier side) and elderly specific needs (demand side) with our three-level design, enables elderly and their families to follow and control their own health management and connect with the service provider, community of practice (CoP), and health policy makers.

Conclusion: It's beneficial to involve elderly and gerontechnology stakeholders as part of Community-Based Participatory Research (CBPR) before and throughout the developing and delivery phases an integrated and age-friendly

^{*}Correspondence: chenglan@ust.hk

¹ Big Data Bio-Intelligence Lab, Big Data Institute, The Hong Kong

University of Science and Technology, Clear Water Bay, Hong Kong

Full list of author information is available at the end of the article

digital intervention. The challenges in applying and disseminating telemedicine reflected by the elderly and caregivers can be used as important input for further development and indicators for the sustainable and integrated elderly primary care framework.

Keywords: Elderly mental health, Telemedicine, COVID-19 pandemic, Digital divide

Introduction

Background

The COVID-19 global pandemic has brought unprecedented and devastating effects both locally and beyond [1]. There have been pressing needs for an enhanced, stratified, and targeted mental healthcare system since the beginning of the outbreak [2]. With the tremendous healthcare burden, a growing body of evidence suggested that the COVID-19 pandemic deepen digital divide for mental health care [3]. It is well known that social isolation among elderly is a "serious public health concern". A higher rate of mental health incidence has been widely observed in socially vulnerable groups, especially for aging population. Specifically, Depression is one of the most common chronic conditions among older people. For instance, in Hong Kong, approximately 1 in 10 older people has clinically significant depressive symptoms [4, 5]. Depression is prevalent in aging population due to the increased vulnerability throughout aging process, which exacerbate by multiple risk factors such as loneliness, lack of social support, network, and interaction, activities, chronic diseases [3, 6].

Hong Kong is an economically advanced and mostly urban city located in the Southeast part of China. As a densely populated city with around 7.5 million people, it can serve as an exemplary setting to address the elderly heath care challenges amid COVID-19 given its extreme wealth inequality with an all-time high Gini coefficient of 0.53 in 2021. Relatively high the elderly dependency ratio that indicates how great a burden is placed on those of working age by those of non-working age has reached around 19.1 percent in 2021 [4, 5, 7, 8], and its stringent social distancing measures that impacted on the whole population and social activity. Furthermore, Hong Kong is undergoing rapid population ageing along with the global trends. The population aged 65 years or above is projected to increase from 15% of the total population in 2014 to 26% by 2029, and to 33% (33.1%) by 2064, which implies that there 1 in 3 people in Hong Kong will be an elderly after forty years, meanwhile, the pressing situation is accompanied with an increasing level of dependency ratio [4, 5, 8, 9]. In addition to the direct infectious disease risk control and health emergency preparedness burden, the COVID-19 outbreak and its associated containment measures such as shutdown of social activities facilities, social distancing policy, change of work arrangements from offline to mixed mode, also have challenging wider socioeconomic impacts on the aging population, especially for those under-resourced groups who normally lack of social and emotional support.

Strategic importance of telemedicine under the COVID-19

The outbreak of COVID-19 has tremendously impacted the global healthcare delivery system and resulted in a paradigm shift towards telemedicine ecosystem. One of the most at-risk groups during the COVID-19 crisis is elderly, especially those who are living alone or in care facilities. Online consultation has also become an increasingly imperative alternative for healthcare delivery. The World Health Organization (WHO) is also advocating telemedicine for patients in need to reduce the risk of virus spreading via in-person visit to hospitals.

To provide personalized medical care to patient timely, there has been an increasing application of telemedicine under the generous policy support from the government and NGOs. However, the application of telemedicine requires patients to have the basic knowledge and capacity to access and operate digital devices, as well as the ability to communicate with "virtual doctor" for appropriate treatments often without any in-person support. Many elderly patients may not be able to handle these because of various disabilities or inexperience with technology. This study looks at how elderly patients may be left out in the transformation to telemedicine. Considering the huge mental health service gaps in Hong Kong [5, 10]. There are viewpoints that the public healthcare system has been unprecedently paralyzed since the outbreak of the fifth wave of the COVID-19. One of the primary reasons could account for this is the failure of healthcare policies to integrate with the concept of smart healthcare to improve public healthcare services and therefore enhance the operational efficiency of publicprivate-partnerships [9, 11, 12].

In contrast to the growing number of telemedicine concerned, there are only a few explorative studies [13–17] investigating the views and experiences of patients above 65 years old with symptoms of depression. Furthermore, these studies predominantly had broader inclusion criteria regarding age, thus patients younger than 65 years but has emerging needs for prevention and treatment menta health never be included. Therefore, we conducted this study to explore the perspectives of above the age of 60 of age regarding mental health, treatments, and telemedicine prospects. The aim of this study was to explore elderly' knowledge, attitudes and experiences, expectation, suggestion on telemedicine for mental health wellbeing and subsequently derive potential barriers to and opportunities for the telemedicine scale up for the community.

Levers and barriers of telemedicine for elderly mental health wellbeing

The utilisation of telemedicine has been rapidly increasing globally. As a result of the increased awareness and application, methods of defining and triaging within telemedicine have emerged [8, 9, 11]. In this study, we follow WHO's telemedicine definition as "the transformation of how disruptive technologies that provide digital and objective data accessible to both caregivers and patients leads to an equal level doctor-patient relationship with shared decision-making and the democratization of care" [18].

Telemedicine developments in mental health care have generated a huge demand for research on how digital health care service delivery model affect health care quality [6, 12], design [8, 19], and accessibility [12, 15, 17, 20]. Despite emerging interest and global trends from users, service provider, health decision makers, and academics, the research base on these issues is still limited [21]. The existing research available digital mental health therapeutics area focuses mainly on specific implementations, such as the psychotherapeutic treatment of mental illnesses or the diagnosis of mental diseases using digital tools [6, 12]. However, more research is urgently needed on telemedicine from multi-level perspectives to form a holistic picture for community-based mental healthcare paradigm shift, which lies in the factors that contexts and conditions that are currently for digital health care services have not yet been investigated, meanwhile, new digital tools that can change user behaviour and digital and physical health care services processes are constantly being developed and need to be evaluated comprehensively [3, 22-24]. Despite there are possible disparities in access to telemedicine Interventions with basis digital literacy, digital technologies could be harnessed to provide social support networks and a sense of virtual caring that cultivate more frequent contacts with close family members, peers, and friends.

Telemedicine for smart aging

Grounded on quantitative and qualitative research methods, we aim to establish a tech-driven translational research that strives to achieve three main research objectives below:

- Collect and analyse results from the region-specific needs assessment to identify barriers and advantages in addressing the aging issues in a holistic manner, providing foundations for actions, and building capacity for further synergizing.
- (2) Understand and focus on the needs of elderly within their own social and environmental contexts, providing basis for the development of integrated elderly care initiatives and converging the activities of different stakeholders, spanning across multiple strategic priority areas.
- (3) Serve as a starting point for the development of agefriendly community initiatives in more cities within the Greater China region and establish a platform for ongoing partnerships for translational research, aging related NGOs, and commercial elderly health care institutions to promote smart aging, keep track of developments, and exchange knowledge generated from projects in a diverse contexts beyond Hong Kong and within Great China Region.

To Align with the above objectives, this paper aims to aggress following Research Questions (RQ):

- RQ1: What are the current challenges and barriers of telemedicine in Hong Kong communities for smart aging?
- RQ2: What recommendations can be implemented to address elderly mental health challenges and therefore improve telemedicine adoption?
- RQ3: What are the future directions and considerations for telemedicine transformation in the fight against pandemic and embrace the new normal?

Research design

The SMART Tech project applies Community-Based Participatory Research (CBPR) and strategically integrates the Co-Design new concept throughout its three phases: (1) Response, (2) Intervention, and (3) Connection these three healthcare delivery pipelines. Upon establishing a project partnership between districted-based community, community-based mental health clinics, and mental health technology R&D team, Phase 1 follows four core elements of human-centred social design (design from empathy, needs identification, ideation discovery, prototyping for dissemination) for telemedicine baseline assessment, concept briefs, and advocacy targeting for main stakeholders. These information and consultation session have been held in four telemedicine contexts (home, clinic, remote, and community) with elderly,

caregivers, healthcare professional, and telemedicine providers; Phase 2 synergizes feedbacks and anticipated deliverables in the co-design process of digital therapeutics for mental health screening and intervention service innovations, in turn, for R&D project team further co-design, pilot testing, and wider advocacy during the project; Phase 3 highlights the connection function to bridge the digital divide among elderly, caregivers, and telemedicine developer to jointly shape the telemedicine user guidance, templates, protocols, and tools that will be used during the pilots stage. Throughout each phase, the project collects and analyses both qualitative and quantitative data to capture, determine, and enhance the project's scholarly value and social impact. The telemedicine "SMART" is designed to meet with elderly, family members and major representatives from a concerned community to listen to their concerns on existing service gaps.

Study design and methods

An exploratory and descriptive qualitative design was used in this study. One of the major advantages of content analysis is that it allows our R&D team to apply a mix of quantitative and qualitative research methods, which results in a more scientifically rigorous analysis. The research objectives guiding the whole research design and data collection process are:

- Assess the telemedicine perception and needs from the district-based community for sake of building momentum in developing the age-friendly telemedicine.
- (2) Recommend a framework for continuous improvement on elderly mental health well-being
- (3) Arise public awareness and encourage community participation in capacity building for scaling up telemedicine

Focus groups research method have been widely used to examine participant' experiences and perception with a scientific manner, and this method is chosen considering that the designed focus group setting is socially oriented, age friendly, and cohesively connected among the participants, therefore, could progressively lead to enhanced diversity, inclusion, and openness.

Participants

After the COVID-19 outbreak, elderly is especially vulnerable to social distancing policy posed by Hong Kong Government, particularly for those living alone, during the Hong Long's fifth wave of the COVID-19 outbreak. Hospitalisation rates is high among those living with Non-Communicable Diseases (NCD). One in every 2.3 deaths by suicide in Hong Kong in 2021 involved the elderly and a suicide prevention group put part of the blame for the statistic on the long-running coronavirus pandemic [25].

Drawing on the previous evidence of negative psychological responses observed during previous epidemics (e.g. SARS, MERS, etc.) [22, 26, 27], concerns is increasingly surging among multisectoral stakeholders that there would be adverse effects of the COVID-19 pandemic on mental health and wellbeing. It's evident that the governmental isolation rules in response to the health emergency, psychosocial consequences such anxiety, depression, and loneliness exacerbated the mental health challenges among aging proportion [28, 29], leading to negative effects on psychological and physical health [23, 24, 30]. However, public survey evidence suggests older adults on average are more inclined to turn to digital service for self-help to experience more stable interventions compared with previous inflectors outbreak periods [25, 29, 31]. However, it is presently unclear about what kind of underlying factors accounted for the experiences reflected by elderly during and beyond the COVID-19 pandemic and how is the underling mechanism towards the telemedicine paradigm shift.

All our project respondents were community residents of Chinese origin, aged 60 s and above, normally residing in Hong Kong and can speak Cantonese at time of participation. Respondents were mostly recruited directly from the community with a minor proportion of elders who regularly visit District Elderly Community Centres (DECC).

Procedures

A structured questionnaire was used in the survey that consisted of multiple-choice questions to address three major aspects that could influence elderly perception of telemedicine: (1) socio-demographic characteristics, including age, gender, education level, living arrangement, employment status, and residential area; (2) selfrelated mental health status; (3) digital adoption of telemedicine during the past years. The survey can be found in Supplementary.

A total of 10 voluntary helpers were recruited as SMART Ambassador since Mar 2020 and they assisted the whole project development and follow up as a longterm commitment for smart aging service. To ensure the survey protocol would be standardized, several rounds of mandatory training sessions were held on before the survey and focus group discussion to support the helpers in delivering the surveys and focus group discussion. The running of focus group was carried out by a focus group leader (interviewer), and two to three SMART Ambassador (project assistants) depending on group size. The project team members were responsible for various duties including coordinating with elderly or caregivers for the interview schedules, facilitating question comprehension that participants had about the project, and supervising the signing of consent forms, organizing briefing sessions, setting up meeting rooms.

We begin the data collection phase since 2020 after establishing the SMART protocol and survey and interview guide, having relevant team member well trained for supporting the capacity building schemes, consultations with elderly, and research activities. Data were finally collected via on-site visit in district-based parks, social and recreational activities centres from Mar 2021 to June 2021. The study used convenience sampling to recruit individuals aged 60 years and above from ten community-based facilities located in Hong Kong. The participants were recruited after getting their consensus, which involves the questionnaire included questions about demographics, lifestyle, and socioeconomic position, as well as telemedicine revenant variables examined, such as mental health and digital adoption of telemedicine. The data provided here were centered on factors associated with elderly telemedicine for mental health well-being perception, usage, expectations.

Focus group interview

A semi structured focus group interview guide was developed according to the study aims (details enclosed in the supplementary). The aim was to collect elderly and their caregivers' response telemedicine specific to their own needs and the community. Furthermore, we elaborated the focus discussion objectives and impact when soliciting elderly' voluntary help to join, and we also encourage them to bring their caregivers (relatives, domestic helper, center helpers, etc.). Once getting their consent to join, we also elaborate further the personal information protection principles to ensure confidentiality of participants are also explained. A consent form similar to the one used with the questionnaire interview was distributed to each participant for signature after the explanation by project coordinators.

Prior to each focus group discussion, each elderly participants have completed a brief questionnaire that asked about their demographic characteristics (age, gender, education, marital status, living arrangement). The focus group discussion is designed to be opened with an introduction of the study, the objectives of the discussion, and its implication and impact. One function room located in Tai Wai region (Near the railway station) was booked for participants in carrying out each focus group. A total of 1.5 to 2 hours were allocated for each group, with light refreshments offered to participants.

Each group interview implementation follows a standard procedure began with a brief introduction of the SMART Tech project and followed the purpose of the focus group interview and impact of how participants' response could contribute to the project and further to the elderly's mental health wellbeing for society impact. Name tags with preferred name were provided to participants, interviewer, and assistants. In addition, iPad, water, and snake were prepared and used to facilitate the introduction each interview topic and warm discussion among participants. Project leader moderated the focus groups, at the same time, project assistants and SMART ambassadors facilitated the discussions and participant's enquiries. All participants were given sufficient opportunity to share their views and comments with time constraint. Probing questions were used when appropraite, for example, "Could you please further describe the situation using a concrete example?" More specific questions were used to prompt participants to explore additional issues once an issue has been sufficiently explored. We conducted five group discussions in total and the discussion materials and consents forms have been enclosed in the supplementary.

Analysis and result

Participants demographics

A total of 110 participants were recruited. They represented residents in the sub district communities of North (9.1%), Wong Tai Sin (10%), Sai Kung (10.9%), Wan Chai (11.8%), Kwun Tong (10%), Sha Tin (10.9%), Tai Po (8.2%), Yuen Long (10.9%), Tsuen Wan (10%) and Southern (8.2%) (Table 1).

Participants' sociodemographic characteristics are summarized below. The Majority (55.5%) of participants were female and aged 60 to 70 (39.1%). Of all participants, nearly 38.2% are married (excluding widows) with

Table1	Number of	participants	(aged above	60) in	the	10
district	communitie	es of the Hong	g Kong			

10 District communities	Ν	%
North	10	9.1
Wong Tai Sin	11	10
Sai Kung	12	10.9
Wan Chai	13	11.8
Kwun Tong	11	10
Sha Tin	12	10.9
Tai Po	9	8.2
Yuen Long	12	10.9
Tsuen Wan	11	10
Southern	9	8.2
	110	100.0

5 Elderly and 4 caregivers	60–65	Low	Moderate
8 Elderly and 5 caregivers	60–65	Moderate	Bad to extremely bad
7 Elderly and 5 caregivers	70 above	Low	Moderate
6 Elderly and 4 caregivers	65-70	Moderate	Good to extremely good
7 Elderly and 6 caregivers	65–70	High	Bad to extremely bad
	5 Elderly and 4 caregivers 8 Elderly and 5 caregivers 7 Elderly and 5 caregivers 6 Elderly and 4 caregivers 7 Elderly and 6 caregivers	5 Elderly and 4 caregivers60–658 Elderly and 5 caregivers60–657 Elderly and 5 caregivers70 above6 Elderly and 4 caregivers65–707 Elderly and 6 caregivers65–70	5 Elderly and 4 caregivers60–65Low8 Elderly and 5 caregivers60–65Moderate7 Elderly and 5 caregivers70 aboveLow6 Elderly and 4 caregivers65–70Moderate7 Elderly and 6 caregivers65–70High

Table 2 Focus group interview constitution

secondary education or above (85.5%). With regard to the employment status and living arrangement, 24.5% are retired while nearly 2/3 are either living alone or only living with their spouse (38.2%), and 13.6% of them are living with domestic helper. About one in five participants rated their own mental health status as extremely good (20%). Although minority (23.6%) of them often had digital adoption of telemedicine, the frequency showed average status.

Efforts have been made to recruit eight to ten elderly and their accompanied caregivers in each group and classify participants into groups according to their age, digital adoptions, and levels of self-rated mental health, with similar numbers of male and female for each. Different socio-demographic profiles covering gender, age groups (60–65, 65–70, 70 above), are invited to participate in the survey with an aim of collecting views of different groups of people, which has been depicted in Table 2 below.

The results are based on the thematic analyses of focus group interviews where a total of 57 participants of elderly and their caregivers. Table 3 depicts the discussion topics across three themes and nice subthemes, the selected scripts, and codes. There are different factors leading to elderly mental healthcare seeking and telemedicine adoption, as well as the various structural barriers and challenges from the multi-level perspectives. This paper aims to analyse and explore important perspectives that emerged from multi-stakeholders. We specially divide the feedbacks from the interview session into elderly and caregiver's perspective when analysing and coding the qualitative data.

Conclusion

This study seeks to address the under-developed facets of telemedicine in engaging and linking stakeholders within the established health system. As such, we proposed a novel co-design data-driven healthcare delivery framework which is based on specific healthcare delivery practices. With a mission to help building a cohesive and harmonious community with healthcare stakeholders in the society, our R&D team seek to aid the under-represented, aging population impacted by the pandemic. This telemedicine project attempted to provided support to community projects and leverage on our partners' expertise to serve the real-world health needs of the elderly community.

Mixed-method study was conducted, and verbal data were collected, transcribed, and translated from Cantonese to English via the in-depth interview and focus group discussions among key stakeholders identified in our proposed Multi-level Telemedicine healthcare framework, which could conclude as follows:

(1) Synergy between healthcare and technology

A health care solution implemented or powered by complex and advanced technology may be producing a relatively simple effect in the view of end users. Elderlies and caregivers may be hesitant in relying on these technology products and choose traditional solutions instead. Our baseline-needs assessments have studied some of these preconceptions through the interviews. Results are showing that there are: (1) shortages of counsellor and mental health professional services in the market; (2) obstacles in accessibility of health service, including long waiting time in terms of years for public consultation service; (3) insufficient consultation time, for instance only 5 min of professional consultation after waiting for 3 h. This led to poor quality of diagnosis and treatments; (4) high costs which are not affordable for the public. Majority of respondents regarded costs of healthcare as a major barrier; (5) ineffective care resulted from the lack of continued follow up services for elderly. Our focus group interviews also provided deeper insights that focused on how elderly perceive technology-driven products and the corresponding primary care service.

(2) Bridge digital divide across users

A growing number of telemedicine products aimed to provide mental health support and wellbeing are available on digital platforms such as mobile apps. However, despite the increase in everyday usage of digital technologies by the elderlies and their affiliated family, there have been relatively few studies which can provide a multi-level, holistic view on the general attitudes of elderlies, caregivers, product designers, and healthcare professionals towards the adaptation of these telemedicine.

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Table 3(Coding Qualitative data		
Focus groups (elderly)	Discussion topic	Interview scripts extract (selected from transcripts)	Codes
Section 1: E	Elderly's perspective		
-	A: motivation for using telemedicine	Poor mental health is common later in life, we feel loneli- ness, depressed, and anxiety, some of us realty afraid that we cannot remember how to return home or help ourselves if there is no timely and efficient help	Isolation, Loneliness, Mild Cognitive Disorder, Uncertainty Lack of support (family, community)
5	A: motivation for applying telemedicine	Mental health is a crucial factor in determining our ability to live independently and in good condition in the com- munity, we welcome "elderly-friendly" digital therapy that could help us overcome the mental health issues	Emotional health and wellbeing Awareness raising
m	A: motivation for applying telemedicine	While implemented public health measures were critical to combat the viral spread, we elderly were forced to live alone and affected by centers closures, cancellations or modification of organized recreation activities, and the enforcement of stay at home is really challenging us as we do not how to seek digital or social help by ourselves	Environmental Factors that contribute to the development of mental health disorders (peers, COVID-19, public policy)
4	A: motivation for applying telemedicine	How to overcome Long COVID-19 an externally important schedule for all of us as we all suffered a lot, especially for elderly with pre-existing mental health issues during the COVID-19 pandemic	Post-COVID-19 stress disorder; Stress and trauma management
Ś	A: motivation for applying telemedicine	Our elderly's needs or option is not sufficient for designing a cost-effective telemedicine as mental health involves multi-dimensional coordination and support. In a time we are experiencing the spread of a pandemic and long recovery period, it is critical to evaluate the potential surge of the telemedicine phenomena with multiple stakehold- ers (e.g. clinical professional, NGO staff)	Stress-related health; Knowledge-shaping and attitude-changing for therapeutics content and delivery Multi-lateral stakeholder engagement
-	B: barriers and levers for applying telemedicine	Health care staff and other frontline workers should learn to disseminate the telemedicine brief to our elderly when we are in hospital or centres. Positive promotion or brief- ing is much more efficient than we take extra effects to ask them or search for enquiry	The collaborative role of educational institutions in support- ing capacity build for telemedicine
7	B: barriers and levers for applying telemedicine	Difficult to Keep in regular contact with loved ones without existing telemedicine, but it remains difficult to keep regular routines and schedules as much as possible for activities we enjoy with existing telemedicine. Even I have get used to telemedicine, it's less useful and interesting if my peers are reluctant to use it	Digital Divide Social Solidarity

Focus groups (elderly)	Discussion topic	Interview scripts extract (selected from transcripts)	Codes
m	B: barriers and levers for applying telemedicine	We need to use telemedicine services independently which is uncomfortable for us seniors. We also have concerns about our privacy if totally rely on system We normally lack confidence in telemedicine services because we are worried that virtual services cannot clearly describe health condition over the smartphone or digital device	Health security; Personal data privacy; Both quantitative and qualitative Measuring and evidencing wellbeing
4	B: barriers and levers for applying telemedicine	It's hard to apply any new digital service or product without the network approach, health coverage is especially important to scale up any new ideas, ways, service deliv- ery model	Social network determinants of effective treatment coverage
Ŋ	B: barriers and levers for applying telemedicine	Mental health is sensitive to "one health", therefore, other health service or operations models should be improved on the same page, and we normally rely heavily on public- funded medical resources, we hope that government could have more resources support on digital health advocacy and usage	Holistic/integrated public mental health models and policies
-	C: evidence-based knowledge network for designing telemedicine	Pressing needs to investigate the current state of evidence relating to the telemedicine application on relieving the psychosocial impact of the elderly in the community when they are lack of face-to-face diagnosis and interac- tions with healthcare professionals	Perceived helpfulness of service sectors used for mental health
7	C: evidence-based knowledge network for designing telemedicine	We have psychological issues because of living under the outbreak for a long time and it seems there is a long way to go for the new normal. we do not have a rough picture ahead for how to re-design the life both for medical care and daily activities	Community resilience, Social inclusion
m	C: evidence-based knowledge network for designing telemedicine	Depressive symptoms are common in the elderly, but the underling mechanism is still not clear for high-risk groups and generally population. The elementary training about the primacy care for mental to guide elderly or family members is the prerequires for any innovative digital therapy or device	Experimental and Therapeutic Medicine; Risk factors (Non-Communicable Diseases); Capacity building
4	C: evidence-based knowledge network for designing telemedicine	Frontline health professional and telemedicine R&D team could invite and engage caregivers to map out the base- line assessment, analysis, and evaluation together to more precisely detect the risk level and triage. Under covid-19, we need to join hands for prepare and overcome crisis for the new normal	Risk level detection and Triage; Health emergences preparedness, response, and prevention

Table 3 (continued)

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Focus Bioups leidenty) Discussion topic Interview scripts extract (select leidenty) 5 C. evidence-based knowledge network for designing COVID-19 brings burdens as well thermadicine on meral health issue video games) 5 C. evidence-based knowledge network for designing COVID-19 brings burdens as well there are misinformation and stig video games) 5 C. evidence-based knowledge network for designing COVID-19 brings burdens as well thereafter and risk involved with video games) 5 C. evidence-based knowledge network for designing on the community Discussion and stig video games) 5 A: motivation for applying telemedicine Mertal health sizu video games) 3 A: motivation for applying telemedicine It is a particulated support video games) 3 A: motivation for applying telemedicine It is a particulated support video game of the video for video dates of for video for support of video dates of for video for vid	Table 3	(continued)		
5 C. evidence-based knowledge network for designing telemedicine COVID-19 brings burdens as well neatment and risk involved with video games) 7 There are misiformation and sig video games) There are misiformation and sig video games) 7 A: motivation for applying telemedicine Mantal health staus treatment and risk involved with video games) 7 A: motivation for applying telemedicine Mantal health staus the community 5 A: motivation for applying telemedicine Mantal health staus the community 3 A: motivation for applying telemedicine It is a particular concern when we and public-funded support for us 3 A: motivation for applying telemedicine It is a particular concern when we and public-funded support for the treatment should be custor 4 A: motivation for applying telemedicine We have higter elevice offers, warm help resources. 5 A: motivation for applying telemedicine We have higter elevice offers. 6 A: motivation for applying telemedicine We have higter elevice offers. 1 B: barrier wor the treatment should be custor We have higter elevice offers. 3 A: motivation for applying telemedicine We have higter elevice offers. 4 A: motivation for applying tel	Focus groups (elderly)	Discussion topic	Interview scripts extract (selected from transcripts)	Codes
 Section 2: Caregiver's perspective A: motivation for applying telemedicine B: barrier sond for applying telemedicine B: barriers and levers for applying telemedicine 	ц	C: evidence-based knowledge network for designing telemedicine	COVID-19 brings burdens as well as new opportunity for telemedicine on mental health, the digital adoption is much higher than ever (e.g., Video-Based Intervention, video games) There are misinformation and stigma for mental health treatment and risk involved when interacting or treating elderly with mental health issues, appropriate and scien- tific guidelines and framework is needed to throughout the community	Digital adoption; Effectiveness of Reducing perceptions of fear, loneliness, and Stigma under COVID-19
1 A: motivation for applying telemedicine Mental health status highly relate and its associated physical disating the know what is going on Elderly usually needs the help of on Elderly usually needs the help of tion services to seek psychiatric follow-up appointments in clinit telemedicine, it could reduce huber the elder sources. 2 A: motivation for applying telemedicine Rental health status highly reast sociated physical disating follow-up appointments in clinit telemedicine, it could reduce huber sources and public-funded support durities apparticular concern when we and public-funded support durities (provup) appointments in clinit telemedicine when shee vector sources approved by the sources. 3 A: motivation for applying telemedicine It is a particular concern when we and public-funded support durities (provup) appointments in the seconces. 3 A: motivation for applying telemedicine Re have different symptoms of more than used apport durities and invasion for us. 4 A: motivation for applying telemedicine We have huge reluctance to visit tals considering the vinus transfit which result in the missed apport tals. 5 A: motivation for applying telemedicine We have huge reluctance to visit tals considering the partement should be custor. 1 B: barriers and levers for applying telemedicine New and rivual considering with the missed apport the different should be custor. 1 B: barriers and levers for applying telemedicine New and rivual considering with the treatunent should be custor. <	Section 2:	Caregiver's perspective		
2 A: motivation for applying telemedicine It is a particular concern when we and public-funded support dur demic when face-to-face gathe digital device offers "warm help resources, languages barrier wo for us 3 A: motivation for applying telemedicine It is a particular concern when we and public-funded support dur demic when face-to-face gathe digital device offers "warm help resources, languages barrier wo for us 3 A: motivation for applying telemedicine We have different symptoms of the treatment should be custor we may have everybody has the treatment should be custor which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result in the missed appc inflating during the virus transit which result is considering the virus transit which result is considering the virus transit which result is considering the virus transit with the virus transit which results and levers for applying telemedicine 1 B: barriers	-	A: motivation for applying telemedicine	Mental health status highly related with chronic diseases and its associated physical disability. They should have the right to know what is going on about their mental health Elderly usually needs the help of caregivers or transporta- tion services to seek psychiatric consultations or attend follow-up appointments in clinics or hospitals. With telemedicine, it could reduce huge cost in time, caregiver effects, and medical resources	Keep informed; Cost-effectiveness Social contact empowerment
 A: motivation for applying telemedicine We have huge reluctance to visit tals considering the virus transference to visit tals considering telemedicine B: barriers and levers for applying telemedicine New and virtual comminutions behave that there are professionals with the virus tas command mobile arows to a tas zoom and mobile arows to a tas a tas zoom and mobile arows to a tas a tas zoom and mobile arows to a tas a tas	7	A: motivation for applying telemedicine	It is a particular concern when we are lacking family support and public-funded support during the COVID-19 pan- demic when face-to-face gathering are restricted. Some digital device offers "warm help" without the constraint of resources, languages barrier would be quite interesting for us	Have a self-health management routine
4 A: motivation for applying telemedicine We have huge reluctance to visit tals considering the virus transfer which result in the missed appo inflating during the pandemic. 5 A: motivation for applying telemedicine We hope that there is NO misund health issues from or friends, s of life. They should know that it enon for each one when gettin healthcare professionals with th such as Zoom and mobile apps such as Zoom and mobile apps	m	A: motivation for applying telemedicine	We have different symptoms of mental health issues, and we may have everybody has their own story, therefore, the treatment should be customized to our specific needs	Transformative Community Care
5 A: motivation for applying telemedicine We hope that there is NO misund health issues from our friends, s of life. They should know that it enon for each one when gettin enon for each one when gettin 1 B: barriers and levers for applying telemedicine New and virtual comminutions b healthcare professionals with th such as Zoom and mobile apps	4	A: motivation for applying telemedicine	We have huge reluctance to visit health centres and hospi- tals considering the virus transformation in public space, which result in the missed appointment rate has been inflating during the pandemic. In turn, our mental health is deteriorated without further help and care	Skipping psychiatric appointment
1 B: barriers and levers for applying telemedicine New and virtual comminutions b healthcare professionals with th such as Zoom and mobile apps	Ŋ	A: motivation for applying telemedicine	We hope that there is NO misunderstanding of the mental health issues from our friends, staff around, and all walks of life. They should know that it's a common phenom- enon for each one when getting older	Home-based aging Public stigma
	-	B: barriers and levers for applying telemedicine	New and virtual comminutions between individuals and healthcare professionals with the help of telemedicine, such as Zoom and mobile apps	Two-way synchronized communication

Focus groups (elderly)	Discussion topic	Interview scripts extract (selected from transcripts)	Codes
5	B: barriers and levers for applying telemedicine	APP has become a major trend in recent years. Some of us must use it to receive the latest news (e.g. religious event), but still need to get used to such digital service with continuous support	Digital Barriers to mental health services utilisation
m	B: barriers and levers for applying telemedicine	More on-site workshops or information sessions should be organized to highlight an elaborate telemedicine outcome in reliving the psychosocial impact for wider community communications	Improve accountability; Adapting social dialogue to rapidly changing environment;
4	B: barriers and levers for applying telemedicine	The role of telehealth in mental health of elderly could be promoted near MTR or elderly centres. Not simply show- case, but more interactive activities	Interactive outreach event;
Ŋ	B: barriers and levers for applying telemedicine	Oversimplification and overstatement are two main issues we meet, clear and simple functional introduction of the product and service is most useful. We also like to share or search others' user comments for reference	Baseline needs identification, analysis and synthesis
-	C: evidence-based knowledge network for designing telemedicine	The product/service design should be universal with the consideration of vulnerable elderly groups, not only those well-educated, wealthy, and have full support already The treatment gap for mental disorders remains a challenge both for elderly and caregiver Identifying reasons for nontreatment may contribute to reducing this gap	Health Equity; Cost-effectiveness of using telemedicine on psychosocial impacts of elderly
2	C: evidence-based knowledge network for designing telemedicine	We need to know risk factors and classify them between and within specific level; Awareness should be established by public education sec- tor (better initiated by professionals) to mitigate negative attitudes and beliefs that fear, reject, avoid, and discrimi- nate against elderly with mental health issues	Risk factors collection and risk stratification Government policy implication; Communicate ideas with health systems governance
Μ	C: evidence-based knowledge network for designing telemedicine	The future use and dissemination of telehealth services on elderly should be further developed and discussed Gather a comprehensive body of R&D for promotion and healthcare delivery	Social engagement Scaling up health outcomes
4	C: evidence-based knowledge network for designing telemedicine	The innovative services that telemedicine can provide to older adults should applied to various contexts The device and service should monitor the symptoms and needs on a timely and regular basis	Diversified contexts; Real-time monitoring, online screening and examinations
ſ	C: evidence-based knowledge network for designing telemedicine	The role of telemedicine in mental health of older adults should "redefine", map out the key needs and mitigate the risks and bottlenecks	Investigate symptoms and intervention of depression and anxiety with a holistic perspective

Emerging studies have reported that telemedicine is an effective alternative to traditional face-to-face scanning and treatment. Therefore, this study further recognized the challenges and obstacles yet to be overcome as digitalisation of healthcare delivery continues to advance. The digital divide is still growing which left the elderly population in a disadvantage. To overcome digital literacy stigma, Knowledge of digital literacy is of fundamental importance for elderlies to enjoy the benefits of AI-supported digital interventions. Products and services must be designed based on elderly's prior technology knowledge so that help and information can be delivered to them effectively without technology stigma. In the technology front, artificial intelligence (AI) is increasingly utilized in user-oriented technology. However, public accessibility and understanding about these kinds of technology is still quite limited. There are fundamental obstacles which must be mitigated before we can make use of new technology to solve the issues that aging healthcare is facing.

(3) Strengthening Universal Health Coverage (UHC) and impact for elderly through capacity building schemes

Telemedicine has been regard as a tool for humancentered care that creates the contexts for wellfounded heathcare decisions for elderly with mental health issues. There are pressing needs to analyse various telemedicine contexts and their impact on social development, emerging challenges, bioethical issues as well as social implications for elderly, at the same time proposes and promotes appropriate responses in respect of health policy concerns, including risk mitigation solution, government resource allocation and the public policy. It's a strategic imperative to improve multi-dimensional health information platform on elderly mental health wellbeing for health policy direction and programme action design, data-driven analysis for action prioritization, planning, and development which will play a pivotal role in scalingup specific social policy initiatives to reduce elderly mental health diseases incidence rate and risk level.

Framework establishment

In exploring healthcare paradigm shift, we must observe the health ecosystem through both a micro and a macro lens in order to obtain a complete understanding. Our study tried to observe the motivational factors in enhancing the delivery of elderly healthcare services though multi-level collaborative layers across the spectrum of government departments, healthcare industries, NGOs and the communities of elderly population and caregivers. In doing so, we tried to gain an overarching insight on formulating a community-based conceptual framework that can help us explore the underlying mechanisms in driving the development of innovative telemedicine for the elderly population. We concluded that the framework should take a bottom-up, data-driven approach addressing real-world problems, incorporate innovative technologies with active engagements with stakeholders, attract multidisciplinary experts for collective wisdom, and able to create translational research pipelines which not only describe the phenomena but also drive forward applications by converting research outputs into implementable practice.

The project aims to reach out to elderly and highlight their views and feedback through a diverse, multidimensional, and overarching research framework that are depicted in Fig. 1.Telemedicine involves the use of software and apps for treatment and therefore the treatment should include driving changes in heath behaviour that stressed after the COVID-19, which not only include socioeconomic and health-related factors but also policy level, community level, individual level factors, risk factors for mental health, and these are linked organically to serve as a useful reference for future aging initiatives.

The proposed framework depicted in Fig. 1 provides scientific and strategic support to the conceptualization of the linkages between mental health crisis amid COVID-19 and the national public health system, which provides translational research intelligence to the institution, group, and individual in designing and implementing its strategy to assist the governmental policy to expand its social healthcare system to include vulnerable aging groups, which usually be neglected.

Implication

Finally, in the analysis of this literature review, consultations with major stakeholders, recommendations collection to address elderly mental health challenges amid COVID-19, future telemedicine R&D directions are presented. For policy makers in public health, this study provides an in-depth review of issues that must be addressed before scaling up telemedicine to reduce healthcare burden and medical resources from public and private perspective. We highlight recommendations to improve the motivation and mitigate risks to use such digital technologies, in turn, could facilitate wider acceptance amongst elderly and their caregivers.

Guided by the multi-level telemedicine healthcare delivery framework proposed and investigated in Fig. 2, this R&D project aims at improving (a) data-driven digital therapeutics to reduce elderly mental health issues; (b) social health coverage and impact on elderly; (c) Equity, inclusion, and efficiency of age-friendly public, private, and Public–Private-Partnership (PPP) health resources optimization; and (d) health data governance and accountability measures to increase public participation



and the quality, equity and coverage of telemedicine services. This encompasses both direct R&D work with government and civil society partners as well as linkages and partnership within and between groups working on education, health, and gerontechnology.

Our telemedicine approach in utilizing data-driven technology can reduce mental health disparities by bringing affordable, effective, and accessible intervention with confidentiality. We are living in a world where mental health issues are rising at the unprecedented rate under the pandemic, especially among elderlies who generally have limited access to help and resources. Although healthcare services in general are relatively slow in adopting new technologies, we are seeing increased utilization of data-driven technology in application including early the detection of mental health symptoms. By offering person-centered interactions and quick diagnostics, data-driven technology can help in building community resilience and offering support to those in need of mental healthcare.

To address the above challenges faced by the ageing population amid the pandemic, our research team have taken collective and inventive efforts in exploring the use of digital medicine to improve healthcare outcomes through developing targeted healthcare solutions and more effective interventions. As a result, our team developed the platform called: Sustainable, Memorable, Affordable, Real-time Therapist (SMART). This platform is our first start-up project as a community-based, technology-driven translational research. Working in partnership with local community in Hong Kong, our project journeyed from introducing digital therapeutics platform to elderly population with the needs of mental healthcare and their caregivers, motivating them to join and utilize the mobile and web applications, exploring appropriate intervention programme via digital therapeutics, and facilitating elderly users and their caregivers to engage in the platform to cultivate a collaborative and sustainable digital mental healthcare community.

Limitation

This study is limited by its sampling. We only surveyed 110 elderly and further interviewed 57 elderly and their caregivers spanning 10 districts located in Hong Kong Special Administrative Region, China, which limiting its coverage and generalisability, however feedbacks and comments from multiple sources were included and not limit the underlying cultural assumptions and approaches offered.

Future research plan

COVID-19 global pandemic triggered the fastest growing mental crisis since 2020, The present study revealed that a substantial portion of family caregivers of elderly people responded that they did not have knowledge about the community resources which they can get to facilitate them to take care of their frail elderly family members at home. Therefore, there is a need to promote the availability and increase the provision of community care services (CCS). In the coming stage of this research, the results from this pilot project will be the reference for follow up explementary studies in other regions of the world. We call for further quantitative and qualitative research into the larger and complex global problems that cross the boundaries of professionalism and mindset.

In conclusion, the social resources relating to public mental health strive to address important burning issues for the new normal. Supportive, comprehensive, empirically grounded resources can help maintain mental wellbeing for elderly and their caregivers, thus reducing future impact on mental health services. Given the high risk of future pandemics, the recommendations and comments could inform future mass mental health support interventions and health system development with multi-dimensional and multi-level health data.

Supplementary Information

The online version contains supplementary material available at https://doi. org/10.1007/s13755-022-00198-4.

Below is the link to the electronic supplementary material. Supplementary file1 (XLSX 15 kb)

Supplementary file2 (PDF 320 kb)

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Lan Cheng and Harry Qin. The first draft of the manuscript was written by all authors. All authors read and approved the final manuscript.

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Declarations

Conflict of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Author details

¹Big Data Bio-Intelligence Lab, Big Data Institute, The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong. ²Department of Computer Science and Engineering, Chinese University of Hong Kong, Sha Tin, Hong Kong. ³School of Government, Nanjing University, Nanjing, China. ⁴Faculty of Health and Social Sciences, The Hong Kong Polytechnic University, Kowloon, Hong Kong.

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