



# ICT-facilitated Health Interventions for Indigenous Communities: A Critical Literature Review

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Despite significant cultural strengths and knowledge, Indigenous people around the world experience substantial health inequities due to the historic and ongoing impacts of settler colonialism. As information and communication technologies (ICTs) are increasingly used as part of health interventions to help bridge equity gaps, it is important to characterize and critically evaluate how ICT-facilitated health interventions are designed for and used by Indigenous people. This critical literature review queried articles from three archives focused on health and technology with the goal of identifying cross-cutting challenges and opportunities for ICT-facilitated health interventions in Indigenous communities. Importantly, we use the lens of decolonization to understand important issues that impact Indigenous sovereignty, including the incorporation of Indigenous Knowledge and engagement with data sovereignty.

CCS Concepts: • **Applied computing** → **Health care information systems**; • **Human-centered computing**;

## 1 Introduction

Over the past two decades, there has been an explosion of ICT-facilitated healthcare, ranging from telehealth systems that connect patients to care providers over long distances to wearable biosensors that allow individuals to monitor their vitals in real-time. These innovations have been investigated in both developed economies as well as in developing contexts (e.g., ICT for development). In this article, we systematically examine how ICT-facilitated health interventions (IFHIs) are designed and implemented with Indigenous people—people who have collective cultural and ancestral ties to the land where they live [92]—around the world.

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A 2022 report from the World Health Organization found that only 67% of the global population had access to quality and affordable health services they need [93]. While this number has slowly been increasing, the report noted that the increase masks many within-country inequalities. Indigenous people, in particular, experience substantial health inequalities due to the historic and ongoing impacts of settler colonialism as well as forced relocation due to climate change. While addressing these inequities requires systemic changes to policy and practice, many health advocates note that health solutions that incorporate digital information and communication technologies (ICTs) represent an important space for health innovations that can accelerate the closure of gaps in accessible healthcare [94]. Systematically understanding challenges and opportunities for technology components used in healthcare interventions with Indigenous people can facilitate better approaches to supporting unique cultural strengths and addressing pernicious health gaps. Moreover, the lens of decolonization helps us understand how IFHIs leverage the many cultural strengths and knowledge of Indigenous communities while preventing continued harms that settler colonialism has inflicted on Indigenous communities [1, 32].

To this end, this paper presents a critical, systematic review of literature published between 2012 and 2022 from three publication databases focused on health or ICT innovations. Our initial query resulted in 584 articles and after applying filtering processes, we coded and examined 84 articles to answer the following questions:

1. *What are critical challenges and opportunities surrounding the design and implementation of IFHIs for Indigenous people and communities?*
2. *To what extent do existing IFHIs support decolonization and sovereignty of Indigenous people?*

Using a constant comparative approach, we identified four key themes related to cross-cutting challenges and opportunities, including: design practices for incorporating Indigenous Knowledge, engaging Indigenous participants in research, generalizability and transferability of IFHIs across disparate cultural communities, and digital inequities. We also found that fewer than 5% of the articles we examined explicitly engaged with digital or information sovereignty in any capacity. To the best of our knowledge, this paper presents the first systematic review of IFHIs that have been designed for, with, or by Indigenous communities. This effort is aligned with emergent ACM efforts in computing that seek to understand how integration of “indigeneity” into ICT design distinguishes sociotechnical projects from other social justice projects [16].

The remainder of the paper is organized as follows: First, we provide a background about Indigenous people, IFHIs, and decolonization in Section 2. Second, we describe the methodologies we used to develop and analyze our corpus of articles. Third, we report the results of our review organized by theme in Section 4 and then discuss our findings in Section 5. We conclude in Section 6.

## 2 Background

In this section, we contextualize our critical review with background on Indigenous healthcare and ICT-facilitated healthcare.

### 2.1 ICT-facilitated Healthcare

For this review, we understand “ICT-facilitated healthcare” as health-enhancing interventions that are mediated by digital information or communications technologies. There are a range of terms used in relationship to ICT-facilitated healthcare. To help operationalize how these are used in the literature, we review and define them here.

ICT encompasses tools and resources used to transmit, store, create, share or exchange digital information. These include physical devices (smartphones, tablets, desktop computers, wearable devices, hard drives), communication media (television, radio, Internet), software (smartphone apps, websites), and protocols (email, SMS). For each of the articles reviewed, we surfaced the specific ICTs that comprised the intervention.

We also seek to standardize the terms used to discuss the intersection of ICTs and healthcare. One of the most general terms used in the context of ICT-facilitated healthcare is *electronic healthcare* or *eHealth*. Sometimes, this convention is applied to more specific health focuses, such as the case of *eMentalHealth*. The ICT elements of *eHealth* are wide-ranging [24]. They can include components such as email and SMS, wearable biosensors, smartphone apps, web applications, and video conferencing. It can also encompass the use of informatics and computation to synthesize and make meaning from data related to health. While all of the articles reviewed in this paper fall under the category of *eHealth*, we note that they only cover the areas of *eHealth* concerned with ICT as components of a health intervention and they do not cover areas of *eHealth* focused on leveraging computational techniques to analyze health data. Related to *eHealth* is *mobile health* (or *mHealth*), which encompasses all healthcare that leverages mobile devices, such as smartphones, tablets, or wearable devices.

Another term frequently used in the literature is *telehealth* or *telemedicine*. The US Health and Human Services Department defines telehealth as a way of providing healthcare services that “lets your health care provider care for you without an in-person office visit. Telehealth is done primarily online with internet access on your computer, tablet, or smartphone [87].” Telehealth can also involve remote monitoring of vitals through wearable biosensors. Importantly, telehealth is typically characterized by a relationship between a patient and a specific care provider and the technology is focused on facilitating interpersonal interactions between them. Conversely, there are other interventions that do not necessarily involve interpersonal interactions; rather, they may focus on supporting interactions between the user and software and digital media that conveys health information. Or, they may support interactions between the user and their own body by providing feedback from biosensors.

We use the term *ICT-facilitated health interventions (IFHIs)* as an alternative to *eHealth* that encompasses only components where ICTs are leveraged as a component of the intervention and not solely as components of recruitment into intervention programs or components of data analysis. Importantly, our definition of IFHI led us to eliminate several articles from our queried set of articles as they did not meet these criteria (see Section 3).

## 2.2 Indigenous People

We recognize that indigeneity encompasses a diverse group of people and has been defined in many different ways by different groups and organizations. To facilitate the operationalization of the term, we rely on the definition from World Bank: “*Indigenous Peoples are distinct social and cultural groups that share collective ancestral ties to the lands and natural resources where they live, occupy or from which they have been displaced. The land and natural resources on which they depend are inextricably linked to their identities, cultures, livelihoods, as well as their physical and spiritual well-being. They often subscribe to their customary leaders and organizations for representation that are distinct or separate from those of the mainstream society or culture* [92].”

As noted by the United Nations Permanent Forum on Indigenous Issues, “Indigenous” has been a term used to generically identify Indigenous Peoples from around the globe for a number of years and is intended to encompass a number of localized terms such as First Peoples/Nations, Aboriginal, and tribes [86]. We use the phrase “Indigenous Peoples” to refer to multiple, distinct ethnic Indigenous groups. We use the phrase “Indigenous people” to refer to individual persons from multiple Indigenous groups.

Given their deep ancestral connections to the land and natural resources, Indigenous Peoples are important knowledge holders who possess key insights into sustainable environmental practice and resilience to natural disaster. In a changing climate, Indigenous People safeguard important natural resources and have long promoted best-practices for sustaining biodiversity [55].

Unfortunately, Indigenous people have experienced (and continue to experience) violence, forced removal from homelands, and disenfranchisement at the hands of settler colonialism [92]. This has resulted in several challenging realities, including overrepresentation amongst the world’s “extreme poor” and significantly shorter life expectancy than non-Indigenous people [31]. Due to historical and contemporary settler colonial policies,

Indigenous people are typically the last to receive public investments in basic services and infrastructures [92]. Critically, the lack of public investment into basic services has led to a lack of health services designed for and delivered to Indigenous communities. There is often a lack of trained healthcare professionals and healthcare facilities that serve Indigenous communities. Even when healthcare personnel, facilities, and services are available, implemented health interventions often lack cultural resonance and acceptance with Indigenous people, leading to poor uptake and efficacy [31, 86, 92]. Methodologies such as community-based participatory design have helped create interventions that have better cultural resonance with Indigenous communities, while telehealth and mobile health have created new opportunities for delivering healthcare to areas with limited healthcare infrastructure. However, ICT-facilitated healthcare is not a panacea for Indigenous communities. Many Indigenous communities experience significant digital disparities, including lack of Internet access, lack of digital literacy, and lack of human capacity to sustain ICT-facilitated projects. *Thus, it is imperative to critically examine how ICT-facilitated healthcare interventions for Indigenous people consider digital equity issues as part of their design.*

### 2.3 Decolonial Computing

As we investigate work at the nexus of IFHIs and Indigenous people, it is necessary to consider *postcolonial* [32] and *decolonial* [1] computing as important orientations toward ICT. Postcolonial computing is a theoretical orientation that offers ICT designers, practioners, and researchers tools that acknowledge account for the impacts (and harms) of colonization through the processes of design, implementation, and research. Decolonial computing takes this a step further by prompting ICT designers and researchers to think through “what it might mean to design and build computing systems with and for those situated at the peripheries of the world system, informed by the ways of thinking and knowing (epistemologies) located at such sites, *with a view to undermining the asymmetry of local-global power relationships, and effecting the decentering of Eurocentric/ Western-centric universals* [1].” When we write about decolonizing IFHI, we refer specifically to IFHI technologies and programs that seek to shift power to Indigenous people and knowledge systems. This can be accomplished in a number of ways, including but not limited to the use of Indigenous language and knowledge as part of IFHI systems, through the consultation of Indigenous stakeholders, and through the process of Indigenous capacity-building (or Nation-building) as a targeted outcome for IFHI. *We examine the articles in this review to see how many actually engage Indigenous language, Indigenous knowledge, and participatory methodologies for the design, implementation, and governance of IFHI.*

One of the most powerful political mechanisms for decolonization is *sovereignty*. Around the world, Indigenous communities have centered substantial political discourse around the concept of sovereignty, which Barker (2005) argues “stands in for all the inherent rights of all indigenous peoples [3].” Indigenous sovereignty extends to various spaces, including (but not limited to) land and resource rights, resource reclamation, governance and policy, cultural knowledge, and economic self-determination. Included in visions of Indigenous sovereignty are concepts of Indigenous data sovereignty, which asserts the right of Indigenous Peoples to “maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as their right to maintain, control, protect and develop their intellectual property over these. [38].” For ICT-facilitated health interventions, data sovereignty is crucial for the designers and operators of any information system or communication technology. In this context, *we critically examine how data sovereignty is acknowledged and accommodated by ICT-facilitated healthcare interventions for Indigenous people.*

### 2.4 Related Work

We identified four literature reviews that already existed in the databases we queried for our review. Of these, two were related to the scope of our review. Most directly related was the scoping review by Malhotra et al. [45], which synthesized findings from field studies in India to provide design recommendations for inclusive social



Fig. 1. Query terms. Wildcard characters are indicated with “\*”.

and behavior change communication that leverage ICTs for marginalized castes and tribes in India. Rajamani et al. [63] conducted a scoping review of peer-reviewed literature published in PubMed and PCORI Engagement in Health Research Literature Explorer to characterize how health informatics tools intersected with community engaged health research to reduce health disparities. Our work is distinctive in two key ways. First, our review centered Indigenous identity (culture and language) and sovereignty (analytic power) as a explicit elements by which ICT-facilitated healthcare interventions should be examined. Second, while Malhotra et al. examined field studies in India, this scoping review was limited in geographic scope and thus does not examine Indigeneity from a global perspective. By taking a systematic approach that centers its questions around Indigeneity, we are able to critically examine how Indigeneity is conceptualized and engaged in health interventions that incorporate ICTs.

### 3 Methodology

#### 3.1 Planning

To understand the current state-of-the-art for designing, deploying, and evaluating ICT-facilitated healthcare interventions for Indigenous communities, we performed a systematic literature review of the ACM Digital Library ( $n = 7$ ), PubMed ( $n = 77$ ), and Web of Science ( $n = 500$ ) databases. We reviewed these particular databases because they were the most likely to provide coverage of a highly transdisciplinary area that involves research from computer science, public health and health sciences, and applied Indigenous studies.

We used query terms related to ICT, health and Indigeneity. We provide an overview of our query terms in Figure 1. The query terms for ICT were selected by Vigil-Hayes and Amresh to be as inclusive as possible of a variety of information technologies. The query terms for health were selected by Collier to also be as inclusive as possible of a variety of health domains. The query terms for Indigeneity were selected by authors Vigil-Hayes, Collier, and Joseph based on their expertise conducting research with Indigenous communities (detailed in Section 3.4). For articles to fit our initial query criteria, they needed to include at least one term from each category. We constrained our search to articles that were published between 2012 and 2022.

We use a PRISMA diagram in Figure 2 to illustrate the steps involved in identifying papers for initial review and screening papers to remove duplicates that appeared multiple times across the three databases. Ultimately, we identified 584 unique papers that matched our query terms. From this set of 584 papers, each abstract was reviewed by authors Panguluri and Hossain to determine if the papers should be included based on how ICT was conceptualized. If the ICT was something that individuals interfaced with directly as part of the *delivery of a health intervention*, the full paper was included for review. However, if the ICT was not used directly for the delivery of the intervention, we excluded the paper from our review. For instance, papers that only focused on using ICTs to analyze health records that informed an intervention or that used ICTs to recruit participants for an intervention were excluded from review. At the end of this process we had 92 papers. Between the two coders, there was an IRR of 97%. For the 18 papers that coders disagreed on, the lead author made final inclusion decisions and broke ties.

The lead author developed a provisional codebook [68] with 33 codes based on past ICT research with Indigenous communities and the research questions (e.g., Indigenous sovereignty and decolonization). Provisional

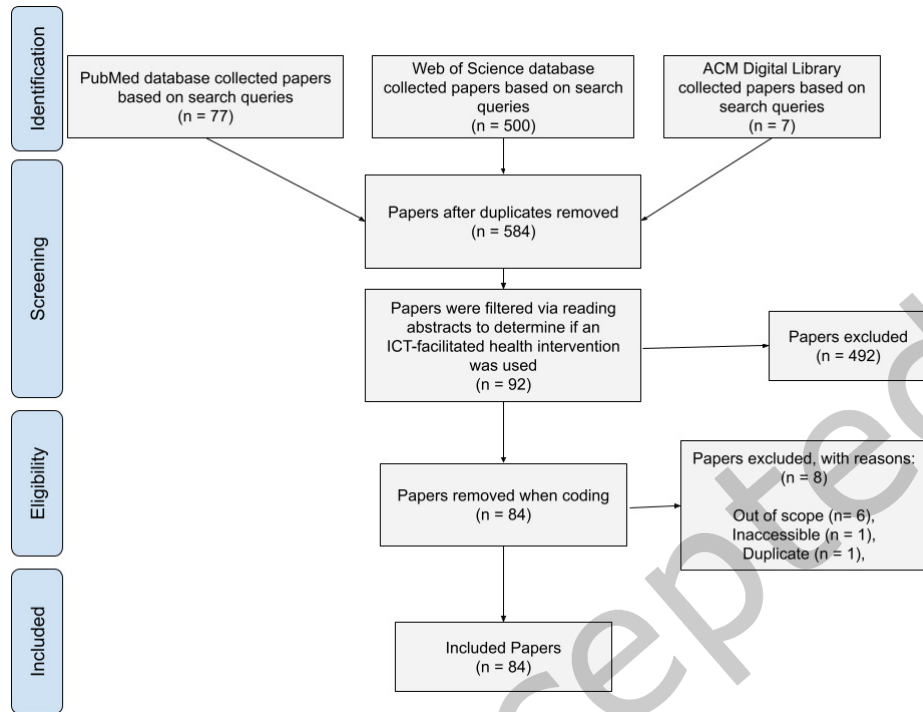


Fig. 2. PRISMA diagram with inclusion criteria and filtering process.

codes were updated to reflect the diversity of locations, ICTs, and health foci encountered in the literature. Our final codebook included 10 code categories with 64 subcodes. We provide details about the codebook and the categories and subcodes applied in Appendix A.

### 3.2 Conducting

Two authors reviewed the 92 papers that made it through our abstract screening process and both authors reviewed each paper. To ensure consistency, the lead author and the two authors involved in coding engaged in two 2.5-hour meetings to review the codes applied to each paper. There was near 100% inter-rater agreement on code categories that were applied to *Study type*, *Methodologies*, *Health focus*, *ICTs involved*, *Location*, and participant details. However, the two authors who did the initial coding were not as familiar with nuances of culturally-informed health interventions. As a group, the authors discussed the nuance of the *Indigenous culture*, *Indigenous language*, and *data sovereignty* codes. Then, all three authors collectively reviewed each of the papers during their meetings to come to a consensus on the codes that should be applied in these categories.

As illustrated by the PRISMA diagram (Figure 2), we ended up excluding an additional eight papers as we coded papers. 6 of the papers were removed because we ultimately considered them to be outside the scope of the review. In all cases of papers excluded for inappropriate scope, the abstract mentioned application of ICT health interventions to Indigenous communities as a part of a collective of minority groups to whom interventions might apply, but ultimately the paper did not actually investigate the intersection or impact of ICT health interventions and Indigeneity directly. One paper was excluded because we were not able to access the full manuscript through our institutional libraries. One paper was removed because it was actually a duplicate and the databases had

provided inconsistent title information between the two copies. As a result, our final analysis included a total of 84 full articles. We provide an overview of how the articles are distributed over time and over different countries in Figures 3a and 3b, respectively.

### 3.3 Analyzing Results

We used descriptive statistical methods to quantify the percentage of articles that engaged Indigeneity and to quantify the articles at the intersections between specific technologies and health foci.

To analyze our coded results and answer our research questions, three authors took a grounded theory approach [27] to identify common axial themes related to how different articles interacted with Indigenous culture and conceptualized data sovereignty. We did this by meeting in two 1.5-hour sessions to examine the coded articles and apply open codes as to how specific articles were engaging with Indigenous culture with IFHIs and considering data sovereignty. Then, through discussion and consensus, we categorized these open codes into overarching axial themes. Ultimately, we identified four axial themes: *incorporation of Indigenous Knowledge and social values*; *engaging Indigenous participants in research*; *generalizability and transferability of IFHIs*; and *data sovereignty*. We contextualize these themes in Section 4.

We describe our findings in Section 4 along the four axial themes. We then discuss our findings and highlight areas for future research in Section 5.

### 3.4 Statement of Positionality

The lead author, Vigil-Hayes, is an associate professor of computer science who has been engaged in community-based technical research projects with several Native American communities for over 12 years, specifically focusing on designing network infrastructures and mobile systems that operate in spaces with intermittent Internet connectivity. She has also led several projects focused on developing culturally-responsive mHealth interventions and computer science curriculum for Native American communities. Authors Collier, Amresh, and Joseph have substantial experience working with Indigenous communities on public health projects. Collier is a researcher and clinical psychologist who has over two decades of experience developing mental health interventions and wellness programs for Hopi in southwestern US, Alaska Natives in Anchorage, Pacific Islanders in Palau, and Hmong refugees in midwestern US. Joseph is a special education and applied Indigenous studies researcher who investigates factors that enable Indigenous students with disabilities to persist in higher education and develops models for promoting cultural resilience in curricular materials. He is a member of the Hopi Tribe. Amresh is an associate professor of computer science who has experience designing and piloting serious games as mobile apps to support public health interventions with Alaska Native teens. Critically, these four authors used their combined decades of experience working with Indigenous communities to inform our query terms, selection of databases, and the development of our codebook.

Authors Hossain, DeCecco, and Panguluri are students in computer science programs. At the time of writing, Hossain and Panguluri are graduate students from Bangladesh and India, respectively. DeCecco is an undergraduate student from the United States. All three students have been actively engaged in projects that design and implement software for Native American communities in the southwestern United States.

## 4 Results

In Table 1, we identified the number of papers that explicitly engaged with Indigenous culture, language, and data sovereignty. We report the number of articles per year in Figure 3a to reveal an upward trend in articles about IFHI for Indigenous people. Figure 3b plots the location where different IFHI studies take place with Indigenous communities. Importantly, we note that there has been a steady upward trend in articles focused on IFHIs for Indigenous communities in the past decade, with the majority of articles focusing on communities in the United

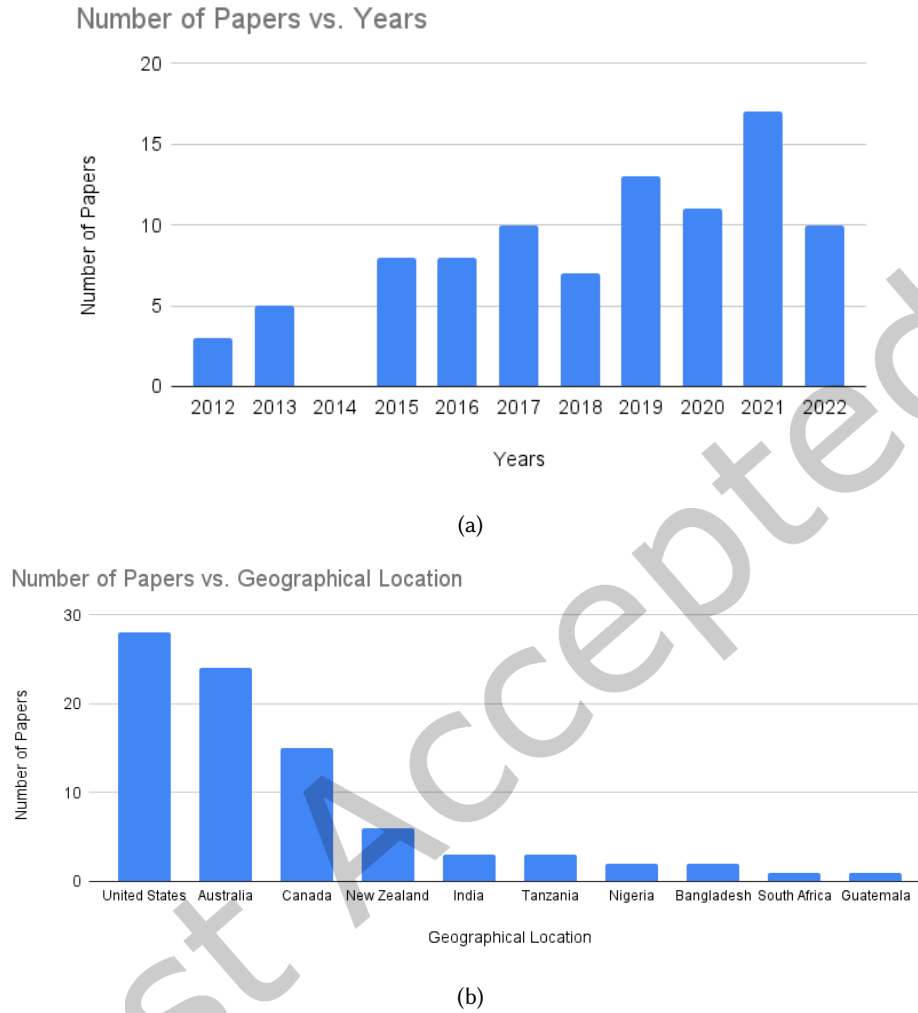


Fig. 3. (An overview of the number of articles (a) published per year in our review window and (b) that described studies in each country.

States, Australia, and Canada; though there are numerous articles that focus on Indigenous communities from across the Global South—particularly in South Asia and Africa.

#### 4.1 Incorporation of Indigenous Knowledge and Social Values

33 of the articles we reviewed sought to integrate Indigenous social values and/or *Indigenous Knowledge* (IK) into IFHIs. Succinctly, IK is “a body of observations, oral and written knowledge, innovations, practices, and beliefs developed by Tribes and Indigenous Peoples through interaction and experience with the environment [61].” Social values are a collection of practices and beliefs that implement cultural values in shifting contemporary contexts.

Table 1. Overview of decolonizing considerations used in each study type and the average number of participants involved in each study type. We detail the “Other” category in Appendix A.

| Study type                  | Paper count | %Indigenous culture | % Indigenous language | %Data Sovereignty | Mean study participants (std. dev.) |
|-----------------------------|-------------|---------------------|-----------------------|-------------------|-------------------------------------|
| Exploratory and Formative   | 15          | 26.66%              | 6.66%                 | 0%                | 599 (1263.41)                       |
| Intervention Design         | 23          | 57.14%              | 42.85%                | 0.13%             | 199 (326.74)                        |
| Implementation & Evaluation | 29          | 34.48%              | 17.24%                | 0.03%             | 95.76 (125.60)                      |
| Experience Reports          | 7           | 16.66%              | 33.33%                | NA                | 367.33 (514.58)                     |
| Literature Reviews          | 4           | NA                  | NA                    | NA                | NA                                  |
| Other                       | 6           | 40%                 | 0%                    | NA                | 865.66 (822.82)                     |

Two of the most prevalent methods used to incorporate IK and cultural values into IFHIs were community-based participatory research (CBPR) and participatory design (PD). In practice, these methodologies were implemented in similar ways, relying on interview and focus group studies along with community advisory boards to provide feedback on technology prototypes, content, programmatic structure, and study measures. Perhaps the key difference is that participatory design typically implies that the community input will be focused towards a specific artifact for an intervention; whereas for CBPR, input may be directed more broadly across dimensions of a particular intervention.

Through the process of PD across numerous projects focused on the development of technologies (e.g., apps and computer games), there were a number of common themes surrounding how IFHI could be designed to be culturally responsive to Indigenous users. One of the most common themes was that Indigenous people wanted to have Indigenous language incorporated into content that was supported by IFHI [4, 42, 44, 48, 56, 89]. However, it seems that in practice, integrating Indigenous language was difficult. Of the articles that considered IK, only 21.4% mentioned that Indigenous language was incorporated into the IFHI. One of the reasons for this is that many Indigenous languages do not have formal dictionaries and do not exist in a written form [92]. Maar et al. (2016) noted that in conversations with Tanzanian participants about the development of Swahili SMS messages for promoting cardiovascular health, it was necessary to carefully check translations to ensure that the connotation of verbiage was “polite” and did not present as too authoritarian [44]. Similarly, Oluwagbemi et al. noted that using automated translation tools as part of an HIV-focused IFHI led to numerous mispronunciations of words in Afrikaans, Zulu and IsiXhosa [56].

Several studies also noted the challenge of translating Western concepts into Indigenous language [4, 44, 56, 71, 72, 81]. For example, in the creation of a cognitive behavioral therapy game for Māori youth, Shepherd et al. (2015) found that users reported it challenging to match Western words for depression to colloquialisms they used to describe the experience [71]. However, they also noted that there could be an opportunity for Western-trained clinicians to listen to Māori patients and learn about how Māori people describe the experience of depression. Moreover, in some contexts, it may be more appropriate to abandon Western approaches (e.g., cognitive behavioral therapy) in favor of culturally-grounded therapeutic approaches.

Another common theme was the need to incorporate more visual and auditory content (rather than just text) to appeal to Indigenous users—particularly for IFHI designed for youth users [42, 50, 57, 81, 89]. In focus groups around the design of the iBobbly suicide prevention app for Aboriginal and Torres Strait Islander youth, several participants noted the importance of audiovisual content such as videos and voiceovers to help keep

user attention and bridge issues with literacy [81]. This may connect to the fact that many Indigenous cultures tend to be more oral and Indigenous languages are often spoken more than they are written. On a related note, focus groups around IFHI artifacts and prototypes commented that they wanted to see content that was representative of Indigenous people [50, 57, 71, 72, 89]. In Perkes et al. (2022) co-design of a maternal and child mHealth intervention, several Aboriginal participants stated that they wanted to see Aboriginal people depicted in photos and videos used in the app—otherwise the IFHI would not feel like it was really intended for them [57]. However, as discussed in Section 5.1, this can be a major bootstrapping challenge for the teams that develop IFHI artifacts and content. One study noted that “there are very few stock photos of Aboriginal people (outside of tribal stereotypes) [50].” Thus, many projects relied on generating their own images for use in their app.

While many papers noted common themes surrounding language usage, respect for traditional practices, and use of representative audiovisual content, there was a tension that surfaced in several of the articles was that between communal Indigenous cultural values and values of Indigenous individuals participating in IFHIs. In the creation of content for a mobile app promoting mental health for Hopi and Navajo youth, Vigil-Hayes et al. (2021) noted numerous tensions between what a community advisory board stated as cultural values and what youth focus group participants noted as desirable [89]. For instance, whereas the community advisory board agreed that collaboration was a very important community value for both Navajo and Hopi cultures, youth focus group participants largely preferred competitive ways of interacting with other users. Likewise, what seemed like clear visual indicators of cultural relevance to community advisory board members (who were all adults) did not come across clearly to youth focus group participants. Thus, it is important that participatory design efforts include members representing the cultural background of intended users as well as members who reflect the age and gender (and other pertinent demographic components) of intended users as well.

## 4.2 Engaging Indigenous Participants in Research

One of the themes that surfaced across the articles was the challenge of engaging Indigenous participants in studies involving IFHI. Challenges emerged for several reasons. One was the longstanding agonistic relationship between Indigenous communities and colonial research processes, which have historically been extractive and damaging to Indigenous people [76]. This history made Indigenous people hesitant to participate in research.

Depending on the type of study, a number of methods were used to recruit and engage Indigenous participants. Indeed, both the study type and health focus seemed to influence the methodology used for recruitment. For instance, design studies tended to rely on snowball sampling and community advisory boards whereas implementation studies relied on community health workers, awareness-raising events, and pre-existing relationships between healthcare providers and patients to recruit people as study participants. One approach was to recruit participants during events focused on raising awareness about particular health issues [4, 83]. These tended to be used for IFHI focused on health issues that were generally free from social and cultural stigmas, such as childhood nutrition, exercise, and cardiovascular health. Another strategy was to leverage existing provider-patient relationships for recruitment. This could include recruiting participants for studies as part of regular appointments [30, 67], using hospital staff to recruit inpatients [67], or having healthcare providers refer patients to IFHI resources [2, 69]. It might also include mass recruitment messages (physical mail as well as electronic mail and SMS) to everyone who had received services at a particular healthcare center [39, 46, 66, 83, 96].

Related to the approaches that leveraged pre-existing relationships between potential participants and health organizations were those that leveraged relationships between potential participants and community organizations at large. These strategies included recruitment fliers at schools and places employment, and tabling at events that were tangentially related to the health focus of the IFHI [70, 82, 83, 91].

A different approach that was used included naturalistic approaches. In a study of how a transition to telehealth during COVID-19 impacted patient attendance and revenue, Couch et al. (2021) relied on a natural experiment

based on policy changes and did not recruit Indigenous participants specifically [12]. In their co-design study of IHCI for mental health for youth, Cheng et al. used a naturalistic approach and inclusively recruited patients from mental healthcare service centers that had a substantial Aboriginal or Torres Strait Islander patient demographic [11]. While the study team was able to engage 105 participants in co-design activities, only nine were confirmed to have been Aboriginal or Torres Strait Islanders.

One project based in Australia used an ethnographic, *in situ* approach to recruiting participants to participate in interviews and focus groups about the health impacts of alcohol awareness messaging broadcast over radio and television [84]. This method involved having informal discussions with Indigenous youth on the streets of service areas about the impact of the intervention ( $n = 5$ ) and following up on those discussions with structured interviews that were carried out by trained Indigenous youth ( $n = 117$ )—though the author did not elaborate as to how the structured interview participants were recruited.

In several studies, mass media was used to recruit participants in studies. This included social media announcements to known message boards [66, 70, 96] as well as radio and newspaper advertisements [82]. Social media was also used with relationality for snowball sampling to recruit focus group participants [89].

Related to recruitment was the compensation of study participants. The most common approach to compensation involved providing gift cards to online stores or local merchants to study participants for completing surveys and participating in co-design sessions and focus groups [11, 83, 89, 96]. Compensation amounts ranged from \$15–\$175 per activity. Tomayko et al. (2021) also mentioned incentivizing participation with specific components of the intervention with physical items related to the health focus, such as cooking utensils, calendars that tracked goals and progress, and sports equipment [83].

#### 4.3 Generalizability and Transferability

We rely on de Leeuw et al.’s definitions of generalizability and transferability to conceptualize how applied health research envisions transitions to practice [18]. *Generalizability* of research refers to the ability to apply the findings of a study to a broader context. In health research, this means being able to expect similar results of IFHI when it is used with general populations. Conversely, *transferability* of research is the ability to apply findings and artifacts to an alternative population or community. Many of the papers report limitations with either generalizability or transferability. Here we surface the themes that emerged surrounding these specific challenges and we discuss the implications in Section 5.1.

One of the common “limitations” that 12 studies noted was limited sample size [2, 8, 14, 28, 29, 34, 59, 65, 67, 72, 82, 96]. Sample size was generally discussed in the context of recruitment challenges (see Section 4.2), but it was frequently regarded as something that prevented the generalizability of findings. This limitation impacted a range of study types. Perhaps most critically, small sample size was fairly common for the implementation and evaluation articles reviewed in this study, on average,  $n = 95.76$  ( $\sigma = 125.60$ ). Some implementation studies had  $n$  values as low as 17 [35]. It is important to note, though, that small sample sizes should be expected given that Indigenous people comprise 6% of the total global population and individual Indigenous culture groups vary substantially in terms of population size [92].

Perhaps a more salient theme given the context of Indigeneity is transferability. Overall, 31 articles commented explicitly on the transferability of their findings from one community to another. Commentary focused on the challenges of transferability from one cultural context to another, given the cultural specificity needed to ensure that IFHI content was culturally responsive and appropriate. Indeed, many of the studies that centered on designing IFHI for Indigenous people noted the amount of effort and care that went into the design and creation of culturally responsive media and information—particularly given the lack of “stock” media that adequately represented Indigenous people [11, 15, 23, 40, 42, 50, 56, 57, 60, 72, 89, 98]. The content generation process could be incredibly resource intensive, with some projects hiring Indigenous artists [89], creating culturally

tailored animations and visualizations [50, 71, 72], generating audiorecordings in Indigenous languages [40], and translating evidence-based content into more culturally-appropriate language [44]. One article that took a different approach was a study by Oluwagbemi et al. (2020), which attempted to use automated translation via Google Translate and Microsoft Translate to generate multilingual text and audio for an HIV diagnostic system implemented in South Africa [56]. Even with the aid of native speakers to correct translations from English into three Indigenous languages, the audio recordings produced by the translation software had multiple pronunciation errors.

One of the most expansive examples of transferability came from a formative study by Maar et al. (2016), which examined the use of community-based participatory research for crafting culturally responsive language for SMS messages that promoted healthy behaviors that prevented hypertension [44]. This study evaluated the methodology in three culturally and geographically diverse First Nations communities in Canada as well as an Indigenous community in rural Tanzania. The study performed a grounded theory analysis of focus group recordings to understand cross-cutting themes that would support translating evidence-based health messages into culturally appropriate wording. While the sample size was moderately small ( $n = 45$ ), the representation from diverse Indigenous communities provided a unique opportunity to understand best practices in information presentation. Key findings emphasized the persuasive power of positive message framing, feeling incapacitated by fear- and stress-inducing messages, feelings of resistance in response to authoritarian tones in messages, and feeling empowered by messages that connect directly to cultural practices and knowledge.

We discuss the implications of these findings around transferability and content creation in depth in Section 5.1.

#### 4.4 Data Sovereignty

As noted in Section 2.3, sovereignty is a critical mechanism for decolonization. As digital information systems become increasingly integrated into the processes of governance, data sovereignty becomes an important way that ICTs can be part of decolonizing processes. When examining the articles in our corpus, we found that only four discussed issues of data sovereignty.

The papers that engaged most specifically with digital sovereignty were both focused on interventions to support the mental health of Indigenous youth [42, 89]. They both used participatory design methodology (see Section 4.1). In their work with Mi'kmaq youth in Canada, Loebach et al. (2019) examined how collaborative videography impacted mental health [42]. As part of the project, the research team worked with youth to develop a legal framework that granted youth sole ownership over videos developed through the project—even at the risk of having youth decline to provide the research team with access to the content. Through the participatory design of a mobile health app for Indigenous youth in the Southwestern United States, Vigil-Hayes et al. (2021) discussed how data storage and telecommunications architectures supporting IFHI must be designed with tribal communities to respect sovereignty [88, 89]. Importantly, their work proposed a network architecture that could support tribal sovereignty of both data and network infrastructure by ensuring that data services could be delivered via cloud or community-owned network infrastructure.

In general, though, even when papers mention data sovereignty and governance, the details surrounding the specifics of data sovereignty (e.g., *what data and information falls under sovereign ownership and control? what policies and mechanisms are used to support data sovereignty?*) are omitted. In their implementation of a Zoom-based telehealth intervention for hepatitis C virus screening and treatment in Canada, Dunn et al. mention using the First Nations principles of data ownership, control, access, and possession as part of their study design, but they do not specify how this was implemented [21]. In Australia, Cheng et al. (2021) conducted a series of 10 co-design sessions to evaluate existing mental health-focused websites and apps [11]. While the co-design process did not probe data sovereignty issues (they focused on the application components of IFHI rather than infrastructural aspects), they did note that data governance and security were critical issues that needed to be

considered in the actual implementation of IFHI with Indigenous communities. Finally, in a study on the impact of telehealth on patient attendance and revenue within an Australian Aboriginal community-controlled health organization during COVID-19, Couch et al. (2021) noted that data sovereignty had been adequately considered by having the study developed and led by an Indigenous-controlled health organization [12].

How IHFI plan for data sovereignty and implement policies and frameworks to support data sovereignty is a key component for engaging ethically with Indigenous people. We discuss the lack of engagement with data sovereignty in Section 5.3.

#### 4.5 Digital Equity

The National Digital Inclusion Alliance defines *digital equity* as “a condition in which all individuals and communities have the information technology capacity needed for full participation in our society, democracy, and economy [53].” 13 of the articles we reviewed noted that even as IFHI promised to address health inequities, it was often stymied by digital inequities. Key themes around digital inequity involved lack of telecommunications (especially Internet) connectivity, access to digital devices, and digital literacy.

While the articles that we reviewed involved Indigenous communities from around the world, a cross-cutting theme was that the geographic remoteness of Indigenous communities and homelands made it challenging to design and utilize IFHI that relied on ubiquitous, high-speed Internet connectivity [4–7, 11, 17, 21, 36, 51, 62, 78, 89]. In some articles focused on implementation, IFHI failed to achieve its anticipated impact due to lack of connectivity [45, 63, 78]. In articles focused on exploring the feasibility of IFHI, the lack of connectivity arose as an important consideration that must be factored into an overall IFHI program [11, 78]. Indeed, some efforts designed IFHI to be aware of Internet connectivity issues by implementing software to adapt its operation based on connectivity. These design efforts were largely centered on the creation of mobile health applications, where it was assumed that users might mobilize between spaces of high and low (or no) connectivity. For instance, Vigil-Hayes et al. (2021) discussed the creation of online and offline modes of operation for the ARORA mental health app [88, 89] and one of the apps reviewed by Kipp et al. used a hybrid approach that would synthesize information from paper-based forms, a mobile app, and a web portal to support multiple modes of data collection that take place in various states of connectivity [36, 75].

Some studies described the process of deploying new telecommunications infrastructure for the sole purpose of supporting IFHI. St. Clair et al. (2018) described the infrastructure necessary to support telehealth programs for Indigenous people in remote homeland communities in Australia [78]. The authors note the important shift that programs must take in considering necessary telecommunications infrastructure, which reframes questions about the *necessity of high-speed Internet connectivity to support telehealth programs* to questions about *how telehealth programs will afford high-speed Internet*. The critical takeaway from this work is that governments and healthcare initiatives must invest in high-speed telecommunications infrastructure to support the many benefits that telehealth (and IHFI more broadly) provides Indigenous communities.

While not every study explicitly notes a lack of telecommunication infrastructure as a critical challenge, it is noteworthy that across the reviewed articles, there was a heavy reliance on technologies that support asynchronous information exchanges, which are inherently well-suited for users who mobilize between spaces of varying telecommunications connectivity. SMS-based interventions, email interventions, and social media posting and messaging were all found to be successful modes of connecting with study participants and conveying health promotion information [4, 6, 7, 9, 14, 29, 35, 37, 39, 43, 44, 46, 57, 62, 64, 66, 73, 79, 82, 83, 85, 95, 96, 98].

A lack of access to devices such as computers, tablets, and phones was cited as an explicit limitation for IHFI in six articles [4, 5, 17, 21, 51, 54]. Nelson and Zamora-Kapoor (2015) described some of the challenges with conducting mHealth research with urban American Indian and Alaska Native mothers between 2013–2014 and found that while projections for the general population seemed to indicate a high uptake of smartphone

technology, this was not the case for the community they worked with [54]. Indeed, lack of access can be particularly problematic. Nelson and Zamora-Kapoor discussed the complex logistics of gifting smartphones to study participants and noted two considerations that may limit this model of increasing access to IHFI. First, is the issue of sustainability. If a study participant took over ownership of the device, they would be burdened with service subscription fees after the end of the study. Second, is the issue of liability. The research team describes the Institutional Review Board discussion of liability should a smartphone be used for illegal activity. These are critical logistical concerns, and we discuss them in the context of ethical research and sustainability in Section 5.3.

Finally, another theme related to digital equity was that of digital literacy. Pillai et al. (2018) conducted a study examining the connection between health awareness and digital literacy with people from the Irula and Muthuvan tribal communities in India [58]. Importantly, the study demonstrated that by including basic digital literacy training as part of a substance abuse awareness training, there was a better understanding of physical and social health impacts of substance abuse. Several other articles incorporated digital literacy training into IFHI interventions to support both health professionals prescribing or implementing IFHI as part of treatment plans [14, 19, 64].

## 5 Discussion

In this section, we discuss the results of our review in the context of our two research questions: (1) *What are critical challenges and opportunities surrounding the design and implementation of ICT-facilitated healthcare interventions for Indigenous people and communities?* (Section 5.4); and (2) *To what extent do existing ICT-facilitated healthcare interventions support decolonization and sovereignty of Indigenous people?* (Sections 5.1– 5.3)

In Section 5.5, we identify methodological limitations surrounding the reproducibility of our study.

### 5.1 Transferability

With respect to the first research question, one of the major challenges for IFHIs is that of transferability from one Indigenous community to another. This challenge arises not so much because there are no common values across different Indigenous contexts, but because of the important cultural specificity surrounding language, art, and traditions of Indigenous communities. As noted in Section 4.1, there are a number of ways that Indigenous Knowledge and cultural values are integrated into IFHIs. Indeed, cultural acceptability of IFHIs is more dependent on content than on the technology interfaces. That is, none of the articles reported that technology interfaces were fundamentally problematic from a cultural perspective. However, many articles described how the digital content used in IFHIs—images, audio, videos, text, art—should be closely tailored to the culture of Indigenous people using the app. Importantly, culturally responsive digital content might look like audiorecorded voiceovers in Indigenous language, Indigenous models in photos and videos, Indigenous characters wearing clothing reflective of contemporary Indigenous culture, use of Indigenous words to convey important ideas and meaning, and even visualizations that used colors and patterns related to Indigenous culture and art.

Thus, a major challenge for the transferability of IFHIs from one Indigenous community to another is largely based on the relevance of the digital content that is presented through the technology interface. Current practice requires new digital content to be recreated for each Indigenous cultural group. This can be costly in terms of time and resources and organizations that wish to adapt IFHIs from one Indigenous group to another must plan a substantial content production effort with significant cultural consultation as part of their implementation plan.

### 5.2 Digital Equity

In Section 4.5, we identified several key issues surrounding digital equity that presented substantial challenges for IFHIs, including access to telecommunications infrastructure, access to devices, and digital literacy. While several of the articles illuminate how systemic solutions to these challenges necessitate engagement with policymakers,

there are several solutions that should be pursued independent of policy. The first set of solutions are a matter of ICT design. One way to design practically for Indigenous communities is to ensure that IFHIs that require telecommunications are able to engage with infrastructure in a resilient manner and are able to accommodate states of disconnectivity as a matter of fact. IFHIs can also address digital equity issues through thoughtful interface design using theories such as Universal Design to minimize barriers to use [74, 80]

The second way IFHIs can address digital equity issues—particularly surrounding digital literacy—is through plans for *capacity-building*. Indeed, capacity-building is a critical mechanism for supporting Indigenous sovereignty and can also be an important way for researchers and practitioners to engage in reciprocal exchanges of knowledge. Digital literacy capacity-building in IFHIs can range from in-application guided walkthroughs to companion training programs that use videos [97] or program trainers that can provide technical training and support in the initial phase (or throughout the duration) of an IFHI. A particularly decolonizing approach to digital capacity-building would be IFHIs that teach community participants how to build or manage ICT components of IFHIs as part of the community engagement process. Not only would this build digital literacy, but it could promote sustainability and Indigenous ownership of IFHI programs that are intended for long-term use in a community.

### 5.3 Data Sovereignty

One of the most critical takeaways from our analysis was the lack of explicit engagement that IFHIs had with data sovereignty. As noted in Section 4.4, very few papers provided an acknowledgement about the issue of data sovereignty, let alone an explicit plan for how data sovereignty was afforded by the IFHI. Given the importance of data sovereignty to decolonization (Section 2.3) and the fundamental intersection between data management and ICT systems, a major contribution to information and computing ethics would be a framework for operationalizing the affordances that particular technologies and systems make for supporting (or challenging) digital sovereignty.

Fortunately, there are existing frameworks that can help researchers, practitioners, and Indigenous partners consider data sovereignty as part of a larger conversation around data ethics. For instance, the First Nations Principles of Ownership, Control, Access, and Possession (OCAP) is a helpful framework for conceptualizing critical dimensions of data sovereignty policy and has been used in a number of the articles reviewed (Section 4.4) [25].

### 5.4 Next Steps for Research

**5.4.1 Exploring emergent ICTs.** There are numerous gaps at intersections between various health foci and ICTs used as part of IFHIs. While we do not suggest that exhaustive exploration of these gaps is necessary (or even appropriate), there are several intersections that are worth investigation based on overarching health inequities and knowledge about Indigenous community and cultural attitudes towards ICTs. Specifically, the authors recommend using a cautious approach to investigating acceptability of some of these technologies *prior* to designing specific IFHIs.

One particularly intriguing area for potential future research would examine the role that wearable biosensors might have in supporting physical activity interventions. Recently, Cruz et al. examined the perceptions that people from low-socioeconomic backgrounds had of wearable technologies and set a research agenda to support co-creating wearables for marginalized communities [13]. While this study focused on perceptions of wearables that could be used to support safety, there are several “valuable” or “threatening” features that warrant critical investigation from various Indigenous perspectives. As noted by Cruz et al., the use of microphones, location-sharing, and cameras (while extremely valuable for some applications) can be problematic from the perspective of non-consensual surveillance. In some communities like the northern Pueblos of New Mexico, there are certain places and times where digital recording is prohibited as a means of protecting sacred cultural knowledge [47].

Thus, designing ethical approaches to wearables might involve location and context-awareness that prevents certain data collection and may require data interpolation and modeling to be used to fill gaps in recorded data.

Another area for critical future research would explore mixed reality approaches to delivering interventions. In our analysis, we only identified one study that speculated on augmented reality as part of an IFHI [88]. Currently, it is unclear which experiences are culturally appropriate to be rendered as virtual or augmented realities and who is allowed to experience and participate in those realities. Indeed, an intriguing path forward would support community authorship tools that would allow Indigenous communities to easily develop and manage these immersive experiences themselves. While there is not yet substantial literature investigating such self-authorship tools for AR/VR, there have been explorations into the ways that self-authoring tools for creating and sharing videos can be empowering to marginalized voices [10, 90]. Future research would investigate how more complex, and sensory rich experiences might similarly support the flourishing of Indigenous communities as well as the digital literacy needs that would need to be considered in the design of such self-authorship tools.

**5.4.2 Tools to support transferability.** As noted in Section 4.3, a substantial challenge for IFHIs created for Indigenous communities is the transferability of resulting solutions and systems. Indeed, this is a challenge for all systems and programs designed via community-based participatory approaches in general [18]. One area of research that could substantially impact this common challenge are tools that better support collaborative, cross-cultural content creation. Currently, large language models (LLMs) are emerging as technologies that can help augment content production pipelines [22]. However, there are substantial critical ethical considerations that need to be examined and explored before actually using LLMs to support cross-cultural creation of content. First, many Indigenous communities are likely not well-represented or accurately represented in the data used to train many LLMs [49]. Thus, it is not clear at all whether off-the-shelf LLMs would even be capable of supporting the creation of content that would be sensitive or relevant to Indigenous experiences—though preliminary studies indicate that they would not [77].

Moreover, in considering approaches to making LLMs more sensitive to Indigenous experience and culture, there is a clear ethical concern as to whose labor would be required to identify and correct biases, which content would be required for tuning, and ownership of resultant knowledge. Throughout history, there are substantial instances of Indigenous people and knowledge being misrepresented maliciously or through misinformation [33] so there is an understandable skepticism surrounding the use of these tools [52], particularly because there have been no standardized safeguards against “prompt injection attacks” that could lead to LLMs reinforcing misinformed concepts [41]. Finally, it is unclear how known challenges such as digital inequities surrounding tech literacy may impact the feasibility of leveraging digital tools to support cross-cultural content creation. It may be the case that meaningful cross-cultural content creation needs to continue relying on the bespoke toolchains and processes that are community-specific.

Beyond exploring these ethical considerations, there are fundamental ethical questions that need to be answered: *How would we design content creation systems that protect and center (rather than minimize) human labor and knowledge?* What ICT policies and safeguards would need to be codified for researchers and technologists using and creating tools for cross-cultural content creation?

**5.4.3 Frameworks to support data sovereignty.** Synergistic with Sections 5.4.1 and 5.4.2, there is a need for research that examines how ICTs used within IFHIs can explicate data sovereignty. One idea for investigation would be the development of a framework that maps ICT affordances to threats and opportunities for data sovereignty. For instance, if a data sovereignty policy states that an Indigenous governing body should have sole physical possession of data used as part of an IFHI, it would be important to have a framework that highlighted that a third-party, cloud-based server would not be appropriate as part of the service architecture.

In light of the discussion surrounding digital equity (Section 5.2), such a framework would need to be communicated transparently to people engaged with Indigenous governance. In the United States, there are 574 federally

recognized tribes, each with their own sovereign tribal governments and oversight processes. However, not all tribes have IT departments or formal IRB processes that could make decisions surrounding data management practices afforded by an IFHI and its comprising ICTs. Instead, the decision-making might fall to tribal leaders who do not have technical knowledge necessary to make critical decisions that would ultimately impact data sovereignty and project sustainability in the community. Thus, one long-term research agenda that could help ensure that IFHIs (and ICTs in general) are ethically deployed with Indigenous communities are investigations into best practices for digital dimensions of nation-building. In this way, IFHIs could be evaluated not only for health impact, but also for commitment to decolonization efforts by examining the extent to which communities have been provided with capacity to “take control.”

### 5.5 Limitations

We are confident that our article inclusion and exclusion criteria and coding results for study type, community methodologies, health focus, ICTs involved, location, participant count, and participant ages could be reproduced. However, we found that finding coding consensus surrounding Indigenous culture, language, and data sovereignty required substantial discussion and guidance from lead authors who had more experience conducting research with Indigenous communities. To reduce the variability of these codes (and to support reproducibility), we modified our codebook to apply simple binary codes to these categories. So, rather than coding for specific elements of Indigenous culture that were engaged as part of a study, we just indicated whether the study engaged with Indigenous culture or not.

## 6 Conclusion

This paper performed a critical, systematic literature review of articles that discussed ICT-facilitated health interventions (IFHIs) for Indigenous people. Our inclusion criteria resulted in 84 articles that were queried across three different archives. Specifically, we sought to examine major challenges and opportunities that presented themselves across the body of work and we probed the extent to which IFHIs supported decolonization and Indigenous Knowledge. From an ICT perspective, a major cross-cutting challenge we identified was that of transferability of digital content presented through ICTs as part of IFHIs. Importantly, we conceptualized this challenge as an open research question for AI-generated content and we outlined the opportunities, challenges, and ethical considerations surrounding this research direction. We also found that while there was substantial engagement with methodologies to incorporate Indigenous Knowledge and language into IFHIs, there was a significant lack of discussion surrounding data sovereignty. Furthermore, even when data sovereignty was discussed, there were even fewer articles that discussed the specific mechanisms that would support data sovereignty. While the concept of data sovereignty is fairly emergent, it is a critical ethical consideration for ICT systems at-large and particularly for ICT systems that engage with Indigenous health data. Thus, we advocate that future research and development should work towards operationalizing specific ICT mechanisms that support and challenge data sovereignty in addition to frameworks that elucidate the articulation between policies surrounding data sovereignty and technical mechanisms that implement these policies.

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## A Codebook

Our codebook is summarized in Table 2, which reports code categories and specific codes. We indicate whether we applied multiple codes from a category to a particular paper using the “Multiple” column. For instance, some articles incorporated multiple ICTs as part of a health intervention, so there were multiple codes associated with “ICTs involved.”

A summary of the code categories is as follows: *Study type* refers to the type of study that was described in the article. We defined *Exploratory* studies as those that were carried out prior to the design or implementation of any particular intervention; these were typically feasibility studies that assessed attitudes and perceptions surrounding the ICTs and health topics. *Formative* studies centered on the development of intervention protocols and *Intervention Design* studies focused on the process of designing IFHIs, often using methodologies such as community-based participatory research and participatory design. *Implementation* studies involved short-term pilots or long-term deployments of ICT-based interventions. *Reviews* studies provided systematic reviews of literature.

Articles that did not fit into any group were coded as *Other*. There were only six articles that were coded as “Other.” Two of these articles reported on training procedures used to support clinicians and healthcare providers in the integration of IFHIs into larger health programs [19, 64]. One presented a theoretical approach for engaging in value-sensitive design with Alaska Natives [20]. Two examined the use of a digital storytelling platforms with community health aides and elders [14, 26]. Finally, one article was an experience report that detailed the technical challenges associated with deploying a backhaul network to support telemedicine in rural Australia [78].

*Community Methodologies* refers to the use of community-based methodologies, including (but not limited to) community-based participatory research, participatory design, co-design, participatory action research, and tribal-based participatory research. This is coded as “yes” if a community-based participatory method is used and “no” if not.

*Health focus* refers to the health issues or topics addressed by the intervention. *ICTs involved* refers to the specific digital information and communication technologies that are used as part of the health intervention(s) described in the article. *Location* describes the country where the study took place. *Participant count* refers to the

Table 2. Summary of codebook used in the analysis of articles. *Multiple* refers to whether or not multiple codes were applied in a category.

| Category                | Codes                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Multiple? |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Study type              | <i>Exploratory; Formative; Intervention Design; Implementation; Experience Reports; Literature Reviews; Other</i>                                                                                                                                                                                                                                                                                                                                                            | No        |
| Community Methodologies | <i>Yes; No</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Yes       |
| Health focus            | <i>Mental Wellness; Hypertension; Sexual Health; Substance Abuse; Maternal and Infant Health; Health Education; COVID-19 Related Issues; Physical Activity; Chronic and Terminal Disease; Health Information Management</i>                                                                                                                                                                                                                                                  | Yes       |
| ICTs involved           | <i>Mobile Phones; Desktop Computers; Desktops; Tablets; Video Conferencing; Mobile Apps; Social Media; Websites; Web Apps; SMS; Voice Calls; Email; Radio; Broadcast Television; Fax; Robot; Video Recording and Sharing; Video Editing and Sharing; Search Engines; Mapping Software; Translation Software; Database; Augmented Reality; Cellular Network; Bluetooth Network; Portable/Wearable Bio-Sensors; Universal Serial Bus (USB) Drive; Digital Video Disc (DVD)</i> | Yes       |
| Location                | <i>Australia; Bangladesh; Canada; India; New Zealand; Nigeria; South Africa; Tanzania; USA</i>                                                                                                                                                                                                                                                                                                                                                                               | Yes       |
| Participant count       | <i>Min: 5; Max: 3,932; N/A</i>                                                                                                                                                                                                                                                                                                                                                                                                                                               | No        |
| Participant age(s)      | <i>0-9 (Children); 10-24 (Adolescents); 25-34 (Young Adults); 35-54 (Middle Age); 55-74 (Older Adults); 75+ (Geriatric)</i>                                                                                                                                                                                                                                                                                                                                                  | Yes       |
| Indigenous culture      | <i>Yes; No</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                               | No        |
| Indigenous language     | <i>Yes; No</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                               | No        |
| Data sovereignty        | <i>Yes; No</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                               | No        |

number of participants (if applicable) that participated in the study and *participant age(s)* refers to the age range or age ranges of participants involved in the study.

The last three codes focus on topics central to decolonization. *Indigenous culture* refers to whether or not the intervention integrated Indigenous culture or foregrounded culturally-responsive approaches. *Indigenous language* refers to whether or not the intervention integrated Indigenous language as part of the intervention. *Data sovereignty* refers to whether or not the study discusses data or information sovereignty in the context of data ownership, control, access, possession, and governance as delineated by the First Nations Information Governance Centre's Principles of OCAP [25].

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