Rural HCI Research: Definitions, Distinctions, Methods, and Opportunities

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HCI researchers are increasingly conducting research in rural communities. This paper interrogates how rurality has been treated in previous HCI research conducted in developed and high-income countries. We draw from research outside of HCI to suggest how we can effectively engage with rurality in research. We present results of a scoping review of HCI literature that asks: 1) How do HCI researchers define rurality?; 2) How do the unique characteristics of rural communities enter into study findings?; 3) What methods are used in rural research?; and 4) Where has rural research been conducted? More than twice as many rural HCI articles have been conducted in low-income and/or developing countries than in high-income and/or developed countries. HCI researchers rarely define rurality, and when they do, they primarily define it using descriptive rather than sociocultural or symbolic definitions. Rural research findings have primarily addressed infrastructure and distance/geographic isolation as unique rural characteristics, while qualitative, observational, and cross-sectional methods dominate this research. There are further opportunities for HCI research to more productively advance understanding of what rurality is, and how it matters for sociotechnical systems.

CCS Concepts: **Human-centered computing** ~ *HCI theory, concepts and models*

KEYWORDS

Rural HCI; rural studies; rural computing; geography; scoping review

ACM Reference format:

Jean Hardy, Susan Wyche, and Tiffany Veinot. 2019. Rural HCI Research: Definitions, distinctions, methods, and opportunities. *Proc. ACM Hum.-Comput. Interact.* 3, CSCW, Article 196 (November 2019), 33 pages. <https://doi.org/10.1145/3359298>

1 INTRODUCTION

Rural areas are at the forefront of many global issues, from increasing mechanization of agriculture to migration, which strain resources and municipal infrastructures while leaving rural places with problems of youth outmigration. Rural areas are often characterized by what they lack: large and dense populations, robust infrastructures (e.g., internet access), economic resources, and proximity to specialist knowledge. In contrast, this paper synthesizes previous research in order to challenge that dominant narrative, characterizing rural areas as rich and productive spaces with much to offer human-computer interaction (HCI) research.

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2573-0142/2019/November-ART196 \$15.00

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<https://doi.org/10.1145/3359298>

HCI researchers have begun to examine technology use and design in rural areas. This research reveals considerable variability in terms of how rurality is defined, of which types of communities are studied, and of which approaches are used to study them. Accordingly, there is need to synthesize rural HCI research to date, and to unearth commonalities and differences in prior work. At the same time, HCI research has had limited dialogue with fields that have long considered rural difference, such as rural sociology and geography. Thus, the primary goal of this paper is to draw upon this research to analyze the treatment of rurality in HCI research. In so doing, we call attention to opportunities for rural HCI research to engage more fully with its context. In turn, we believe that such an analysis will demonstrate how HCI can broaden understandings of the rural. To achieve this goal, we conducted a scoping review of HCI research through 2018 to identify and summarize the place of rurality in existing research.

Several recent and notable publications have assessed HCI research in developing/low and middle-income countries, including with attention to rural areas [35,39,53,158]. However, little attention has been accorded to evaluating rural HCI research in developed and high-income countries. A recent workshop at CSCW [62] called attention to this gap for the CSCW community. While there are many potential commonalities between developed and developing rural areas, rural HCI research conducted in developing regions largely focuses on areas with limited or no infrastructure (or charts the introduction of infrastructure), and on communities that have not been normatively associated with digital technology use (e.g., oral cultures, people with limited formal education). A closer look at rural HCI research in developed and high-income countries gives us an opportunity to identify relevant aspects of rurality in better-resourced areas with higher technology access. This is important since rural areas in developed and high-income areas remain understudied, and—as we will outline—face unique issues within developed countries. These issues place such areas at an infrastructural advantage compared to those in developing countries, but at a disadvantage when compared with wealthier urban areas in developed countries. Further, given the globalization of labor, and the inherent economic differences between high- and low-income countries [178], the changing economic landscape for rural communities similarly has important implications for technology design and use. Given the substantial technology-relevant differences between developed and developing rural areas, particularly with respect to economics and infrastructure, we see a real need to solidify an understanding of rural HCI research in developed countries in order to make future work and comparisons more possible. As HCI research continues to diversify and expand its scope into understanding computing for diverse identities and geographies, we anticipate an increasing focus on the rural within HCI research. This paper provides conceptual and methodological resources for such research.

This paper's contributions are conceptual, empirical, agenda-setting, and methodological. Conceptually, drawing from non-HCI research on rural communities in developed and/or high-income countries, we contribute two typologies with which to analyze rural HCI research: one focused on types of definitions of "rurality", and one that identifies the unique characteristics of rural areas; we also map connections between these typologies. Empirically, we then contribute a systematic scoping review of HCI studies using these typologies as an analytical framework, as well as additional details about study locations and methods. Our review unearths commonalities between disparate rural areas in developed and/or high-income areas, enabling broader synthesis across multiple studies. Simultaneously, this analysis opens dialogue with adjacent fields from which the typologies were developed. In order to set an agenda for future rural HCI research in developed and/or high-income countries, we highlight areas of opportunity for further rural HCI research. Building on this, we provide methodological guidance for those planning rural HCI

studies. Together, these contributions aim to both catalyze and enrich rural HCI research by encouraging further conceptual clarity, increasing interdisciplinary dialogue, and consolidating past learning.

2 RELATED WORK

We first situate our research within literature on rural communities from the fields of sociology, geography, and rural studies. In doing so, one of our contributions is bridging these fields of study, and bringing their insights to HCI research. Using this literature, we divide our related work section into two questions: 1) what is rural? and 2) what is unique about rural areas? We use these questions to construct two typologies (see Table 1) for understanding rurality, that we then use to analyze studies contained in the scoping review presented in this paper. Due to the preponderance of available literature, research reviewed in this section is largely based in Western perspectives, especially the United States (US) and United Kingdom (UK).

Definitions presented here explicitly focus on demarcating a boundary or threshold between “rural” and “urban.” These definitions thus characterize rural as *separate* from the urban. As others have noted [98], sharp distinctions erase opportunities for understanding the relationships that exist — and are expanding — between rural and urban people and places. As Lichter and Brown [98] note, “economic restructuring, globalization, technological innovation, and the changing relationships between levels of government” have brought urban and rural areas closer than ever before. It is important for researchers and designers to recognize the various interdependencies that influence global flows of people, money, and ideas across the shifting and often artificial geographic boundaries which humans place upon the landscape. But it is also necessary to understand why these boundaries exist in the first place, and their real political, economic, and cultural implications, as well as the differences they represent. At the same time, we highlight the growing emphasis on relational definitions of rurality in the field, highlighting several examples below.

2.1 What is rural?

Scholars have investigated differences between rural and urban regions for over a century [11,50,57], resulting in waves of research that continue to ask, “*what is rural?*” “Rural” is a relational category, used to denote social and spatial difference; thus, it is always held in contrast to “urban” and “suburban”. To frame our overview of different approaches to rurality, we draw heavily from influential frameworks developed by Halfacree [57] and Bell [12], though they are by no means representative of every approach to defining rural. Our framework divides definitions of rural areas into **descriptive**, **sociocultural**, and **symbolic** approaches, which we detail below. We argue that an understanding of these types of definitions can allow researchers to more precisely define rurality, while helping HCI researchers make fruitful comparisons across disparate rural areas. Such comparisons can ultimately allow us to gain a more holistic understanding of relationships between technology and place.

2.1.1 Descriptive rurals²

Descriptive definitions of rural areas “concentrate upon that which is observable and measurable” [57], such as population size and density, distance, or economic indicators.

² We intentionally use the plural “rurals” rather than the singular “rural” as the multiple intersecting definitions of rural is key to understanding how rurality is understood at a societal level.

Population size and density

Population size and density are frequently-cited descriptive indicators of rurality. Governmental agencies in particular classify areas based on rurality to make service and funding allocation decisions. For example, the US federal government has three primary classifications of “rurality”, that are used by three different government agencies with different mandates. The US Census defines a municipality as “rural” if they are not urban, thus directly codifying rural-urban difference. In this scheme, urban areas are defined as incorporated municipalities with at least 2500 people [127].

The US Office of Management and Budget (OMB) defines rurality at the county instead of municipal level. The OMB keeps a rural-urban distinction based on population size, but adds distinctions concerning the presence of an “urbanized” area in the county — thus introducing a more relational dimension to the definition. Thus, “Metropolitan” regions contain at least one urbanized area of 50,000 people or more, and “Micropolitan” regions contain at least one urbanized area of 10,000 people or more. The “Neither” category does not meet the definition of Metropolitan or Micropolitan, though all non-Metropolitan counties are considered “rural” by the OMB. In a highly relational approach to rurality, the US Department of Agriculture (USDA) recognizes many different definitions of rurality, but has established its own “Rural-Urban Continuum Code” that differentiates counties on a scale from 1-9; this scale includes criteria based on population size and adjacency to metropolitan regions [163].

In Canada, by contrast, a federal government definition of rurality is based on a combination of population size and density: the population must be less than 1,000, and the population density must be less than 400 people per square kilometer [144]. While these are not the only ways to define rural through measuring population size and/or density thresholds [171], the classification of rural solely through the lens of population size and density has long been critiqued because it overlooks the unique socio-economic and cultural factors that differentiate rural from urban areas [11,12,57,143].

Proximity to urban areas and isolation

As suggested above, rurality has also been defined based on proximity to urban areas, and the related phenomenon of isolation [43]; this approach can be seen as inherently relational. The Federal Office of Rural Health and Policy, the Department of Health and Human Services, and the Washington, Wyoming, Alaska, Montana, Idaho Rural Health Research Center developed a Rural-Urban Commuting Area Codes (RUCAs) to specifically address rural healthcare access based on isolation. This more recent classification scheme measures the relationship between rural and urban areas based on the percentage of commuters who travel to a larger population center for work [132]. It has been further developed to measure travel time and distance, in addition to the ratio of people commuting, in order to measure remoteness. This approach to rurality is deployed most often in studies examining healthcare supply and access in rural areas [24]. Such definitions have been used for healthcare resource allocation decisions, and as a rationale for launching telemedicine programs [133].

Economic indicators

Other scholars have argued for and developed ways of classifying rural areas [25] that include additional economic indicators such as industries and prevalent occupations [12]. For example, rural economies have typically been oriented towards agriculture and resource extraction industries such as logging, mining, and fishing.

2.1.2 Sociocultural and symbolic rurals

Sociocultural definitions of rural areas “[highlight] the extent to which people’s sociocultural characteristics vary with the type of environment in which they live” [57], such as community values and perceptions of rural culture. Accordingly, for nearly 80 years [57], sociologists have argued that certain landmark features of rural areas (e.g., population density, remoteness) are correlated with human behaviors, attitudes, and values that distinguish them from urban areas [57,75]. Borrowing from Halfacree [57], we call the difference that arises in this evaluation a “sociocultural” way of defining rural areas. While there is no direct causal relationship between location and behavior, there are largely structural differences mentioned above (e.g., population, economics) that shape localized differences along an urban-rural continuum [57]. For example, a recent representative survey from the Washington Post [174] found significant rural-urban differences between perceptions of religion, “neighborliness,” and immigration. Additionally, while there is no universal set of rural values [116,119], the same poll showed that rural residents largely believe that their values³ are similar to others who live in rural areas and different from those of urban residents [174].⁴

Symbolic definitions focus upon how people use words, concepts, and feelings to connect themselves to the rural [12]. Symbolic approaches address how people relate to categories and discursively connect themselves to rural areas. Bell [12] makes the distinction between “first rural” (i.e., measurable and observable) and “second rural” (i.e., immaterial, discursive, and deconstructed). A symbolic (“second”) rural can be seen in how terms are used to describe rural areas, and become part of people’s associations with the rural [12,57]. Symbolic understandings of rurality may also find their origins in marketing of rural places for the purposes of tourism [76]. In his research in rural England, Halfacree [57] identified several symbolic associations with rurality as a category. For example, the term “traditional” is used to represent a difference between urban and rural areas (i.e., rural areas have different traditions, and manifest them in ways that urban areas do not). Traditionalism was associated with the built environment (e.g., the layout of villages and building materials used to construct houses) and the typical attractions associated with rural life (e.g., fall harvest festivals). However, as Halfacree notes, terms such as “traditional” and “idyllic” are used to describe vastly different rural areas [57]. This shows that such symbolic terms shape both how people subjectively relate to their location, and how that understanding may influence their perceptions of other rural areas. In other words, the various symbols and the meanings attributed to rural areas by inhabitants and outsiders allow for “the rural” to manifest as something that can be understood at a scale beyond the local. This contributes to perceived socio-cultural differences between urban and rural areas described above.

2.2 What are the unique characteristics of rural areas?

In the following, we outline the characteristics of rural life that researchers have identified as unique to such areas. We synthesize this work by developing a typology (i.e., classification) which we use to conceptually organize prior literature. While we establish these typologies as separate

³“Values” was not defined in the survey.

⁴74% of rural residents said that people who live in rural areas and small towns have values that are similar, while only 57% of urban residents said that people who live in big cities have values that are similar. Further, 68% of rural residents said that people who live in big cities have values that are different, while only 48% of urban residents said that people who live in rural areas and small towns have different values.

(given that one is seeking to understand how we define rurality at a higher level and the other is looking at more explicit and localized characteristics of rurality), we see clear relationships between the two. See Table 1 at the end of this section 2.2 for potential relationships.

2.2.1 Infrastructure

Rural areas have a range of unique infrastructural problems. While Internet infrastructure gaps are frequently noted in rural areas of developed and high-income countries [72,136,145,173], they face other infrastructural gaps such as lack of access to public transportation [86,147]. Without public transit, rural residents are typically reliant upon personal vehicles for transportation, yet fewer rural than urban households lack any vehicle (4.2% vs. 10.1%) [109]. In rural communities, shared mobility services such as Lyft and Uber may also be unavailable; in fact, a 2016 study found that only 3% of rural residents (vs. 21% of urban residents) had ever used such a services [133]. Furthermore, lack of population density may make these models unsustainable in rural areas, as may long distances.

2.2.2 Distance and geographic isolation

As described, distance from urban centers and their associated density of resources is a primary measure for defining rurality, as mentioned above. The effects of poverty are amplified, and geographic isolation increased, by the distance from services and the aforementioned gaps in transportation infrastructure [86,98,121]. While distance is often seen as a mediator of rural inequality, Young [180] argues that as a key mediator of economic relationships, distance can also be a site of opportunity. Distance from urban areas can be a useful tool for tourism and economic development if rural areas are seen as sites of temporary respite and leisure.

2.2.3 Culture and values

Localization of values and trust can be important aspects of rural society [57,75] — leading to potential distrust of outsiders such as immigrants [134]. Distrust may also extend to large institutions perceived to be from elsewhere (i.e., government, universities, and technology corporations). For example, rural place-based identities largely influence rural people's perceptions of politicians as elite outsiders, even when the politicians are ostensibly allies of rural regions [32]. As we previously mentioned, rural dwellers may also view themselves as being more “neighborly” than urban dwellers [174]. Additionally, while a universal set of rural values does not exist [116,119], it is notable that rural residents in the US do tend to be more religious (primarily Christian) than their urban counterparts [9,102]—particularly within the southeast and Midwestern regions [20]. Rural churches can also be important providers of services and support for their members [73].

2.2.4 Economies and business

Economic planning and a policy focus on urbanization throughout the 20th century have had longstanding effects on the development of rural areas [108]. Agriculture and natural resource extraction (e.g., mining, forestry, and fishing) have traditionally been key economic drivers of rural areas, and these industries are also inherently tied to social imaginaries of rurality. Manufacturing industries have also played a major role in rural economies [100,140]. However, the landscape for dominant industries is changing due to the rapid globalization of manufacturing in the late 20th century [178] and the related “post-productivist” stage, in which rural economies are increasingly focused on consumption-oriented activities such as tourism, retirement migration, and second homes for urban dwellers [58,106,107]. Rural areas have a higher proportion of small business owners than urban areas [181]. Further, rural entrepreneurs by and large are not

motivated to start businesses to incur massive profits, but rather to fill local resource needs and/or provide for their families [13].

2.2.5 Digital literacy and computer skills

Opportunities to learn computer skills and acquire digital literacies are tied to people's exposure, and access, to information technologies [139]. Rural areas continue to lag behind urban areas with respect to all measures of technology exposure, including home broadband and technology ownership (i.e., smartphone, tablet, personal computer) [123]. A key facilitator of technology adoption is influence from local social networks [16]. Introducing technology, especially into particular rural social spheres (e.g., local pubs), can also improve adoption of ICTs [139].

2.2.6 Social and health services

Generally, health services in rural areas are less diverse and comprehensive than those in urban areas. Widespread decreases in funding for social services have disproportionately affected rural areas, due to the presence of fewer organizations [46]. The loss of social services and other economic needs (e.g., local shopping destinations) are often seen as being easily addressed through technological advancement (e.g., online shopping) and basic lifestyle changes (e.g., driving farther distances for healthcare appointments) [86]. However, this can lead to the loss of local identity [86]. Additionally, life in rural areas carries different health risks, often tied to occupational and environmental hazards, and to lack of access to healthcare [110,122,167].

2.2.7 Population size and density

As previously mentioned, size and density are the most frequently-cited indicators of rurality. Like density, this characteristic is frequently bound up in other unique aspects of rurality. For example, smaller population sizes result in increased familiarity of locals and an "everyone knows everyone" feeling that facilitates trust [57,75]. This permeates other aspects of rural communities, such as the ways in which businesses operate [129,157].

2.2.8 Population demographics

Rural populations often have unique demographic characteristics. In the US, educational attainment may be lower in urban than rural areas [162]. Increasing racial diversity in rural areas is blurring the line between racial differentiation between urban and rural areas [93], although there are fewer immigrants in the rural US [162]. Additionally, rural populations are aging [86,162], a phenomenon accompanied by youth out-migration [18].

2.2.9 Social networks

Tight-knit communities are often seen as defining features of rural areas [59]. The density, or overlap, of social networks is higher in rural than in urban communities [44,177]. Furthermore, rural communities may be particularly high in bonding social capital [142]. Indeed, rural dwellers also tend to have more family members in their personal networks than urban residents, whose networks tend to include more friends [42,177]. Rural dwellers may also have more local social networks than urban dwellers [111,135], although with long-term rural youth out-migration [28,47], some family members may live in urban areas.

Network-mediated aid in rural areas may also come more frequently from family members, whereas in urban areas, this comes more from friends [74]. As rural economies and population demographics shift, so do the make-up of rural families [17,98]. In particular, increased poverty and racial inequalities among rural families [17] can lead to greater pressure for assistance within social networks in rural communities.

2.2.10 Relationships with nature

Rural people may have different relationships with nature due to their proximity to, and frequent economic reliance upon, natural resources. Given that agriculture and other forms of resource extraction are located primarily in rural areas, this also shapes the relationships that people develop with the outdoors. For example, in his ethnographic work in a rural English village, Halfacree [59] characterizes rural residents’ use of language to describe their environments as gifted with “natural beauty.”

Table 1. Relationship between our typologies

<i>Definitions (i.e., “what is rural?”)</i>		<i>Most relevant unique characteristics of rural areas</i>
Descriptive rural	Rural as defined through observable population-level characteristics. Sub-types listed below.	Depending on how they are measured, any of the unique characteristics of rural areas could be relevant in rural areas defined descriptively. See below for more details.
	Population size and density	Infrastructure Social and health services Population size and density Social networks
	Distance/geographic isolation	Distance and isolation Culture and values Social and health services Social networks
	Socioeconomic Indicators	Infrastructure Economics and Business Digital literacy and computer skills Population demographics Relationships with nature
Sociocultural rural	The differences in behavior, attitudes, and values that differentiate rural people from urban people.	Culture and values Digital literacy and computer skills Social networks Relationships with nature.
Symbolic rural	Rurality as a discursive category to which people form attachments.	Culture and Values Relationships with nature

3. UNDERSTANDING THE RURAL IN HCI RESEARCH

There are few examples of prior research in HCI, that assesses the field’s treatments of rurality; even so, specific attention to HCI in particular is important because it is the key scholarly field addressing the design of technologies that have an indelible impact on rural areas. Thus, we synthesize existing rural HCI research by bringing it into dialogue with research conducted in other fields (see Table 1 for our typologies summarizing this prior work). To achieve this goal, we conducted a scoping review of HCI literature published up to September 2018 that addressed the following research questions: 1) Where has rural research been conducted?; 2) How do HCI researchers define “rurality”, if at all?; 3) What methods are used in rural research?; and 4) How are the unique characteristics of rural communities reflected in study findings, if at all?

3.1 Methods

We conducted a ‘Scoping Review’; that is, a “(...) form of knowledge synthesis that addresses an exploratory research question aimed at mapping key concepts, types of evidence and gaps in research related to a defined field by systematically searching, selecting and synthesizing existing knowledge” [26]. Scoping reviews summarize the extent, range, and nature of research activity, and identify gaps in literature [96]. The scoping review is considered a type of empirical study unto itself [3,96]. The steps in conducting a scoping review include: 1) identifying the research question; 2) identifying relevant studies (i.e., systematic literature searching); 3) study selection; 4) charting the data using “descriptive analytical” methods to extract data from the studies; and 5) collating, summarizing, and reporting the results [26]. We outline our approach to steps 2-4 below.

3.1.1 Identifying relevant studies: literature searching

We searched the ACM Digital Library using the following search strategy developed by a librarian: (rural* OR rurality OR village OR countryside OR farming OR farmer). This search returned 1,978 records. To identify HCI research within the resulting set, we screened all papers listed as affiliated with conferences sponsored by ACM SIGCHI (n=285). Furthermore, to guarantee an international perspective, we screened results indexed under ACM’s International Conference Proceedings Series (AICPS) (n=457), ACM DEV (n=58), and DEV-4 (n=13). To ensure coverage of journal literature, we also searched Web of Science using the following search strategy: “(TS=(rural* OR rurality OR village OR countryside OR farming OR farmer) OR TI=(rural* OR rurality OR village OR countryside OR farming OR farmer))”. Results were limited to English-language publications, and book reviews were excluded. To limit the search to HCI journals, we obtained a published list of HCI journals [1], and added the 38 listed HCI journals indexed in Web of Science to the search. After removal of duplicates, this left 870 articles for screening. Our study did not include articles published in Springer’s Lecture Notes in Computer Science, or books and book chapters that may have been published on relevant topics. This limits the conclusions of our review, but conforms to prior systematic reviews at SIGCHI conferences [35,37,137]. This review is representative of published HCI research in developed and high-income countries on rurality.

3.1.2 Study selection: screening

Records were included if they were published in an HCI journal (as per the list above) or an ACM SIGCHI-affiliated conference, identified from published lists of ACM-sponsored and ACM-affiliated conferences; the final list included 86 SIGCHI- conferences. Additionally, to ensure completeness, we also included papers from the Participatory Design Conference and regional HCI conferences not on this list (e.g., IndiaHCI, New Zealand Conference on Human-Computer Interaction). Papers were also included if they reported empirical research conducted in a rural area in at least one of 81 countries designated as developed by the United Nations and/or high-income by the World Bank [161,179].

In total, 465 (53%) of screened papers were excluded because they were not published in HCI journals or the aforementioned conference proceedings. In total, 192 publications (22%, in the HCI field) were excluded because they reported research conducted in a developing and low/middle income country. Furthermore, 99 papers were excluded despite having been returned by the search results, because they did not actually report on research performed in a rural area. Reasons for this included the last name “Farmer,” institutions whose names included the word “rural” , and abstracts which argued for a rural use case without corresponding data collection. As is typical for

a scoping review of studies [3,96], some papers ($n=19$) were also excluded on the basis of not being empirical; this included workshop descriptions ($n=9$), short papers on work to be performed ($n=4$), talk summaries ($n=2$), and thought pieces ($n=4$). In total, 775 papers were excluded, leaving 95 publications in the final set. We present the final process of identifying and selecting studies according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) standard [115] in Figure 1.

Fig. 1. Process of identifying and selecting articles

3.1.3 Charting the data: classification of studies

We used a “descriptive analytical” approach to characterizing the included studies, which involves “applying a common analytical framework to all the primary research reports and collecting standard information on each study” [3]. Two research team members (initials removed for review) independently classified each included citation according to: (1) geographic origins based on the country in which the research was conducted; (2) stated definition of rural, if any, using the typology in Table 1; (3) how the unique characteristics of rural areas were reflected in study findings, using the typology outlined in Table 1; and (4) methods used in the research.

We classified methods as interventional or observational; interventional studies included those in which a researcher deployed and/or evaluated a technology, and in which interactions with that technology were assessed. Observational studies, by contrast, were those in which there was no manipulation by the researcher; this includes observational studies of interaction with technologies already in wide usage (e.g., social media sites). We also classified studies as cross-sectional or longitudinal; longitudinal studies included those with data collection at more than one time point, and/or that involved longitudinal field studies such as ethnographies and field deployments. Cross-sectional studies, by contrast, were those which collected data from their sources at a single point in time.

Any disagreements between the researchers were resolved through discussion and simultaneous review of the paper in question. The final set represents consensus of the two researchers on the relevant classifications for each paper. Finally, we performed chi-square tests to assess the co-occurrence of methodological categories. Other tests related to co-occurrence of categories could not be performed with confidence due to high proportions of small cell counts (e.g., analyses of rural definition by what is special about rural, and definition by methods, had more than 20% of cells with a count of less than five).

3.2 Results

3.2.1 Where has rural HCI research been conducted?

Table 2. Location of rural HCI research in developed and high-income countries

<i>Region</i>	<i>Region/Country name</i>	<i>Considered developed (D), high-income (HI), or both (D/HI)</i>	<i>Number of articles</i>	<i>Proportion of total articles</i>
<i>North America</i>			47	49.5%
	United States	D/HI	44	46.3%
	Canada	D/HI	3	3.2%
<i>Europe</i>			26	27.4%
	United Kingdom	D/HI	17	17.9%
	Spain	D/HI	4	4.2%
	Sweden	D/HI	2	2.1%
	Austria	D/HI	1	1.1%
	Finland	D/HI	1	1.1%
	Netherlands	D/HI	1	1.1%
<i>Australasia</i>			14	14.7%
	Australia	D/HI	10	10.5%
	Japan	D/HI	2	2.1%
	Hong Kong	HI	1	1.1%
	Taiwan	HI	1	1.1%
<i>Latin America</i>			8	8.4%
	Chile	HI	4	4.2%
	Panama	HI	2	2.1%
	Uruguay	HI	1	1.1%
	Argentina	HI	1	1.1%

We first note that, as shown in the methods section, the majority of HCI research performed in rural areas has taken place in developing/low-to-middle income countries (192 vs. 95 articles). Within developing/high-income countries, as Table 2 shows, of the 81 countries that are classified as being developed by the United Nations, high-income by the World Bank, or both, only 17 (21%) were represented in our results. Of these, the US was the most frequent locations of rural HCI research, followed by the UK and Australia. Of the 18 articles from the UK, all but five were performed by two research groups [21,23,23,31,38,55,151,152,154,155]. Of the eight studies that were performed in Latin America, all but one [29] were conducted in a school setting.

Table 3. Types of definitions of rurality deployed

<i>Definition of rural</i>	<i>Number</i>	<i>Proportion⁵</i>
Undefined	53	55.8%
Descriptive: Population size and density	31	32.6%
Descriptive: Distance	16	16.8%
Descriptive: Economic indicators	13	13.7%
Sociocultural	3	3.2%
Symbolic	0	0%

3.2.2 How do researchers define rurality, if at all?

Table 3 shows that the majority of articles (55.8%, 53/95) did not include a definition of rurality. Of those that did provide definitions, however vaguely, the most commonly-used referred to descriptions of community population size and density. Within the papers, defining rural by population size and density frequently took the form of reporting official state statistics, such as those from the US National Center for Health Statistics (see Table 4 for an example). With regard to distance, definitions typically referred to distance of research sites from urban centers. For example, Melvin and Bunt [112] documented this in the “participants” table in their methods section. Economic indicators primarily referred to area poverty (e.g., [48,114]), and/or study of farmers and farming (e.g., [30,88,95,128]). See Table 4 for an example.

Sociocultural definitions of rurality were in limited use, and often emerged through descriptions of what made specific research field sites unique rather than being offered as a formal definition. For example, one paper referred to “localized accents” (e.g., [77], see Table 4). Symbolic definitions were not deployed in any of the included articles.

Table 4. Examples of rural definitions from the scoping review

<i>Definition of rural</i>	<i>Example</i>
Descriptive: Population size and density	“...we utilize the U.S. National Center for Health Statistics’ Urban-Rural Classification Scheme for Counties, which assigns each county in the US an ordinal code from 1 (most urban) to 6 (most rural)” [85].
Descriptive: Distance	The authors have a table that documents the distance each of their participant’s work is from an urban center, ranging from 100km to 1100km [112].
Descriptive: Economic indicators	“Gadsden County in Quincy, Florida is the largest rural county served by [their community partner]. Most of the jobs available in this area are agriculture-based and low-paying” [101].
Sociocultural	“...Villa Cardal, a town of about 1,500 located about 80 kilometers from Uruguay’s capital city, Montevideo. Villa Cardal is situated in a rural area with many dairy farms. <i>In spite of the proximity to the capital city the local culture has a rural flavor, with many inhabitants, for example, having a distinctive rural accent when they speak</i> ” [77].
Symbolic	Not used

⁵ Articles could be identified as using more than one definition of rural.

3.2.3 How are the unique characteristics of rural communities reflected in study findings, if at all?

Table 5. Results of our unique characteristics typology

<i>Unique characteristic of rural area</i>	<i>Number of articles</i>	<i>Proportion of total articles⁶</i>
Infrastructure	26	27.4%
Distance and geographic isolation	19	20%
Values and culture	17	17.9%
Digital literacy and computer skills	14	14.7%
Economies and business	13	13.7%
Social and health services	11	11.6%
Population demographics	9	9.5%
Relationship with nature	9	9.5%
Social networks	9	9.5%
Population size and density	4	4.2%
Not state ⁷	16	16.8%

Infrastructure

In total, 26 papers (27.4%) discussed infrastructure, especially limited Internet access. Several studies documented difficulties with Internet access as a barrier to technology adoption among rural dwellers, including both lay people [55,92,117] and professionals [103,120].

Researchers have also examined how people navigate inconsistent Internet access. In one study, the ability to work when not connected to the Internet emerged as a key design requirement [55]. Melvin and Bunt also consider methods which rural workers use to deal with lack of consistent access to a quality Internet connection [112]. Based on research with families who use the Internet to communicate with dispersed network members, they also suggest that inconsistent access to the Internet may lead to prolonged distrust of ICTs even after infrastructure issues are improved [113]. Several studies also described deployments of technologies in which Internet connectivity problems hampered user experiences with technologies deployed as part of a study [8,27,77,125,128,150].

Researchers also described giving Internet access to participants as part of studies [150]. Community-based efforts to increase rural access to the Internet have been the focus of several studies, including studies of the socio-economic factors, such as social and human capital, financial models, and leadership, in Internet access provision projects [48,67,104,118,172]. Use of alternative technologies to provide connectivity, such as radio, was the focus of one article about rural indigenous communities in the US [169]. In a few cases, projects providing Internet access have been described, from technical and usage perspectives [79,168]. One study also focused on the augmentation of train system infrastructure with information technology [159].

Distance and geographic isolation

Distance and geographic isolation were mentioned in 19 papers’ findings (20%). Technologies intended to bridge between rural and urban parties were a significant type of HCI work addressing distance and isolation. For example, researchers have deployed telehealth technologies to facilitate rural patients’ and healthcare providers’ access to specialist expertise located in urban

⁶ Articles could be classified as discussing more than one aspect of rurality that was unique

⁷ 11.6% of the articles in our corpus neither defined rurality nor identified unique rural characteristics.

centers [2,14,97]. Two studies analyzed the social dynamics of technology-mediated efforts to facilitate communication between researchers/scientists and remote farmers [65,88]. Researchers have also examined the role of geographic isolation in the acceptance of technologies that bridge distance in education [10]. Some research has also focused on reducing geographic isolation between and within rural areas. For example, two projects detailed efforts to facilitate communication between geographically isolated teachers [125,126].

Outside of the context of IT deployments, several studies documented the dynamics and challenges of navigating geographic isolation, with or without technology. One study documented the challenges of travel to attend healthcare appointments [176]. In the context of a natural disaster, media outlets providing information about the event were primarily located at a distance, increasing the importance of social media as an information source for both local residents and accounts presented in the media [33].

Culture and values

Rural culture and values were accounted for in the findings of 16 papers (17.9%). More than half of these papers came from two research groups performing research in rural areas of the UK; this work frequently reflects on the values and culture of the British countryside (e.g., gentility) and how they influenced their technology design decisions. For example, Taylor and colleagues [38,151,153,155] note participants' interest in sharing local historical photos in their initial visits to their rural field site and leverage this interest in the design of display technologies in the community. They highlight the impact of these photos on a sense of local identity, —an important aspect of rural culture. More speculatively, Su and colleagues examines how hunting culture could inform technology design [148].

HCI researchers have also documented mismatches between the design of technologies and rural users' values. For example, Sengers showed that infrastructure projects in rural Newfoundland, Canada, failed to account for participants' communal values [89]. Researchers have also documented how rural users appropriate technology to overcome such value-based mismatches (e.g., [54]).

Economies and business

Rural economies and businesses were mentioned in 13 papers' findings of (13.7%). Of these, nine focused exclusively on agriculture, farming, and adjacent economic activities such as farmer's markets. For instance, researchers sought to develop an online portal and other tools for a rural farmer's market in rural Wales [21,30]. However, designers found that urban assumptions, such as the need to expand their clientele to urban outsiders, were unfounded. Instead, they found that participants desired to be better connected to local customers. Another line of work involved design and testing of technologies designed to assist farmers in their work [71,128].

Four studies focused more generally on rural economies, and their role in technology use. Correa and Pavez [29] showed that people involved in rural tourist industries adopted technologies more for their business than those in other industries. Specifically, those in the rural tourist industries needed to communicate with urban residents frequently, necessitating deep engagement with technology.

Digital literacy and computer skills

In this review, 14 papers (14.7%) discussed digital literacy and computer skills of rural residents. Of the 14 papers that were classified with this category, five were related to health, three to general

Internet and ICT adoption, and two to computer security. Specifically, digital literacy skills were investigated as potential barriers to the use of health-related technologies. For example, Taylor *et al.* [150] deployed a videoconferencing system in rural people's homes for the purpose of pulmonary rehabilitation. Despite a simplified interface, computer skill gaps stood in the way of effective usage in this group.

Efforts to build digital literacy and computer skills have also been the focus of five articles about marginalized groups in rural areas (i.e., children, women, and the elderly). These studies investigated how to teach computer skills to these groups. For example, Garner and Zhao [48] documented the creation of afterschool computer centers in high-poverty rural areas where other opportunities to learn about technology were unavailable.

Social and health services

Rural social and health services, and their unique characteristics, were reflected in 11 papers (11.6%). Of these, all but one focused on health services, and many studies sought to improve or understand the lack of access to local health resources, such as lack of local expertise in a particular domain. As we describe above in "Distance and geographic isolation," a majority of these papers focused on facilitating rural access to specialist expertise across distance through technologies such as telehealth. Accordingly, co-occurrence of the "distance and geographic isolation" categories was relatively common ($n=6$). Two studies, by contrast, focused on how local health services use technology to meet local needs. One considered difficulties with electronic health records and maintaining patient privacy in small healthcare practices [5]. A study of rural cancer navigators examined their needs in the context of limited resources and design opportunities for further support [81].

Population demographics

In nine papers (9.5%), the population demographics of rural areas figured prominently in study findings. Typically, these studies focused on the fact that rural populations often have older populations, and with lower educational attainment, than their urban counterparts. Commonly, the role of these demographics in technology adoption use, along with rurality, are explored [19,29,45]. For example, Kumar *et al.* [91] discussed anxiety and lack of exposure to technology as factors impeding adoption to assistive technology among rural older adults. Similarly, to inform the design of technology, Lustria and colleagues [101] discuss how poverty and lack of health insurance amplify challenges in rural access to cancer services.

Social networks

Nine papers (9.5%) presented findings in which rural social networks were a defining feature. Two studies examined differences between rural and urban users of online social networks in relation to network members' locality and the number of network members [49,52]. For example, Gilbert *et al.*'s research [49] found that rural MySpace users had fewer online friends than urban users, that their MySpace friends were closer geographically to them. They posited that a binary friend-or-not structure in contemporary social networks did not translate as well into rural areas, where tight-knit communities were more prevalent. Several studies also documented rural dwellers' use of social media to extend the geographic range of their social networks by staying in touch with people who have moved away, or in meeting new people locally [51,54,63,113].

Relationship with nature

Relationships with nature were highlighted in nine papers (9.5%). Two of these papers involved a technology deployment in a rural community, accompanied by the observation that people used those technologies to discuss aspects of their natural environments, such as local energy projects, weather, and livestock [23,30,60]. Further, several projects discussed how to accommodate the natural environment in design, including the dynamics of indoor/outdoor activities [95] and making a technology’s form factor fit with the natural environment [159]. Additional work examined design requirements emerging from rural residents’ interactions with nature. For example, Leshed *et al.* [95] discuss the potential role of the seasonal rhythms of agriculture for the design of technologies to facilitate temporal coordination. Two studies also examined the implications of food practices (e.g., hunting and foraging) for design [22,148]. One study also focused on developing scenic driving routes for visitors [105].

Population size and density

Four papers (4.2%) had findings that discussed implications of population size and density in rural areas. Notably, three studies considered urban-rural differences in user-generated content [83–85]. Findings revealed that technical systems that rely predominantly on crowdsourced data and volunteered geographic information (VGI) are less likely to be accurate in rural areas [84,85]. One study showed that the rural-focused articles on Wikipedia and maps on OpenStreetMap were of lower quality, less likely to be produced by locals, and more likely to be created by automated software [83]. Such issues are likely a function of population size, as well as of the aforementioned challenges with infrastructure and digital literacy.

Undefined

While papers were more likely to reflect unique characteristics of rural areas in their findings, 16 did not do so.

3.2.3 What methods are used in rural research?

Table 6. result of our methods classification

<i>Method</i> ⁸	
Interventional	Observational
40% (n=38)	64.2% (n=61)
<i>Data type</i>	
Qualitative	Quantitative
51.6% (n=49)	23.2% (n=22)
<i>Time</i>	
Cross-sectional	Longitudinal
72.6% (n=69)	27.4% (n=26)

⁸Articles could be classified as using both interventional and observational methods.

As shown in Table 6, the majority of rural HCI studies were observational rather than interventional. They also more often deployed qualitative methods, rather than quantitative or a mixed-methods approaches. They were more often cross-sectional in design than longitudinal.

In terms of overlapping categories, a chi square test revealed that method and time point were not independent ($\chi^2=35.278$; $p<.001$; $df=2$); interventional studies were more likely to be longitudinal and observational studies more likely to be cross-sectional than expected. However, there were no significant relationships between method and data type nor data type and time, indicating that these variables were independent.

4 DISCUSSION

Results show that most rural HCI research has been conducted in developing and/or low-income countries. Research in developed and/or high-income countries was dominated by work conducted in the US, UK, and Australia. The majority of rural HCI papers did not define rurality; however, when they did, descriptive definitions were most common. By contrast, only a few papers adopted sociocultural definitions, and none employed symbolic definitions. The dominant rural characteristic reflected in studies was infrastructural limitations, particularly related to the Internet. Findings of included studies also commonly reflected technologies that aimed to bridge distance between rural and urban dwellers. Rural values were discussed in the context of design primarily by one research group, and digital literacy skills (often linked to rural demographics) were noted as a barrier in several studies. Research on economies and services primarily focused on efforts to create technologies to support agriculture and healthcare. Researchers also demonstrated that population size and density were reflected in online social network usage and the production of user-generated content. A sizable minority of studies did not highlight any uniquely rural characteristics of the locations in which they were conducted. Methods used in rural HCI research are predominantly qualitative and cross-sectional approaches, although there was only a slightly greater emphasis on observational than interventional methods.

4.1 An agenda for future rural HCI research

Based on the results of this scoping review, we detail opportunities for future rural HCI research in developed and/or high-income countries. Our focus here is on identifying opportunities based on review results, and inferring potential directions for future research based on rural research outside of HCI as reflected in our typologies. We also expand upon potential contributions of HCI research to broader understandings of rural areas. In particular, we stress the potential role of HCI research for deepening understanding of a central concern in rural studies: rural community change [90]. As the following section shows, HCI research also presents opportunities for interventional research that helps rural communities to mold their futures.

4.1.1 Geographic focus

Thus far, rural HCI research has been dominated by work in developing and/or low-income countries, affirming the value of a review focused specifically on developed and/or high-income countries. However, HCI research in developed and/or high-income countries has focused primarily on the US, UK, and Australia. We regard this as a weakness of current research since rural areas are diverse, not only between nations, but within them as well. For example, in the information science field, Veinot found significant differences in the HIV/AIDS information environments, including use of technology for information-seeking, in three Canadian regions

[165]. Furthermore, there is opportunity to conduct comparative research across rural areas in developed and/or high-income countries. In future work, there is also opportunity to conduct comparative analyses, with rural areas in developing, low-, and middle-income countries.

Given an increasingly networked world and the continued investigation into the relationship between urban and rural communities [98], there is an opportunity for theoretical development in examining how characteristics of rurality manifest in urban sub-communities and sub-populations, and how they are relevant for technology design and use. For example, like rural dwellers, inhabitants of urban immigrant enclaves may similarly have small and dense social networks, or experience culture and value differences in relation to the dominant society. Furthermore, geographic isolation might be compared to other forms of isolation such as social isolation among homebound people living in urban areas. Research examining these commonalities between rural and urban areas may assist in broader understandings of small and dense social networks, culture/value separation, and isolation in technology design and use, respectively.

4.1.2 Rural uniqueness in future HCI research

Each of the unique characteristics of rural areas contained in our typology points to opportunities for richer and more engaged HCI research. The potential fruitfulness of these opportunities is underscored by the previously-reviewed research in non-HCI fields on these topics, and the potential for rural HCI research to provide insight into persistent concerns in both HCI and rural studies research. These opportunities also draw attention to areas in which research could provide rural areas with concepts and empirical findings to support their ongoing efforts to grapple with technology design and use, and their potential roles in community development and change.

Infrastructure

While infrastructural issues related to rurality were well-represented in our review, they focused almost exclusively on Internet infrastructure. However, other aspects of infrastructure, such as access to transportation, are also important aspects of rural experience. Accordingly, following work on underserved urban areas [36], there is opportunity for HCI researchers to develop and test models of shared mobility which may assist rural communities in addressing limitations in transportation infrastructure. We also see opportunities to account for the “human infrastructures”; that is, “[the] actors that must be brought into alignment in order for work to be accomplished” [94]. In particular, studies that are conducted in rural areas in which Internet access is not widespread can draw attention to the creative processes that underlie information exchange among people in such contexts, and to the mixture of resources brought to bear on such exchange. In this way, such research could facilitate further insight into HCI/CSCW concerns about the interplay between humans and technological infrastructures [80]. Moreover, further work in this area could assist rural communities in planning infrastructure projects that appreciate the connections between types of infrastructures, and the critical roles of humans in deploying sustainable technologies.

Distance and geographic isolation

Distance and geographic isolation may define and mediate some rural people’s experiences. The rural HCI research in our review approached distance from diverse viewpoints related to access, to specialized medical services, to education, to remote work, and to sharing breaking news. Yet, this research has mostly focused on using technology to collaborate or access specific resources at a

distance. Such a single-issue or –outcome related approach stands in the way of the ability to make connections across these disparate resources. A broader focus on geographic distance and isolation is needed to unite this work, and such an approach could shed further insight into the spatial aspects of relationships between technology and place—a growing concern in HCI research [69,84,138]. There are also promising opportunities for rural HCI researchers to investigate the local effects of distance and geographic isolation on technology design and use, especially within marginalized subgroups. How might we design social technology for marginalized communities in rural areas so they can build stronger communities locally or across geographies? How does differential access to technology contribute to marginalization, and how might rural HCI researchers build systems with rural communities to address this? Research attention to such issues can contribute theoretical understanding to ongoing work regarding the roles of information and technology in community differentiation [166], while offering concrete guidance to spatially and socially marginalized groups about how to design technology for their purposes.

Culture and values

Rural areas are frequently touted as having unique cultures and values. The research presented here operationalized this predominantly with a focus on community heritage, but there are unaddressed rural values, such as religion and neighborliness [174], that may be relevant for the design and use of sociotechnical systems. How might values such as neighborliness affect how people use a sociotechnical system? Utilizing existing data on sociotechnical systems, such as Nextdoor (a popular social network site for neighborhoods), could allow us to evaluate these issues across disparate geographies. Given that one reviewed study in rural Canada found that individualistic approaches to embedded infrastructure projects conflicted with residents' communal values [89], such studies of the interaction between technology design and rural community values may confer insight into the persistent question in HCI of why technologies are not adopted or have surprising or unintended effects [63,64]. Further, in what ways can HCI researchers work alongside rural communities to disrupt potentially negative manifestations of value systems such as hostility towards immigrants and outsiders?

A promising space for investigation, especially with respect to conversations of globalization and the interconnectedness of the global and local, is how technology can facilitate the relationships between rural, urban, and suburban areas. Indeed, rural areas are present around the world. How do technologies facilitate culture sharing between these places? Given the scant research that operationalizes sociocultural definitions of rurality, how can such approaches come to bear on our understandings of rural values and culture in HCI? Moreover, how can these insights be used within rural communities in technology projects, such as those included in this review [6,38,175], that seek to share and preserve their heritage?

Furthermore, we found no research in HCI that defined rurality symbolically. By looking at symbolic definitions and individual relationships to rurality as a category and experience, we have an opportunity to make better connections between rural dwellers' understandings of their place of residence and technology use, thus enriching our understanding of this relationship within the broader HCI field.

Economies and business

HCI as a discipline has traditionally focused on work within formal institutions, including businesses which are typically located in urban areas. To date, this focus has excluded industries that are more common in rural areas (e.g., farming, forestry, manufacturing, and mining). Without

knowing how work activities are carried out, it is difficult to build relevant technologies for them, or to even to know if technological interventions may be necessary at all in these contexts. This makes such industries promising sites for future HCI/CSCW research, including evaluating their existing technological practices and the tools already in use. For example, modern agriculture can be highly technical, but there are many approaches to understanding the role of technology in its daily practice [99,146]. Furthermore, as rural economies shift towards consumption-oriented industries such as tourism [58,178], how can these economic activities be supported technologically and understood critically? Finally, how can HCI help us to understand broad shifts in rural labor and economies? Accordingly, HCI research can fruitfully contribute to the rural studies research regarding new rural economies [106].

Digital literacy and computer skills

To date, HCI research has primarily focused on documenting digital literacy gaps and attempting to remedy them through training. However, we argue for a more assets-based approach. As Bidwell and Hardy [15] sought to explore in developing settings, what do alternative literacies and computer skills look like in rural areas? Notably, extractive industries in rural communities are becoming increasingly mechanized and technical. How might rural HCI research look to those industries and economic practices as alternative sources of unique digital literacy and technical skills? Further, once we have identified those literacies, how do we design technologies and change our approach to these problems, and how can rural communities use these new approaches to support and develop residents' skills? Public libraries are an example of an institution that provides opportunities for information literacy and informal learning in rural communities, making them excellent sites for further research that builds on reviewed studies that focused on libraries and broadband access projects [104].

Social and health services

The rural HCI research reviewed here primarily focused on remote monitoring of patients, and on how isolated rural residents can better maintain contact with health providers. Building on [81], there are clear opportunities to understand how rural health services can be improved to reflect local needs — and benefits to rural communities in gaining this understanding. Further, given the role of religiosity in rural areas [9,102], churches may frequently play a major role in providing community-based social services in rural areas, yet this has not been fully accounted for in HCI literature. How can rural churches and other places of worship become a focus of HCI research engagement on local services [56]? Of note, since religious perspectives are frequently not accounted for in HCI research, such engagement has the potential to extend our understanding of the formation and sustenance of research collaborations across social differences; as reviewed in the section on “researcher positionality” below, this is an important methodological issue in rural HCI research.

Because rural social networks are dense and involve connections across multiple contexts, it can be especially difficult for privacy to be maintained in health and social services in rural areas [5]; such privacy concerns can be further exacerbated for those with stigmatized health conditions [164]. One reviewed HCI study showed privacy lapses in use of electronic health records [5]. As more rural healthcare organizations adopt electronic health records (e.g., [70]) and virtual consultations (e.g., [82]), there is a need to further investigate privacy-related perspectives and practices among rural dwellers—including those who work or volunteer for health and social

services. We posit that rural HCI research may help to further develop privacy theory in relation to similarly dense social networks, such as new immigrant communities in urban areas.

Population size and density

Given that population size and density are so prevalent in how rural areas are defined, Johnson and colleagues [83–85] have shown us how that affects the creation and maintenance of user-generated content (e.g., volunteered geographic information). In what other ways might population size and density affect user experience and design beyond just data produced? For example, if Wikipedia articles in rural areas are of lower quality, and less likely to be written by rural residents, what effect does that have on public understanding of rural communities and their marginalization? From a theoretical standpoint, rural HCI research has the potential to contribute to theoretical debates about scale, and in particular our reliance upon scale as a metric to evaluate the success of sociotechnical systems [61,63]. Practically, attention to these matters can help rural communities to understand how sociotechnical interventions should be built to better accommodate rural demography.

Population demographics

As it stands, when rural HCI research has minimally engaged with the population demographics of rural areas, it has done so primarily with the elderly and schoolchildren. With population demographics shifting in rural areas, particularly in increasing racial diversity [93] and growing rates of poverty [156], there are opportunities for HCI to expand on work in participatory research with these marginalized groups and to deploy technologies that reflect local population needs, interests and capabilities. Research with temporary or seasonal residents of rural areas (e.g., migrant workers, second-home owners) might also provide insight into unique coordination issues across the urban/rural divide and relations between disparate geographic areas. Such work could also contribute to rural studies research concerning rural-urban migration.

Social Networks

Prior research has investigated associations between rural residence and user behavior in online social networks. In addition, researchers could focus on design specifically to enrich bonding ties, including family relationships, in rural areas. Such work could build upon prior HCI research on the role of the family in sociotechnical systems [87], while also facilitating multigenerational interactions such as those necessary in the face of youth out-migration. Furthermore, given the heavy reliance on families for any form of assistance in rural areas, technology could focus on helping rural families and organizations to mobilize resources in the face of challenges such as financial strain, health crises, or natural disasters. Dense and overlapping relationships in rural areas, as well as smaller numbers of network members, may also cause us to rethink economic models for social network systems that rely upon delivering masses of users to advertisers [61].

Relationships to nature

Contemporary HCI research on rural people's relationships with nature is limited; that is, studies primarily focus on agriculture and food cultures. There is a lack of attention to contemporary forms of resource extraction in rural areas, and we advocate for greater HCI attention to the ways in which ICT-based industries may exploit rural resources. As one example, Google's massive servers are located in rural areas (e.g., Moncks Corner, South Carolina [124]), and involve large-scale and locally-controversial consumption of local water resources to cool them [131]. Similarly,

Bitcoin mining requires large amounts of electricity; due to access to cheap electricity, urban dwellers have recently crowded into the Columbia River basin in the US[131]. This has transformed life in this area. Critical HCI research could document and theorize these new forms of computing-based resource extraction, and its impact on rural residents. In so doing, it should demonstrate the interdependence of urban computing, resource extraction, and uneven development, striving to render the rural visible in these new global economies. The existing conversation in HCI also largely misses opportunity to engage with the unique depth of local knowledge related to the natural world and the importance of environmental stewardship for the livelihoods of rural communities. Following the work of Su and Cheon [148], how might rural HCI research better engage with the unique relationships with nature that rural people have?

HCI as a potential driver of insight about rural areas

As shown in our results, HCI currently lacks a unifying understanding of rurality; in fact, most studies do not define rurality at all. In addition to contributing to the specific topical areas as described above, there is an opportunity for HCI researchers to extend the rural typologies presented in this scoping review by conducting empirical studies in rural areas through a technological lens. Researchers can also expand the typology of what makes rural areas unique by adopting theoretical perspectives on rurality that have not yet entered HCI, such as symbolic approaches. Research based on such approaches could deepen our understandings of both HCI and rural areas; for example, regarding the deployment of technology as a symbol of economic development for rural areas.

4.2 Methodological considerations for conducting rural HCI research

The majority of studies in our scoping review were observational rather than interventional. They also used qualitative methods more frequently than quantitative or mixed-methods. Further, these studies tended to be cross-sectional rather than longitudinal. We see value in the current research focus on qualitative research, given the exploratory stage of much rural HCI research; however, over time, quantitative studies can facilitate assessment of the generalizability of findings and permit comparisons across populations. Interventional research also has an important place in rural HCI research given the challenges facing many of these areas in high-income and/or developed countries; we encourage continued work of this type. We also highlight a need for more longitudinal studies, particularly insofar as they can permit the study of rural change in relation to technology.

We now present methodological considerations for HCI researchers who wish to operationalize or incorporate insights from this scoping review into their work. If researchers want to collect rural-focused data, engage with rural communities, or enhance ongoing engagements, what do they need to take into consideration? While this is not an exhaustive list of considerations, this list provides important steps for pursuing rural HCI research based on our reflections on scoping review results.

Definition and deployment of rural.

Findings showed that a large proportion of studies conducted in rural areas did not define rurality. As we have shown, there are many definitions of rurality. To do productive research with rural communities and/or use data from rural places, we assert that researchers should have an operationalized understanding of rurality. This should not come solely in the form of a rigid definition [12] (e.g., population size or economic activity); rather, this understanding of rurality

should consider a variety of factors that characterize rurality in relation to the study at hand. The two interrelated typologies outlined in this paper are a good starting point to understanding possible definitions and characteristics of rurality. The typologies also provide citations for understanding how others deploy the concept of “rural” using diverse research methods and data, including qualitative and quantitative data.

Existing scholarly conversations about what rurality means are largely Western-centric. Therefore, researchers should, whenever possible, be aware of how local residents in a rural area come to understand their location or place as rural, and what rurality means to them. Research that seeks to make broader generalizations about what rurality means for users and their technological behavior (see [49] as an example), should take care to contextualize descriptive definitions of rurality. Given that rurality can have complex socio-cultural and symbolic meanings, it is also valuable to gain a local understanding of these matters. When conducting research with human subjects, researchers should ask question of their participants such as ,”Do you consider where you live to be rural? What makes where you live rural?” and “What does rurality mean to you? How does rurality affect your life, if at all?” When using quantitative data and relying upon the more descriptive definitions of rurality (e.g., Rural-Urban Commuting Area Codes) to make comparisons between rural and urban user behavior, researchers may find it useful to conduct sensitivity analyses to see if results are affected by use of different definitions. For example, do results change if a RUCA code or population size-based definition is used?

Lastly, and related to “postcolonial computing” discourse in HCI [78], we believe greater engagement with rural areas is one way to challenge computing’s colonial impulse [41]. Specifically, researchers in Human Computer Interaction for Development (HCI4D), continue to focus on topics, such as improving internet access in “developing” countries. These challenges are often framed as problems “over there”; where “there” is “other, apart, and disconnected” from “here” [149]. Widening the boundaries of HCI and CSCW research to include rural areas, that are “here” in developed/high income countries, can draw attention to the similarities, and not just the differences between different regions (as has been traditional in HCI4D). Moreover, such focus has the potential to motivate discussions about the ways in which limited internet access is a pervasive problem in almost every country, and may reveal that similar processes perpetuate disparities between rural and urban areas.

Attention to sample size, data quality, and sources

As prior research has made clear [84,85], digital data quality can vary depending on geographic location. User generated digital data can be especially susceptible to wide variances in data availability and quality. This means that conclusions drawn from existing behavioral data from users in sociotechnical systems (e.g., Twitter) may misrepresent user behavior in rural areas. More so, location inference algorithms perform poorly for rural users, even when data quality issues are addressed, due to inherent biases in the design of those algorithms [85]. Given this, there is a need for HCI researchers either to correct for bias in rural samples, perhaps by triangulating multiple data sources, by weighting cases, or by collecting their own data.

Conducting quantitative human subjects research with rural populations is especially difficult due to small population sizes that militate against the recruitment of large samples. In such cases, it may be necessary to expand the geographic area under study, or conduct multi-sited research that combines data from multiple areas [165].

Doing qualitative or mixed-methods research that relies on finding participants in rural areas has its own barriers. Local values and trust can be important aspects of rural society [57,75]

leading to potential distrust of outsiders or large institutions (i.e., universities and technology corporations). Therefore, gaining access to a research population can be problematic for outsiders. Prior rural research [31,63,68,165] has been successful in partnering with local organizations and leveraging local social networks for recruitment. One approach which may be helpful for making such connections is community-based participatory research (CBPR), common in health-related research, which offers guidelines for engaging community members at all stages of a technology project [160]. Of utmost importance is to be able to communicate familiarity with a region, and to show that understanding to participants in order to demonstrate that the interpretations of the research will be faithful to local realities.

Managing researcher positionality

The vast majority of organizations and individuals conducting HCI research are based in metropolitan areas or liberal college towns; these are perceived as being physically and culturally divorced from the realities of rurality [32]. As others have noted [4], technology companies and “innovation hubs” are almost always based in major urban areas (e.g., Silicon Valley). This suggests that researchers’ positionality, especially in terms of whether or not they live in an urban area, may bias their work. For example, in their research designing with rural business owners in Wales, Crabtree and Chamberlain [30] helpfully reflected upon their initial beliefs, later proven incorrect, that rural businesses would want to increase access to outside (often urban) consumer markets. Further, the demands of academic culture and funding requirements may necessitate a deficit-based orientation to research questions, rather than an assets-based one, as a justification for the need for research. In framing research from the perspective of deficits, rather than assets, researchers may fall into the trap of portraying rural areas exclusively in a negative light – i.e., as a problem that needs to be solved, rather than as an opportunity for creating new knowledge and understanding with rural people at the center of the issue at hand.

To counteract some of these effects, we encourage researchers to consider their positionality when entering into a field site or beginning to work with or generate a particular dataset (e.g., are they from, or based in, a rural area?). We also recommend that researchers working in rural areas connect with local organizations and community members; this will help generate a more nuanced understanding of potential biases before formal research begins, and can help researchers establish long-term relationships with communities. As in feminist HCI research [7], we encourage researchers to consider rural ways of seeing the world and how those views may help us counteract urban-centric views of computing [130].

Understanding situated user behaviors.

User behavior is ultimately evaluated and situated within broader structures of perceived cultural difference [41,78] and different subjective and imposed understandings of location [40,66]. It is possible to evaluate and parse out rural users’ unique experiences; this could lead to better design, better research, and ultimately better technology. One way to do this is to develop a holistic understanding of use environments, which may include broader information environments [165]. It is not enough to just interview someone about their use of a social network system, for example; one needs to understand how the rural area in which a participant lives affects that use. One of the most effective approaches to gaining an in-depth understanding of rural areas is through prolonged engagement in rural areas, as has been pursued in prior HCI research [63,112]. Contextual insight can also be offered by quantitative studies that triangulate digital trace data with analyses of contributed content [168], or by studies that merge researcher-

collected data with place-based data collected by federal, state, and local governments (e.g., occupational injury data, economic data), as well as local institutions such as rural hospitals.

Rural resilience and resourcefulness.

To be successful, and to align with an asset- rather than deficit-based approach, researchers should identify the resourcefulness and resiliencies that are present in rural areas [34,170]. Ideally, interventions can then leverage these strengths in their designs. For example, the last author conducted research in three rural regions of Canada. With few resources, a network of family and church members formed a non-profit support organization for people with HIV/AIDS (PHAs) in the region. This organization provided volunteer drivers to health care appointments for local PHAs and created “cooking bees” to fill the freezers of PHAs when they were unwell, so as to make up for a lack of restaurants and meal delivery solutions in the area. Group members described their approaches as “rural solutions,” which were significant points of pride for the group. Any ICT intervention focused on support for PHAs in this area, therefore, could effectively work to support local support efforts rather than importing support from urban areas. We also anticipate that this principle may be found in a range of other domains in which rural residents confront challenges together.

4.3 Limitations of this approach

Several limitations of this study should be kept in mind. As we relied solely on English language documents, other relevant documents could have been excluded. Also, and as previously mentioned, we did not include articles published in Springer’s Lecture Notes in Computer Science, books, or book chapters in our scoping review. Nevertheless, this study presents the first synthesis of research on HCI in high-income and/or developed countries, permitting the identification of gaps and opportunities for future research.

5 CONCLUSION

Technology use and design in rural areas are becoming increasingly important topics in HCI and CSCW. However, as we demonstrate, this research reveals considerable variability in terms of its treatment of rurality. To bring greater coherence to this literature, this paper presents two research-based typologies from non-HCI research, and uses them to characterize rural HCI research. In so doing, we identified shortcomings in the current body of research, including inconsistent use of clear definitions. We also found that aspects of rurality which are considered in technology design and use research focus primarily on infrastructure and bridging distance/geographic isolation; this leads to many promising research opportunities in HCI being overlooked. As our typologies and empirical results show, rural areas are unique, and there are many as-yet-untapped possibilities for productive HCI research. The conceptual and methodological resources outlined in this paper aim to inspire growing research effort in the area of rural HCI.

ACKNOWLEDGEMENTS

The authors would like to thank Silvia Lindtner, Tawanna Dillahun, Padma Chirumamilla, Julie Hui, and the many reviewers who gave feedback on this work through its iterations. This research was funded partially by the National Science Foundation under award 1452479 and the Rackham Graduate School at the University of Michigan.

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Received April 2019; revised June 2019; accepted August 2019.