Community Stakeholder-Driven Technology Solutions Towards Rural Health Equity: A Concept Mapping Study

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Abstract

Background

Promoting inclusive health and social care for rural populations requires new community-focused innovations, technological infrastructure, creative design thinking, and multi-stakeholder collaboration. Technology holds great potential for promoting health equity for rural populations, who have more chronic illnesses than their urban counterparts but less access to services. Yet, more participatory research approaches are needed to gather community-driven health technology solutions. The purpose of this research was to collaboratively identify and prioritize action strategies for using technology to promote rural health equity through community stakeholder engagement.

Methods

Concept mapping, a quantitative statistical technique, embedded within a qualitative approach, was used to surface and synthesize technological solutions towards rural health equity from community stakeholders in three steps: 1. idea generation; 2. sorting and rating feasibility/importance; and 3. group interpretation. Purposeful recruitment strategies were used to recruit key stakeholders and organizational representatives from targeted rural communities.

Results

Overall, 34 rural community stakeholders participated in the concept mapping process. In Step 1, 84 ideas were generated that were reduced to a pool of 30. Multi-dimensional scaling and cluster analysis resulted in a 6-cluster map representing how technological solutions can contribute toward rural health equity. The clusters of ideas included technological solutions and applications, but also ideas to make healthcare more accessible regardless of location, training and support in the use of technology, ensuring digital tools are simplified for ease of use, technologies to support collaboration among healthcare professionals, and ideas for overcoming challenges to data sharing across health systems/networks. Each cluster included ideas and priority areas that were rated as equally important and feasible. Key themes included organizational and individual level solutions, and the development of new technologies while connecting patients to these technologies.

Conclusions

The concept mapping exercise enabled rural community stakeholders to co-identify technological solutions toward rural health equity. Overall, the grouping of solutions revealed that technological applications require not only access, but also support and collaboration. Concept mapping is a tool that can engage rural community stakeholders in the identification of technological solutions for promoting rural health equity.

Background

Health inequities are systemic and avoidable differences in health that are caused by the unfair distribution of resources, wealth, and power in society (Commission of the Pan American Health Organization on Equity and Inequalities in the Americas, 2019). People who experience unearned disadvantages (e.g., due to racism, exclusion, impacts of colonization, socio-economic status, or access to services) also experience greater burdens of health inequities (National Collaborating Centre for Determinants of Health, 2018; WHO Commission on Social Determinants of Health, 2008). Social and structural determinants of health that contribute to rural health inequities include: financial, social, and geographical difficulties such as travel to access care; reduced access to healthcare professionals; lack of health care facilities, services and equipment; inadequate infrastructure; and a lack of rural-specific programs (Nielsen, D'Agostino, & Gregory, 2017; Rural Evidence Review, 2019). Dispersed rural and remote community settings accentuate the drivers of ill health and limit access to health care (Desjardins, 2011; Nielsen et al., 2017). Chronic diseases such as cardiovascular disease, asthma and diabetes along with poor mental health, obesity, lower life expectancy, and potentially avoidable mortality are higher in rural and remote areas than urban areas (Subedi, Greenberg, & Roshanafshar, 2019). Living with chronic illness can increase healthcare needs which can exacerbate the drivers of health inequity. One possible solution for reducing health inequities is the use of technology to promote inclusive health and social care for disadvantaged rural populations. Research examining the ways technology

solutions can best integrate rural needs, values, and strengths can therefore be an important contributor to advancing rural health equity.

Digital health technologies are revolutionizing health and social care, opening new possibilities for increasing access, reducing inequities and promoting equity. For example, mobile technologies such as mobile phone apps hold considerable potential to reduce inequities because of their extensive use across all social groups (Anderson & Olson, 2016). Remote monitoring and synchronous video-based technologies offer opportunities to develop community-based interventions and reduce the need for proximity or travel to healthcare providers (Batsis et al., 2021). Virtual care (including telehealth), defined as any remote interaction between patients and their circle of care using communication/information technology (Shaw et al., 2018), has rapidly expanded to rural and remote communities with the COVID-19 pandemic to provide services previously unavailable (Li et al., 2020; Monaghesh & Hajizadeh, 2020). Although digital access is far from equal across geographic contexts, and many rural communities lack a digital infrastructure (Ruimy, 2018; Weiss et al., 2018), this landscape is shifting. Just prior to COVID-19, one provincial government in Canada invested in development of a Digital Health Strategy and funding for high speed internet to 200 rural and Indigenous communities, enhancing opportunities for harnessing technological solutions for more equitable access to health-related resources, information, and services (Auditor General's Report, 2018; Barclay & Wright, 2019). This expanded infrastructure creates opportunities to move beyond urban contexts to customize technological solutions to rural locales.

Yet, geographical place shapes how technology is used or not used (Oudshoorn, 2012), and the rural context is an especially important consideration with the expedited need for technology across jurisdictions as a result of COVID-19. Participatory community-driven research is ideally suited to identify acceptable and relevant user-driven solutions (Burke et al., 2005). Engaging rural community stakeholders in the co-identification and co-creation of community-centered solutions also facilitates integrated knowledge translation (Jull, Giles, & Graham, 2017). In the current study, a knowledge-to-action technique, known as concept mapping, was used to engage rural community stakeholders, giving them an active voice in generating solutions, and bringing their community, experiential, professional, and tacit knowledge into shaping a collective understanding of how technology relates to rural health equity. The research question guiding the study was: What are priority technology solutions to support the health and well-being of people living with chronic illness in rural communities?

Methods

Study Design

The concept mapping approach aimed to surface and synthesize technology solutions for rural community members living with chronic illness. Concept mapping is well suited to identify future strategic planning and evaluation (Trochim, Milstein, Wood, Jackson, & Pressler, 2004; Trochim, 1989) and to explore lived experience in participatory public health research (Burke et al., 2005). Although qualitative approaches, such as focus groups or interviews, are useful for exploring participant views, concept mapping allows for both individual brainstorming of ideas as well as mapping complex concepts to reveal an underlying structure not directly identified by individual participants (Hanson et al., 2013; Lebel et al., 2011). The concept mapping approach used in this study was informed by the work of Trochim (1989) and Burke et al. (2005) in that quantitative statistical methods, used to synthesize and map participants' solutions to a complex problem, were combined with group discussion and consensus on the final mapped solution. Harmonized ethics approval was received from [University name removed for blind review], the [Health authority name removed for blind review] and the [Provincial Health services name removed for blind review].

Study Setting and Recruitment

This study was conducted in a western region of Canada that is characterized by substantial geographic differences in urban and rural characteristics, with over 40% of the population living outside two major metropolitan areas (Halseth, Markey, & Ryser, n.d.). The geography is diverse (e.g., forests, lakes, deserts, grass plains), with 40,000 islands throughout and 75% of the region covered by mountains (Province of British Columbia, 2021). In contrast to urban areas, demographic aging data indicate a larger proportion of older adults in rural communities (Dandy & Bollman, 2009). In the present study rural was defined based on Statistics Canada's definition of 'rural and small town' as being outside the commuting distance of a larger centre with 10,000 or more population (du Plessis, Beshiri, & Bollma, 2002). We recruited participants residing in the targeted region using emails, advertisements, and the snowball method. A purposeful recruitment method was used to invite rural-living community advocates, health service providers, and

those living with chronic disease or caring for someone with chronic disease as well as those with relevant expertise about technology and rural health.

First, if a member of our team had contacts within a particular community, they reached out to them by email to share an invitation to participate. The invitation included a description of the concept mapping process and details about how to get in contact with the research team. Community contacts were asked to share the invitation with other community members they thought might be interested and invite them to contact the research team. Second, relevant interest groups within the rural communities were contacted through publicly available emails or 'contact us' forms on web pages to inform them about the study and invite representatives from these organizations to participate. Third, information about the study was shared with key stakeholders in the technology/entrepreneurial sector who were asked for their assistance in disseminating our recruitment advertisement to potentially interested participants. Inclusion criteria were: (1) lived or worked in or near a rural community or had relevant expertise about technology or local organizations that might support rural health, (2) was 19 or older and able to provide informed consent, and (3) had adequate internet/online access to participate in the online questionnaire and virtual discussion session.

Data Collection

Polygon Research Inc., a Canadian Company based in Quebec, provided the concept mapping platform, Insight Forming, which was used to facilitate the collection, processing, and visualization of data. Participants were sent a link to the secure platform, where they entered an email address to create an account and 'login' to the study to complete the online questionnaire and consent forms. The online, asynchronous concept mapping process allowed us to reach a broad group of stakeholders, circumventing geographical limitations. However, in the present study our goal was to collaborate with our community partners in mapping the final solution; thus, although community stakeholders were able to complete most of the process individually online, we also organized a virtual group discussion session for participants to co-interpret a visual solution. The online concept mapping process included 3 Steps: Step 1: Generate statements; Step 2a: Sort Statements; Step 2b: Importance and Feasibility Rating; Step 3: Consensus Discussion. (See Fig. 1 for a flow diagram of the concept mapping process). Participants were provided with a \$10 eGift card for participating in Step 1, a \$20 eGift card for participating in Step 2, and a \$50 eGift card for participating in Step 3.

Step 1: Generate Statements

In Step 1, participants completed an idea generation activity between July 14 and September 3, 2020 (7 weeks) in response to the question:

What are possible technology solutions that could address the health and well-being issues of people living with chronic illness in rural BC communities?

The number of responses participants could generate was not limited in this first step. All participants were also asked to complete a short (5 minute) demographic questionnaire. This included: age; gender, marital status, sector/affiliation (e.g., health/social services, non-profit/charitable organization, education, policy/government); education level; ethnicity; status as living with, or caring for someone with, chronic illness; access to the internet at home; adequacy of internet access (reliability/quality) on a scale ranging from poor (1) to excellent (10); and community name.

Once all stakeholders had completed the first step, complex responses were broken down by two study authors (CS and PR) into individual ideas, duplicate responses were collapsed, language was simplified to ensure understanding, and ultimately responses reflecting similar content were synthesized into global statements.

Step 2a: Sort Statements

In Step 2a participants were invited to sort and categorize the final pool of synthesized statements generated. This process involved sorting the statements into higher-order conceptually related groups. Participants could create as many categories to represent the statements as they saw fit. Each participant individually sorted the pool of statements into their own set of conceptually similar groups and provided names for these over a 3-week period (October 10 - October 30, 2020).

Step 2b: Importance and Feasibility Rating

Simultaneously, in Step 2b participants rated each of the synthesized statements in terms of the importance (1 = not important at all to 6 = very important) and feasibility (1 = very low to 6 = very high).

Step 3: Group Consensus Discussion

In Step 3, a 2-hour virtual discussion session (Nov 4, 2020) was held using Zoom where participants discussed the solutions generated and collectively named the clusters through a process of online polling.

Data Analysis

Hierarchical cluster analysis and non-metric multidimensional scaling (nMDS) were used to merge the sorted items into a combined set of clusters (Kane & Trochim, 2007). The concept map visually represented these concepts in two-dimensional space. A Kruskal stress index was computed to assess goodness of fit (Kruskal, 1964).

Two hierarchical clustering methods, unweighted pair-group method using arithmetic averages (UPGMA) and Ward's 2 minimum variance clustering, were compared to assess the reliability of the cluster solution (Gordon, 1999; Legendre & Legendre, 2012). These two solutions were compared on a number of indices. For example, Cophenetic correlations (Spearman rho and Kendall Tau) and dendrograms (alignment quality and Baker's Gamma correlation) were compared for UPGMA and Ward's clustering. An iterative process was used to determine the best fitting solution and the final number of clusters. Silhouette index scores aided the determination of whether individual items belonged in their cluster; positive scores indicate belonging to a cluster (and the higher the silhouette score, the more central the item is to its cluster), null values indicate an item is between two clusters, and negative values indicate an item is closer to another cluster (Rousseeuw, 1987). Finally, cluster stability was assessed by computing the average Jaccard similarities between bootstrapped pairwise clustering solutions (Hennig, 2007). Jaccard similarity coefficient values range from 0 (no relationship) to 1 (perfect relationship) with higher values indicating more valid, stable clusters.

Descriptive statistics were used to summarize the demographic data in SPSS version 27 (IBM Corp, 2020). Mean ratings of feasibility and importance for each technological solution were generated by taking the average of all participant ratings. Then a scatterplot of mean ratings of importance and feasibility was used to generate a 'go-zone'. In concept mapping, a 'go-zone' graph is used to identify items that are rated both highly important and highly feasible (Hanson et al., 2013). Two different methods were compared to determine cutoff points for the 'go-zone', one using a ranking of rating counts and one using a ranking of average ratings (means and median).

The group consensus discussion was audio recorded and transcribed. Using a content analysis approach (Elliott, 2018), participants' interpretation of the clusters and main areas of consensus were identified, and representative quotes were selected to illustrate participants' perceptions.

Results

Participants and Sample Characteristics

A total of 34 people (26 females, 7 males, 1 preferred not to answer) participated in this concept mapping process. Their ages ranged from 26 to 90 years (mean = 55.41 years; SD = 14.82; median = 56.50). The majority of participants were married ($n = 28$; 82.4%), and 24 (70.6%) had a university degree. Five (14.7%) participants identified as First Nations, Metis, or Inuit, 28 (82.4%) identified as Caucasian, and 1 participant (2.9%) preferred to not answer. Participants were affiliated with multiple sectors: 68% self-identified as being in the health and/or social services sector, 44% non-profit/charitable organization, 41% education, and 38% policy/government. Almost half of participants also were either, living with a chronic illness (20%), or were caring for someone living with chronic illness (25%). All 34 (100%) participants reporting having access to the internet at home, and adequacy of internet access (reliability/quality) was rated good/excellent (7, 8, 9 or 10) for 31 (91.2%) participants; however, 3 (8.8%) participants rated their internet quality lower (one 4, one 5, one 6). Most participants ($n = 30$; 88.2%) identified as residents of rural communities in the study region, and 4 (11.8%) were from larger urban centers, but were invited to participate as they had expertise relevant to the project (e.g., of technology and rurality).

Idea Generation, Sorting and Rating

In Step 1, participants generated a total of 84 initial ideas. The three most commonly recurring items surrounded ensuring video conferencing is available for meaningful patient-provider interactions (mentioned 13 times), access to affordable, high quality internet and cellular coverage (mentioned 10 times), and providing ambassadors to support patients and families with training in the use of

technology (mentioned 8 times). The 84 ideas were reduced by the study researchers (as similar or duplicate ideas were combined) into 30 representative statements for sorting and rating (See full list of 30 statements in Table 1). In Step 2, all participants were invited to continue, and of those 16 participants (56% female) returned and sorted the ideas into groups, assigned names to their groups, and then rated items in terms of their importance and feasibility. Figure 2 presents the ideas according to the average rating of importance and feasibility. All 30 ideas received average ratings of importance of 3 or higher. Using either a ranking of rating counts or using a ranking of average ratings (means and median) to determine cutoff points for a 'go-zone', gave results that were quite similar, and the ranking of average ratings is presented. The highest rated statements in terms of both feasibility and importance are captured in the 'go-zone' at the top right of Fig. 2.

Table 1

Statements organized by cluster, including average ratings of importance (range 1–6) and feasibility (range 1–6)

	Importance		Feasibility	
Statement	Mean	Standard Deviation	Mean	Standard Deviation
CLUSTER A: Technological solutions and applications				
24. Develop smartphone applications for remote patient monitoring	5.9	0.3	5.0	0.7
21. Adopt technological solutions to meet supportive, chronic care needs in the community	5.8	0.4	4.1	0.9
11. Develop adaptive technology to address mobility or sensory needs (e.g., hearing impairment, vision loss) of patients connecting by phone	5.5	0.8	2.7	1.0
8. Develop technological solutions for remote and virtual meetings when access to care is difficult (weather, travel distance)	5.3	0.9	4.8	0.9
27. Develop technological solutions to help rural communities gain access to family doctors	4.6	1.0	5.2	0.8
20. Develop digital solutions for real-time mental health care and counselling sessions	4.2	1.1	4.0	0.9
Average Values	5.2	0.7	4.3	0.9
CLUSTER B: Equitable access regardless of location				
28. Ensure follow-ups (e.g., via telephone/video) for patients who've seen a specialist but do not have a family physician	5.9	0.3	3.5	0.9
29. Provide basic services in outreach clinics in small communities using mobile technology	5.9	0.3	4.4	1.1
25. Ensure equitable access to high quality care regardless of location (e.g., home care vs on-site care; rural/urban)	5.9	0.3	3.4	1.0
14. Make telehealth available in a variety of healthcare settings (e.g., acupuncture clinics)	3.8	0.8	2.6	1.2
23. Provide digital solutions that increase on-demand availability of health care services (availability 24/7, shorten wait times)	3.5	0.9	4.9	0.8
Average Values	5.0	0.5	3.7	1.0
CLUSTER C: Staff and patient support				
12. Increase access to free real-time assistance by creating staffing position within health organization for technological support (e.g., an 'IT' department patients can connect with by phone or online chat)	5.5	0.7	3.8	0.9
	Mean	Standard Deviation	Mean	Standard Deviation
13. Provide education/training and support (i.e., paid time) for rural staff to ensure they can use the technologies available to them	5.5	0.7	5.6	0.7
19. Adopt technologies to improve personalized diagnostic and treatment processes	4.2	1.1	5.8	0.6
Average Values	5.1	0.8	5.1	0.7
CLUSTER D: simplify user tools for healthcare options				
18. Increase rural health centre access to equipment (e.g., computers, satellite)	5.7	0.5	3.9	0.9
7. Provide ambassadors to support patients and families with training to use technology	5.3	0.9	5.5	0.7
3. Ensure digital tools are available to patients with new audio-visual capabilities (high quality cameras + microphones) at low-to-no cost	5.3	0.9	3.7	1.0
2. Ensure access to reliable, affordable and high-quality internet and cellular coverage	5.0	0.9	4.6	0.9

	Importance		Feasibility	
5. Ensure video conferencing (e.g., Zoom, Google, GoToMeeting, Skype) available for meaningful patient-provider interactions	3.8	0.8	5.3	0.9
Average Values	5.0	0.8	4.6	0.9
CLUSTER E: collaboration among healthcare professionals				
15. Connect local care providers with specialists in larger centres for continuity of patient care	5.7	0.5	4.9	0.8
30. Use technology to support team-based care	4.8	1.0	5.2	0.8
17. Continue process of emailing prescriptions to pharmacists	4.1	1.0	5.8	0.6
Average Values	4.9	0.8	5.3	0.7
CLUSTER F: overcoming challenges to technological linkages between systems, health records, networks				
26. Ensure all the computer systems within all the health care system are using the same operating system (to improve the transmission of data between centres)	5.9	0.3	5.8	0.7
22. Adopt technological solutions to enhance transmission of information between rural and central health centres	5.9	0.3	4.2	1.0
9. Provide patients and caregivers/family members digital access to patient's health records to support care from a distance.	5.5	0.8	4.9	0.9
10. Explore technological solutions to improve security of personal health data and allow patient to choose who can access.	3.3	1.4	5.6	0.7
1. Digitize up to date health records that link patient's information (health conditions and status) across all service providers	3.2	0.9	2.9	1.0
Average Values	4.8	0.7	4.7	0.8
Statements not part of any clusters (removed)				
16. Implement ongoing evaluation of technological solutions	4.1	1.0	5.8	0.6
4. Create a platform to support online community engagement for communication and planning (e.g., organizing ride share)	3.8	0.8	4.6	0.8
6. Use digital solutions to facilitate connecting with family, friends and support groups to reduce isolation and loneliness	3.4	0.9	4.7	0.9

Generating a Concept Map

Using hierarchical cluster analysis and nMDS, the items individual participants sorted into groups were combined into a set of six clusters. Table 1 presents the abbreviated statements organized by cluster, along with average ratings of importance and feasibility. The Kruskal stress index for this 2-dimensional solution was .199. Three items were removed. The item 'Implement ongoing evaluation of technological solutions' was removed because it was left unsorted by 6 of the 16 participants. The item 'Create a platform to support online community engagement for communication and planning (e.g., organizing ride share)' was removed because it had a negative silhouette value in the final solution, meaning it was closer to another cluster. The item 'Use digital solutions to facilitate contact with family, friends and support groups to reduce isolation and loneliness' was removed because it had a low internal validity for the clustering solutions, meaning most participants sorted it into differing groups.

The UPGMA and Ward's clustering methods provided highly similar results on all indices suggesting the 6-cluster solution was reliable. Ultimately, the UPGMA method was selected, as some indices (e.g., cluster stability) were slightly higher than using Ward's clustering. Using the UPGMA method, average Jaccard similarities between bootstrapped pairwise clustering solutions for the six clusters ranged from .61 to .82, suggesting at least somewhat valid, stable clusters when resampling the data. Figure 3 presents a concept map of the 27 statements with a 6-cluster solution.

Naming the Clusters

In Step 3, ten participants who completed Step 2 attended a 2-hour virtual session to collectively interpret the results. Participants discussed the individual solutions in each cluster and their association. Options for cluster names (based on names participants had given their initial groups when sorting the items) were presented in a poll to participants, and in each they could select 'other' and continue to discuss. The top choices for name were also discussed, and often modified from what was originally presented in the poll.

Technological Solutions and Applications (Cluster A) included smartphone applications and technology solutions. This cluster captured diverse technology applications to meet a range of needs for people with chronic illness in rural communities. Some were general applications such as for supportive, chronic care and some were specific applications to address mobility sensory needs, mental health, monitoring, or giving access to primary care providers. Indeed, as one participant explained, *"Technology could be many simple things as well. It could be manufacturing or med devices"* (P3). Overall, participants interpreted this cluster as being about *"developing technological solutions to help rural communities gain access [to care]"* (P9) which otherwise may be too costly or difficult to access. As one female rural community resident explained: *"Our tertiary hospital would be a good four-hour drive - it's an overnight trip, which means then there's accommodation expenses as well. So in some cases, people just don't engage with those site visits"* (P1). The technology solutions in this cluster were seen as a way to create options for remote engagement with healthcare.

Equitable Access Regardless of Location (Cluster B) consisted of ideas that would make access to healthcare more equitable. These ranged from mobile technology to enable local community outreach clinics to doing virtual visits to ensure remote patients without a family doctor are not 'lost' to follow-up. Ideas in this cluster surrounded ensuring patients could access care in a variety of settings, including digital solutions for timely, on-demand (24/7) care. One female rural community health sector worker explained: *"Most of this is about availability of care in a variety of different contexts and making sure that even if people don't have certain basic things like a family physician, that they still have that available"* (P2).

Staff and Patient Support (Cluster C) involved training and support for both patients and healthcare providers so they can use the available technology. The larger meaning of this cluster for participants was access to real-time assistance and training needed for any technology to be successfully deployed. As one female rural community member described:

One of the things that I've seen is that we've got this technology, but if one person wasn't there, the person that knows how to use it, then nobody gets to use the technology. It's been a concern for all of us because that shouldn't be that way. Right? If the technology is there, there has to be people that can access it for the patient (P10).

Simplify User Tools for Healthcare (Cluster D), encompassed not only training for patients but also ensuring free or low-cost digital tools and internet/mobile coverage were available, enabling people to access meaningful care. This cluster included a range of ideas related to ensuring digital tools and solutions are simplified so that patients can use them. As one male rural community participant explained:

Simple and reliable are not the same. You can reliably have a really complex system that nobody can use.... When you're the user, what you want is almost a manual button that you just push "start" and it works. It's like your car, right? That's a very complex piece of equipment, but it's had user input of, "I don't want to go out and hook up a battery and do this and do that. And all the rest of it." So these days you can just sit in your car with a thing [key fob] in your pocket and your car can start. And so it's part of designing the technology, not to suit the technology developers, but to suit the end user - simple access. (P6)

Collaboration among healthcare professionals (Cluster E), captured technologies for improving provider to provider interactions, along with using technology to support team-based care. After discussion that collaboration *"involved the patient as well, because the patient always has to be at the center"* (P8), participants identified the importance of the patient being at the centre of team-based care as largely missing from the map. One female rural community member explained:

Team-based care is a really important aspect of what we've been talking about today. And so far, we don't have any cluster that really reflects that... Team-based care is really the name of the game. It's why we want to do all of these technological solutions to access to healthcare. We want to expand the team. It's not just a physician and a person anymore (P1).

Overcoming challenges to technology linkages between systems, health records, networks (Cluster F) encompassed interoperability between health system records and primary care provider electronic health records to improve quality of care. For example, linking patient health information across service providers and allowing patients and their caregivers access to digital records. One female

rural community stakeholder explained: *"they're trying to make interoperable networks to enable whoever wants to have[access to a record] go and use it"* (P3).

Interpreting the map

Once all the clusters were named, Cluster A and B were selected as the top priorities for moving forward with solutions and participants discussed the overall organization of the clusters of ideas and collectively began to identify the conceptual regions that could be present in the map. Participants noted that although items at the top right of the map were about the development of new technologies, items at the bottom left highlighted the importance of connecting patients to technology. The 'human' aspects of technology use, including ambassadors, training, and support were seen as critical for *"Connecting patients with new technologies"* (P10). According to one female rural community member:

And that's where I go back to the ambassador, to the actual person who knows what's going on, and can push the buttons, and can ensure that when I want to talk to the specialist, I can talk to the specialist and not worry about clicking and whatever else (P1).

Organizational or team level ideas (e.g., use technology to support team-based care) were grouped towards the top left of the map, whereas items related to specific tools or solutions (e.g., ensure digital tools are available to patients) were grouped to the bottom right of the map. Cluster B, named 'equitable access regardless of location', was at the centre of the map, with all other clusters surrounding it, suggesting these ideas are centrally related to all the others. *"It's about ensuring access anywhere and everywhere"* (P1). In addition, the individual item 'ensure access to reliable, affordable and high-quality internet and cellular coverage', part of Cluster D, was also near the center of the map. Participants explained that network access was key to making technology solutions possible: *"Good access to internet is a technological solution... it's a piece of it"* (P6).

Discussion

The purpose of this study was to collaboratively identify and prioritize action strategies for using technology to promote rural health equity. With engagement of diverse rural community stakeholders, the findings present a co-created set of technology solutions to support the health and well-being of people living with chronic illness in rural communities. Although the study results are based on experiences in rural settings in western Canada, the findings may also hold value for other rural contexts where similar factors influence health inequities.

Findings from this concept mapping study offer technology solutions to begin to redress well known rural inequities and unfair structural and social determinants of health. In addition to cost and travel time/distance, rural communities face additional difficulties travelling for healthcare, such as dangerous weather, mountainous terrain, and the dependence on ferry services for island communities (Rural Evidence Review, 2019). The Technological Solutions and Applications (Cluster A) as well as Equitable Access Regardless of Location (Cluster B) clusters both include solutions for accessing care without travel. The shortage of healthcare professionals in rural communities has adverse consequences for rural-living people, as they may miss treatment or go through treatment and recovery outside of their community without the support of family and friends (Rural Evidence Review, 2019). Again, technology solutions were proposed to help rural communities gain access to primary care providers. This, and the use of mobile technology for outreach clinics mirrored the suggestions from rural citizen-patients in the recent Rural Evidence Review (2019). Our findings suggest that, from the perspective of rural community stakeholders, technology could be used so that living rurally in itself does not serve as a structural determinant of health.

Yet, in the current study participants also introduced Staff and Patient Support (Cluster C), and the need to Simplify User Tools for Healthcare Options (Cluster D) as essential for ensuring technology was accessible. Indeed, in the open-ended feedback, the group did not place technology solutions as their only priority and did not see health technologies as a 'one size fits all' solution. The human aspect of technology was seen as critically important for 'connecting' patients with new technologies. Further, solutions in the Collaboration among Healthcare Professionals (Cluster E) and Overcoming Challenges to Technological Linkages (Cluster F) clusters suggest that technology is not necessarily seen as the main driver that will transform the health system equitably but an essential component that supports building connections between the various actors of the health system. Participants discussed challenges and risks more than the opportunities these technologies represent. They emphasized collaboration, training, and human support in addition to the technology solutions themselves.

Indeed, all of the ideas were rated as highly important, reflecting the complex inter-related challenges often faced by rural communities and the need for multi-level solutions in underserved rural populations to address the lack of equitable access to health care (Nielsen et al., 2017; Orser & Wilson, 2020). Ensuring access to reliable, affordable and high-quality internet and cellular coverage was not only at the center of the concept map, it was also one of the most frequently occurring suggestions in the original pool of 85 ideas. This finding, in part, reflects the fact that in Canada, although 97% of citizens living in urban regions have access to high-speed internet, only 37% of citizens living in rural communities have access to the same service (Canadian Radio-television and Telecommunications Commission, 2016). Adequate digital infrastructure is imperative for rural communities to engage in every area of life and key to reducing inequities experienced by people living in rural communities.

Another commonly recurring suggestion surrounded technology solutions for patient-provider interactions, possibly reflecting the pressing human resource shortages in rural communities (Orser & Wilson, 2020). Yet, virtual care used to its full capacity (e.g., video visits) requires adequate broadband access, which is often limited in rural and underserved settings (Hirko et al., 2020). Indeed, a previous systematic review suggested that videoconferencing improved accuracy of diagnoses and reduced re-admission rates compared to telephone (Rush, Howlett, Munro, & Burton, 2018). If technological solutions are to effectively begin addressing rural healthcare challenges (Nielsen et al., 2017), the necessary technology infrastructure to support high quality care will need to be in place.

It is notable that the highest rated individual ideas in terms of both importance and feasibility (captured in a 'go-zone' in Fig. 2) included statements from five of the six clusters. Of the six items captured in the 'go-zone,' three related to developing digital solutions, but three other solutions, linked indirectly to the development of technology solutions, emphasized selecting, developing, using and evaluating technology solutions while placing the patient and health practitioners at the centre. Providing ambassadors to support training to use technology was among the most frequently occurring suggestion in the original pool of 85 ideas, reinforcing interest in the 'human' support for multiple rural community stakeholders.

An emphasis on digital skills training should be an essential component in the introduction of any new technology. In rural locales in particular, there may be a strong preference for face-to-face training (Easom, Alston, & Coleman, 2013), consistent with the present findings. Yet digital literacy, defined as the ability to use communication and information technologies to find, evaluate, and communicate information (American Library Association, 2013) is often overlooked in the development of technology-based interventions, limiting accessibility (Cheng, Beauchamp, Elsworth, & Osborne, 2020). Indeed, higher digital literacy was related to higher satisfaction with telemedicine in a recent study of rural community telemedicine use during COVID-19 (Rush, Seaton, Li, Oelke, & Pesut, 2021). In order for technology to contribute to advancing equity in rural communities, accessibility considerations encompass hardware, connectivity (cellular and internet service at adequate bandwidth), and informational technology supports and skills.

Importantly, rural voices must be included in the design and delivery of equity-advancing use of technology. The present findings reinforce the need for participatory research to ensure acceptable user-driven solutions are identified (Burke et al., 2005). In a review of 103 manuscripts that included concept mapping methodology, 38% employed high community engagement, with notable benefits such as the development of contextually applicable interventions and long-term sustainability (Vaughn, Jones, Booth, & Burke, 2017). The present research endeavored to synthesize perspectives from diverse rural community stakeholders by inviting participants themselves to collectively interpret the ideas generated, strengthening the external validity of the results.

Limitations and suggestions for future research

Despite the strengths of the present research, there were also several limitations. The sample was composed of 8 (23.5%) adults under 45 years of age, 17 (50%) adults aged 45–65, and 9 (26.5%) participants were 65+ years. The majority were highly educated, identified with policy/government and education sectors, were very knowledgeable about digital technologies and had adequate internet access. The perspectives of other populations (e.g., younger, without internet access, and/or less technology knowledge) should be explored in future research. Further, a smaller number of participants contributed to the sorting, rating, and discussion of the final ideas generated, limiting generalizability of the results. In the present study, the concept mapping design required an important cognitive effort as well as participants who were knowledgeable about and had access to technology. A larger sample to appreciate possible gender, age group, location, issues relevant for Indigenous populations, and various experiences with other marginalized populations (e.g., those living in poverty) would be needed to reduce that bias. In the future, concept mapping as a methodology could be adapted to include semi-structured interviews after Step 2 and before Step 3. Finally, since concept mapping is also a learning

process, individual follow-up with participants could be included after the group session to see what participants learned from the activity and if and how their feedback could translate into 'real world actions'.

Conclusions

Overall, community stakeholders identified that technology solutions alone are not enough to promote rural health equity, but these require advancing the technology infrastructure, multi-stakeholder collaboration, community-oriented or rural-centric training and programs, and permanent human and technology support to ensure successful adoption. The concept mapping process engaged diverse rural community stakeholders in the co-creation of technology solutions for rural health equity. The inclusion of rural community stakeholders in all steps of the concept mapping process generated innovation and user-driven solutions towards rural health equity.

Abbreviations

IT
Information Technology

Declarations

Ethics approval and consent to participate

This study received harmonized ethics approval from the University of British Columbia Research Ethics Board (#H20-00075), the Interior Health Research Ethics Board (2019-20-094-H) and the BC Emergency Health Services (BCEHS) and the Research and Evaluation Subcommittee (File #: 51500-01). All participants completed online informed consent forms.

Consent for publication

Not applicable

Availability of data and materials

The data sets this study are based on are stored on secure servers at UBC Okanagan. Anonymized data are available upon request from the corresponding author.

Competing interests

The authors declare no competing interests.

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Authors' contributions

PR, KR, and EL contributed to the conceptualization of the project, and all authors contributed to the study design. CS oversaw the data collection and facilitated the virtual discussion. CS prepared Figure 1. PR prepared Table 1 and Figure 2. PR and CS in collaboration with Polygon Inc. completed the data analyses including preparation of Figure 3. CS led overall manuscript development and integration. All authors contributed to manuscript drafts and reviewed the final manuscript.

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Authors' information (optional)

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Figures

Figure 1

Flow diagram of the concept mapping process

Figure 2

Statements by participant ratings of importance and feasibility including a 'go-zone' (top right) of items rated both highly important and highly feasible

Figure 3

Concept map of 27 statements with a 6-cluster solution. Note: Higher silhouette index scores suggest items are more central to their cluster