

Subjectively-measured Environmental Support for Physical Activity, Healthy Eating, and Breastfeeding in the Rural United States: A Scoping Review to Inform Opportunities for Public Health Surveillance

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Abstract

The purpose of this scoping review was to identify subjectively-measured environmental initiatives or factors that influence PA, HE, and/or breastfeeding practices within rural U.S. communities. Guided by a scientific research librarian, searches occurred February through July 2020. Grey literature searches spanned Google, Google Scholar, government pages, and public health, federal nutrition assistance program, Cooperative Extension Services, and related webpages. Four academic databases (Medline, PubMed, Web of Science, Agricola) were selected to identify peer-reviewed research and ProQuest Dissertations and Theses Global were used to identify dissertation research. Inclusion criteria included: (1) breastfeeding, HE, and/or PA focus; (2) environmental factors assessed using subjective measures; (3) specific to U.S. rural populations/contexts; and (4) English language. PA environment results focused on initiatives or factors in recreation (parks, playgrounds, facilities; n=54), street/sidewalk (n=44), or school (n=33) settings. PA environmental initiatives/factors included increasing transport/accessibility or addressing geographic disparities for recreation settings, improving/installing walkability features for streets/sidewalks, integrating PA into lessons, or improving PA equipment/spaces for school settings. HE environment results focused on initiatives in retail (n=65) and schools/childcare (n=33) settings. HE environment change initiatives/factors in retail settings included increasing the availability of fruits/vegetables in existing establishments or the prevalence of healthy food outlets. In schools, HE environmental initiatives/factors increased fruits/vegetables served and/or reduced unhealthy foods. Breastfeeding environment results focused on workplace settings (n=3). Breastfeeding environment initiatives/recommendations in workplaces included increasing compatibility for breastfeeding by addressing environmental and cultural barriers. Results from this scoping review were used to create recommendations to improve PA, HE, or breastfeeding environments in rural U.S. settings.

Keywords: Review, environment, surveillance, breastfeeding, physical activity, healthy eating

Chronic disease rates are high in the United States (U.S.), with over 50% of adults experiencing at least one chronic condition, and over 25% experiencing two or more (Boersma 2020; Centers for Disease Control and Prevention, 2022). Public health researchers and practitioners have identified modifiable lifestyle risk factors for intervention across the lifespan to reduce high rates of chronic disease. In addition to well-known modifiable behaviors like physical activity (PA) and healthy eating (HE), breastfeeding has an established role in reducing the risk of chronic diseases such as obesity, type 2 diabetes, and cardiovascular conditions, as supported by recent evidence highlighting its long-term health benefits for both mothers and infants (Romieu et al., 2017; Schmidt 2016). Maintenance of these modifiable lifestyle risk factors are influenced by access to health-promoting resources and contexts (Dunn et al., 2015; Bradford et al., 2017; Sallis & Glanz, 2009; Sallis et al. 2008; Casey et al., 2008). For example, about 25% of U.S. residents lack access to parks or recreation facilities, while 5.6-17.7% of U.S. residents have limited access to stores stocking fresh fruits and vegetables, and only 26.1% of live births occur at baby-friendly facilities with robust breastfeeding support (Roubal, 2015; Karpyn et al., 2019; Centers for Disease Control and Prevention, 2018, 2023). In turn, most adults in the U.S. do not meet recommendations for PA, HE, or breastfeeding (Whitfield, 2019; Lee et al., 2022).

Rural areas experience disparities in environmental supports for PA, HE, and breastfeeding, with more remote areas typically having worse PA, HE, and breastfeeding resource availability compared to urban areas (Grubestic & Durbin, 2020; Wiener & Wiener, 2011; Johnston & Esposito, 2007; Kaczynski et al. 2020; Fan et al., 2017; Wen, Zhang, et al., 2013; Dean & Sharkey, 2011; Wende, Stowe, et al., 2020; Wende, AlHasan et al., 2020; Houghtaling, Shanks, et al., 2020). With rural, disadvantaged neighborhoods having lower access to health-promoting PA resources, food outlets, and breastfeeding facilitators, such as unsafe outdoor environments with higher rates of crime, frequency of less healthy food outlets (e.g., convenience stores), and low support for positive breastfeeding behaviors (Wen, Fan, et al., 2018; Shores & West, 2010; Burgoine et al., 2017; Walker et al., 2010; Grubestic & Durbin, 2017; Allen et al., 2015; Sampson, 1997; Pratt & Cullen, 2005; Lamichhane et al., 2013; Fraser et al. 2010; Sparks, 2010). Relatedly, rural residents are less likely to meet PA, HE,³⁷ and breastfeeding recommendations and tend to have lower household income (McCormack & Meendering, 2016; United States Census Bureau, 2016). In addition, lack of environmental supports in rural neighborhoods may also increase risk of chronic diseases such as heart disease, cancer, chronic lower respiratory disease, and stroke (Hartley, 2004; Do, 2009; Centers for Disease Control and Prevention, 2019; Garcia, 2017). Urban-rural disparities in environmental barriers to healthy behaviors and socioeconomic disadvantage may be a direct result of rural economic factors, such as agricultural extraction, shifting land ownership to larger businesses, diversifying livelihoods (e.g., from farming to service jobs), and environmental degradation (e.g., erosion, flooding) (Rigg,

2006; Johnson, 2001; Gowda et al., 2018; Ulrich-Schad & Duncan, 2021). Adding to this, public health research and initiatives often overlook rural populations and lack a detailed understanding of the health experiences and outcomes in remote areas of the U.S. (Umstadtd Meyer, Moore, et al., 2016).

Public health experts are increasingly focused on environmental interventions, an effective strategy for bringing about population-level change in PA, HE, and breastfeeding adherence by ensuring equitable access to health-promoting resources (Springer et al., 2017; Paskett et al., 2016; United States Department of Health and Human Services, n.d.). Policy, systems, and environmental change strategies draw attention to the importance of intervening on distal, environmental influences to increase support for healthy behaviors (Lyn et al., 2013; Honeycutt, 2015). For instance, research shows that access to nutritious food and recreation facilities is associated with healthier diets and greater PA, respectively (Haire-Joshu & Nanney, 2002; Ding et al. 2011; Frost et al., 2010; Barnett et al., 2017). As another example, research has shown that giving birth at hospitals that provide breastfeeding support and resources shows significant improvements towards breastfeeding adherence and infant health. To inform environmental interventions, many studies assess environments using objective measures which may be easier to collect since most are publicly available (e.g. government data, Geographic Information Systems data) or can be compiled by research staff (e.g., environmental scans/audits), and require low participant burden compared to subjective measures (Peters et al. 2020; Gustafson, Sharkey, et al., 2011). Despite this, research shows that *perceived* access to PA, HE, and breastfeeding resources (e.g., subjective ratings, barriers/facilitators) may show stronger associations with PA, HE, and breastfeeding outcomes compared to more objective measures (Zhang et al., 2018; Weden et al., 2008; Wen, Hawkey, & Cacioppo, 2006; Rollings et al., 2015). Therefore, research is needed that highlights subjective measurements of PA, HE, and breastfeeding environments and resources to complement more common objectively measured environmental assessments.

Some research has compiled existing environmental interventions and factors that impact PA, HE, and breastfeeding to understand which methods have been effective, yet very few existing literature reviews have focused specifically on rural environments which may be the most under-resourced. For PA environments, five reviews have been completed and conclude that PA environment changes significantly impact PA; however, closer examination of rural definitions and more rigorous evaluation of environmental changes is needed (Hansen et al., 2015; Neville et al., 2016; Umstadtd Meyer, Perry, et al., 2016; Olsen, 2013). For HE environments, three reviews have been completed and concluded that improving transportation or distance barriers to accessing healthy foods is effective in rural areas but additional evidence is needed on introducing or assessing healthy foods in rural small food stores (Pinard, Byker Shanks, et al., 2016; Calancie et al., 2015; Lenardson et al., 2015). For breastfeeding environments, there are no reviews on

breastfeeding environments or supports in rural environments, but reviews that include both rural *and* urban locations indicate that hospital and community-based breastfeeding resources and support are crucial (Hadisyatmana et al., 2021; Kaunonen et al., 2012; Haroon et al., 2013; Almohanna et al., 2020; Butzner & Cuffee, 2021; Sinha et al., 2015). Additional literature reviews have looked at environmental factors related to PA, HE, and breastfeeding, but most only focused on peer-reviewed research and have not provided a review of research in recent years (Wendel-Vos et al., 2007; Addy et al., 2004; Perry et al., 2011; Smith, Hosking, et al., 2017; Humpel et al., 2002; Gubbels, 2020; Marcone et al., 2020; Belon et al., 2016; Kvalsvik et al., 2021; Larson & Story, 2009; Zorbas et al., 2018; Giskes et al., 2011; van der Horst et al., 2006; Standish & Parker, 2022; Cohen et al., 2018; Houghtaling, Byker Shanks, & Jenkins, 2017). While objective and subjective measurements of PA, HE, or breastfeeding environments were included in existing reviews on PA, HE, and breastfeeding, none specifically focused on subjective environmental assessments. Adding to this, few existing literature reviews were grounded in a theoretical framework to serve as a foundation for the process of synthesis (Godfrey et al., 2010). Use of theoretical frameworks for systematic reviews can inform the association between variables, guide the search strategy, clarify study outcomes, identify knowledge gaps, and indicate areas for future research. Moreover, theoretical frameworks that acknowledge multiple levels of influence (e.g., policy, systems, and environmental change strategies, Social Ecological Model) are crucial for carrying out an effective search strategy and analyzing existing research, especially with literature reviews on environmental exposures. Lastly, there are no currently available or published *scoping* reviews on the topic of PA, HE, or breastfeeding environmental factors in rural areas of the U.S. Scoping reviews can be particularly useful for integrating peer-reviewed research, grey literature, and graduate theses on community-level interventions, research efforts, and surveillance/measurements techniques that can help identify and address lacking resources in rural areas.

While public health research and interventions are increasingly focused on environmental approaches to addressing low rates of PA, HE, and breastfeeding in the U.S., several literature gaps remain. Novel approaches to improving or examining PA, HE, and breastfeeding environments in rural U.S. areas have been published in recent years, but limited research has reviewed this rural-specific literature to understand which strategies have been most widely used and effective. Current studies describing environmental correlates of and change approaches to improving PA, HE, and breastfeeding, incorporate objective and/or subjective measures (Arriola et al., 2017; Bowen et al., 2015; Holston, 2020). While both objectively and subjectively assessed data is supported as useful to describe settings and inform decisions, the inherent differences between these two methods should be considered in how these findings are interpreted and used. A subjective measurement of the environment refers to an assessment or evaluation that relies on personal opinions, perceptions, or interpretations rather than objective,

quantifiable data. While subjective assessments are less reliable for informing policy decisions or assessing environmental changes, they play a significant role in understanding how people perceive and interact with their environment. For example, subjective environment methods include surveys assessing the quality of environmental features, qualitative interviews, and focus groups. Understanding perceptions of the environment in addition to objectively measured environmental factors can help guide policy makers and practitioners in how to most effectively support and promote PA, HE, and breastfeeding behavior change within their community (e.g., built environment change versus awareness/educational programming).

This scoping review identifies and describes subjectively-measured environmental factors that impact PA, HE, and/or breastfeeding practices among rural U.S. communities. A secondary aim was to describe the subjective measurement approaches being used to assess rural environments and resource access.

Methods

Study Design

A scoping review was conducted in 2020 as part of a large project to inform surveillance of policies, systems, and environmental factors or changes related to PA, HE, and breastfeeding promotion among rural people and places in the U.S. The research team partnered with an academic scientific librarian, a team of trained graduate research assistants, and an expert advisory board to complete this scoping review. Findings related to subjectively-measured environments that encourage/support rural PA, HE, and breastfeeding patterns/practices are reported here and other results (i.e., policies, systems, and qualitative case studies) are reported separately (forthcoming) (Umstadtd Meyer, Houghtaling, et al., 2024). Given the inherent differences between subjective and objective measurement approaches and the utility of the data derived using subjective or objective measures, we are presenting the results from this scoping review project in separate manuscripts for subjectively and objectively-measured environments (see Wende et al., under review for objective measurement results) (Wende, Houghtaling et al., n.d.). A review protocol for this large effort was pre-registered using Open Science Framework (doi: [10.17605/OSF.IO/VXMDU](https://doi.org/10.17605/OSF.IO/VXMDU)).

Search Strategy

As previously reported, a research librarian (RLM) tested and solidified the search strategy used to identify sources. Peer-reviewed scientific literature, grey literature, and thesis and dissertation (hereafter “thesis”) research were all of interest. Searches occurred over a 5-month period between February and July 2020. Trained graduate research assistants visited webpages, identified grey literature documents, and reviewed sources for relevant information. For large documents, keywords (e.g., breastfeed, exercise, healthy eating) were encouraged to identify information meeting the review focus. Data was downloaded and then extracted using a standardized Excel

2024 spreadsheet that was reviewed by a study lead for clarity/completeness.

Four academic databases, including Medline and Agricola via the EBSCOhost interface, PubMed, and Web of Science, were selected to identify peer-reviewed research across PA, HE, and breastfeeding discipline areas. ProQuest Dissertations and Theses (PQDT) Global was used to identify thesis research. Keywords were applied to databases between March and June of 2020 by one researcher with terms focused on topic area (e.g., breastfeed*, diet*, “physical activ*”), geography (e.g., rural*, “United States”), and setting (e.g., policy, environment*) (full search strategy: [DOI:10.17605/OSF.IO/VXMDU](https://doi.org/10.17605/OSF.IO/VXMDU)) (Meyer et al., 2020). The year 2000 was used as a search restriction for peer-reviewed research to ensure up-to-date and relevant environmental PA, HE, and breastfeeding factors were identified. ProQuest searches were limited by topic area.

All search results were downloaded to an EndNote X9 file for title and abstract reviewing that occurred in collaboration with a research assistant. Due to many sources identified meeting review inclusion criteria, full text reviewing occurred independently among project team members. The flow diagram regarding academic and ProQuest sources reviewed and included in our synthesis among all behaviors and policy, systems, and environmental areas was previously published.

Grey literature searches spanned Google, Google Scholar, government pages (inurl:gov) and public health, federal nutrition assistance program, Cooperative Extension Services (Extension – a nationwide practice network that addresses public needs by providing non-formal higher education and learning activities (and policy, systems, and environmental changes) to farmers, ranchers, communities, youth, and families), and other webpages (United States Department of Agriculture, n.d.a). Search lists were generated for PA, HE, and breastfeeding topic areas with some overlap as appropriate (e.g., U.S. Department of Agriculture’s Special Supplemental Nutrition Assistance Program for Women, Infants, and Children (WIC) for both healthy eating and breastfeeding information). Using an iterative process, trained research team members (HD, SE, CM, RS, KHK) reviewed all grey literature sources (with liberal inclusion of source materials), and three project leads (BH, KJK, and MRUM) and trained research team members (KHK, MEW) reviewed the resultant standardized spreadsheets.

Inclusion and Exclusion Criteria

All sources were required to meet five criteria for inclusion, specifically: (1) a focus on at least one of three topic areas (PA, HE, and/or breastfeeding); (2) about environmental factors assessed using subjective measures; (3) relevant results clearly specific to rural populations or places; (4) population/setting based in the U.S. due to the focus on potential CDC surveillance; and (5) English language publication.

“Environments” were defined as “built or physical environments which are visual/observable, but may include economic, social, normative or message”. Results for “subjective” assessments of the environment were only reported for this manuscript, with subjective being defined as any assessments that were based on perceptions, personal opinions, feelings, experiences, and attitudes. This included qualitative interviews (e.g., focus groups, semi-structured interviews), quantitative assessments (e.g., surveys or ratings based on opinions), Photovoice techniques, or other assessments based on personal opinions, feelings, and attitudes rather than external facts or evidence. Articles that included *only* objective assessments of environmental change approaches, including environmental audits, administrative data (e.g., Census statistics), and Geographic Information Systems data, were excluded from this scoping review and will be published elsewhere. It should be noted that there were many examples included in our results where articles had both subjective and objective assessments, or an assessment tool included both subjective and objective components. Additionally, given the number of sources identified, social environment factors were not included in this scoping review to narrow the review focus, given that social factors, such as peer support or social marketing, could be considered less consistent indicators for the purpose of public health surveillance.

For the third criterion, authors either reported rural status using standardized definitions (e.g., Rural Urban Commuting Area codes, Urban Influence Codes), or simply described the study site as “rural.” Study sites were also characterized, when possible (county or town information listed), using a rural-urban typology including: African American South; Aging Farmlands; Evangelical Hubs; Graying America; Hispanic Centers; Latter Day Saints Enclaves; Native American Lands; Rural Middle America; and Working Class Country. Some sources met criteria for “rural,” although met criteria for an urban/less rural typology, including: Big Cities; College Towns; Exurbs; Middle Suburbs; Military Posts; and Urban Suburbs (Bennett et al., 2019; Chinni & Pinkus, 2019).

Results Synthesis

As has been previously reported (CITE BMC paper), outcomes were extracted to standardized spreadsheets that included the study or source design and objective, setting or sector, population characteristics, behavioral focus, and results specific to rural policy, systems, and environmental factors. Definitions for policy, systems, and environmental approaches were sourced from Supplemental Nutrition Assistance Program Education (SNAP-Ed) guidance due to a large organizational focus on using these types of strategies to improve community health outcomes (United States Department of Agriculture n.d.b). Assessments of study quality were not included in our results. One researcher extracted outcomes; however, this process was also iterative as sources were revisited if extracted data was found unclear or incomplete.

Results

The research identified 188 peer reviewed research, grey literature, and thesis sources covering a broad spectrum of study designs including cross-sectional, longitudinal, experimental, mixed-methods, and qualitative approaches. The average sample size varies widely across studies, with some focusing on small, specific groups and others involving larger community or school-based populations. With an average sample size of approximately 214 participants per study, the data reveal notable trends and disparities. For instance, most studies had a higher proportion of female participants compared to males, and there was wide variation in representation from minoritized racial and ethnic backgrounds, education level, and income level based on the geographic location or the focus of the intervention or study.

Physical activity

A total of 92 peer reviewed research articles, 22 grey literature sources, and two graduate theses were identified that include subjectively-measured environments for PA (Tables 1-4) (Findholt, Michael, et al., 2011; Findholt, Michael, & Davis, 2011; Atkinson, Desmond, et al., 2010; Belansky et al., 2013; Jilcott Pitts, Keyserling, et al., 2015, 2017; Ndirangu et al., 2007; Sánchez et al., 2014; Gustafson, McGladrey et al., 2018; Gustafson, 2019; Wallace et al., 2019; Kegler, Escoffery, et al., 2008; Kegler, Swan, et al., 2014; Ahmed, Oshiro, et al., 2011; Escoffery et al., 2011; Alexander et al., 2015; Turner et al., 2016; Devine et al., 2012; Armstrong, 2000; Jernigan, Salvatore, et al., 2012; Bove & Olson, 2006; Snyder et al., 2019; Buro et al., 2015; Daly et al., 2017; Seguin et al., 2014; Wilcox, Saunders, et al., 2018; Demment et al., 2015; Erinosho, Vaughn, et al., 2018; Erinosho, Hales, et al., 2019; Kumar et al., 2016; Barnidge, Radvanvi, et al., 2013; Atkinson, Billing, et al., 2007; Powers, 2019; Schetzina et al., 2009; Scott & Wilson, 2011; Story et al., 2012; Baker et al., 2017; Griffin et al., 2011; Yousefian, Hennessy, et al., 2010; Hill et al., 2016; Moore, Brinkley,

For rural streets/sidewalks, trails, or other pedestrian infrastructure, sources focused on safety hazards (e.g., traffic, strangers, dogs, low visibility/lighting), a lack of sidewalks, trails, or other walkable features, aesthetics (e.g., lack of graffiti, scenery), adequacy/availability of bike lanes, trail amenities, availability of nearby destinations, accessibility/proximity, and weather barriers (e.g., ice, snow). For rural recreational facilities, parks, and playgrounds, sources focused on access to outdoor PA opportunities, access to indoor PA opportunities, access/proximity to recreational facilities or parks, free or low cost options, programming, cultural or gender appropriate facilities, density/availability of recreational facilities or parks, maintenance, incivilities, safety concerns (e.g., traffic, loose dogs, security), weather, and age appropriateness of facilities. For rural schools or other childcare settings, sources focused on the presence/creation of walking tracks, availability of sports (e.g., programming, fields) and/or recess, availability of PA equipment, availability of extracurricular PA programs, transportation options for after-school PA programs, personnel availability, presence of other students to participate in PA, access to school grounds for PA. adequacy of physical

et al., 2013; Moore, Jilcott, et al., 2010; Gilbert et al., 2019; Lo et al., 2017; Scanline et al., 2014; Shores, Moore, & Yin, 2010; Shores, West, et al., 2009; Wilson et al., 2004; Abi Nader et al., 2018; Kegler, Swan, et al., 2012; Kegler, Alcantara, Dubruel, et al., 2013; Kegler, Alcantara, Haardörfer, et al., 2015; Bevans et al., 2010; Edwards, Kanters, et al., 2011; Edwards, Bocarro, & Kanters, 2013; Edwards, Theriault, et al., 2014; Page-Reeves et al., 2014; Bopp et al., 2012; Brownson, Housemann, et al., 2000; Brownson, Hagood, et al., 2005; Chrisman, Nothwehr, Yang, & Oleson 2014, 2015; Chrisman, Nothwehr, Janz, et al., 2015; Comstock et al., 2016; Aronson & Oman, 2004; Eyler & Vest, 2002; Eyler, 2003; Gangeness, 2010; Kristjansson et al., 2015; Riley-Jacome et al., 2010; Sanderson, Littleton, & Pulley, 2002; Wilcox, 2000; Wilcox, Bopp, et al., 2003; Wilcox, Oberrecht, et al., 2005; Zimmerman et al., 2016; Deshpande et al., 2005; Dinkel et al., 2018; Hennessy et al., 2010; Hooker et al., 2005; Kasehagen et al., 2012; Li et al., 2015, 2018; Jahns et al., 2014; Sanderson, Foushee et al., 2003; Omura et al., 2017; Thompson, et al., 2002; Babey et al., 2008; Chadwick et al., 2019; Gamble et al., 2017; Davis et al., 2014; Bishop et al., 2015; Calodich, 2015; Case & Rojina, 2015; Fredericks et al., 2015; Haas et al., 2015; Halverson & Devlin, 2015; Halverson, 2015; Harden & Rudolf, 2015; Harden & Rudolph, 2015; Jensen et al., 2015; Worthen et al., 2015; Clifford, Bellows, et al., 2015; Clifford, Winfield et al., 2015; Lewis et al., 2015; Gatzke et al., 2015; Marcusson et al., 2015; Wayne, 2015; Peutz, 2015; Powers-Hammons et al., 2015; Sant et al., 2015; Tingey et al., 2015; Alabama Extension at Auburn University SNAP-Ed, 2018; Glagora Dunn, 2018; Mead, 2018). Settings for subjective environment results for PA included recreational facilities, parks, and playgrounds (n=75), streets/sidewalks, trails, or other pedestrian infrastructure (n= 66), schools or other childcare settings (n=47), natural environments (n=10), churches (n= 9), the home environment (n=7), workplaces (n=7), and community gardens (n=4).

education, conflicts with other school events/programs, and safety. For rural natural environments, sources focused on access/proximity to natural environments, natural beauty, access to water for hunting/fishing/kayaking/etc., optimal weather conditions, and the presence of hills or terrain for PA. For rural churches, sources focused on PA time during church activities (e.g., Sunday school, youth groups), the presence of exercise equipment/spaces, the presence of messages/signage about PA, and exercise programming in the church environment. For rural home environments, sources focused on implementing exercise equipment, the presence of a yard, and the presence of household chores. For workplaces, sources focused on space and opportunities at work for PA. For rural community gardens, sources focused on availability of land, and gardening tasks.

Subjective tools or methods were used in the identified peer-reviewed research (n=82), grey literature (n=21), and graduate theses (n=1) to capture environmental factors related to PA in rural U.S. communities (Table 5). The most widely used tools measuring PA environments were questionnaires/surveys (e.g., windshield tours with qualitative observations, the Neighborhood Environment Walkability Scale, telephone surveys, open-ended

questions, participatory photographic surveys) (n=68), which assessed the adequacy of community centers or spaces, environmental or programmatic factors at schools or childcare settings influencing youth PA, neighborhood walkability, perceived environmental support for PA, and PA barriers/facilitators. Other widely used tools to subjectively measure environmental support for PA included interviews (e.g., qualitative interviews,

Healthy eating

A total of 102 peer reviewed research articles, 23 grey literature sources, and three graduate theses were identified that used subjective measures of HE environments (Supplemental Tables 1-4) (Ko et al., 2018; Jilcott Pitts, Wu, Truesdale, et al., 2018; Jilcott Pitts, Wu, McGuirt, et al., 2018; McGuirt, Pitts, et al., 2015; Bardenhagen et al., 2017; Belansky et al., 2010; Sharkey et al., 2011, 2012; Thatcher et al., 2017; Yousefian, Leighton, et al., 2011; Chapman et al., 2019; McGuirt, Jilcott Pitts, et al., 2014; McGuirt, Ward, et al., 2014; Askelson, Brady, et al., 2019; Davis et al., 2017; Hanawa Peterson & Procter, 2019; Martínez-Donate et al., 2015; Crooks, 2003; Jilcott et al., 2009; Jilcott Pitts, Wu, Demarest, et al., 2015; Flamm, 2011; Gustafson, Jilcott Pitts, McDonald, et al., 2017; Gustafson, Ng, & Jilcott Pitts, 2019; Honeycutt et al., 2012; Ahmed, Byker Shanks, et al., 2018; Houghtaling, Serrano, et al., 2019, 2020; Izumi, 2015; Blumenschine et al., 2018; Cornish et al., 2016; Pinard, Fricke, et al., 2016; Russomanno & Jabson, 2016; Shah et al., 2019; DeWitt, 2017; Garasky et al., 2006; Quandt et al., 2006; Valdez et al., 2012; Jernigan, Williams et al., 2018; Mann et al., 2017; Andress & Fitch, 2016; Byker Shanks et al., 2017; Dye & Cason, 2005; Hampson et al., 2009; Ramadurai et al., 2012; Smith & Morton 2009; Novotny et al., 2011; Hartline et al., 2017; Haynes-Maslow et al. 2018; Holston et al., 2020; Askelson, Cornish, & Golembiewski, 2015; Barnidge, Hipp, et al., 2013; Nothwehr et al., 2014; Johnson, McKinley, et al., 2018; Misyak et al., 2015; Barnes et al. 2016; Bauer et al., 2012; Caspi et al., 2017; Dev et al., 2020; Friedman et al., 2014; Hearst et al., 2018; Lin & Fly, 2016; MacKenzie et al., 2019; Polacsek et al., 2018; Sherry, 2008; D'Angelo et al., 2017; Panzera et al., 2017; Feldman, 2017; Hutson, 2017; Ma, 2018; Ma et al., 2018). Settings for identified subjectively-measured HE environments included food retail environments (n=84), schools or other childcare settings (n= 43), community gardens (n=20), food assistance programs (n=19), local food producers (n=18), home environments (n=10), churches (n=7), workplaces (n=3), and natural environments (n=2).

For rural food retail environments, sources focused on good quality of healthy food, agricultural setting, shopping atmosphere, advertisements or nudges, cleanliness, customer service, healthy food availability within stores, availability of culturally appropriate food options, access/proximity to stores with healthier options/outlets, corner stores near neighborhoods and schools, the convenience of unhealthy food (e.g., fast food), presence/popularity of supercenters or larger outlets in

stakeholder interviews, focus groups) (n=62), which focused on several PA-related topics, including physical and social environmental factors, PA barriers/facilitators, and suggestions/ideas for environmental improvements. In addition, photovoice (n=3), nominal grouping techniques (n= 1), and health impact assessment screening and scoping processes (n= 1) were used to measure PA environments subjectively.

remote areas, variety of healthy foods, business hours, ability/inability to accept food assistance, perishability of healthier foods, and price/affordability. For rural schools and other childcare settings, sources focused on healthy meal choices during school, school proximity to unhealthy outlets, availability of healthy/unhealthy foods outside the classroom (e.g., vending machines), advertisement/presentation of healthy foods or drinks, price of healthy food, adjustments in portion sizes when incorporating healthy foods, quality and taste of healthier foods, school-based summer meal sites, and food waste associated with healthier foods. For rural community gardens, sources focused on community engagement,¹¹⁴ availability of land, and availability of fruits and vegetables from gardens. For rural food assistance programs, sources focused on difficulties offering food assistance at farmers markets (e.g., administrative and time limitations), availability of community food pantries/banks, variety of fruits/vegetables provided with assistance, strict requirements for enrollment, ease of using benefits, and community-level considerations (e.g., acceptability, available resources, health department characteristics). For rural local food producers, sources focused on the presence and support of farming and agriculture industries, community aspect associated with local food sourcing, prices, improved connections between producers and distributors, and improved local access to fresh produce. For rural home environments, sources focused on the availability of fruits and vegetables in the home, the presence of a home garden, portion sizes served at home, and the availability of informal support networks. For rural churches, sources focused on the availability of healthier options, food drive events, the presence of messages/signage about HE, and the presence of existing infrastructure. For rural workplaces, sources focused on the presence of existing infrastructure, and unhealthy foods in cafeterias and vending machines. For rural natural sources, sources focused on the potential for hunting/foraging and weather barriers to growing fruits/vegetables.

Subjective tools or methods were used in the identified peer-reviewed research (n=91), grey literature (n=21), and graduate theses (n=2) to capture environmental factors related to HE in rural U.S. communities (Supplemental Table 5). The most widely used methods to subjectively measure HE environments were questionnaires or surveys (e.g., windshield tours, intercept surveys, telephone surveys, consumer surveys, open-ended questions, participatory photographic surveys) (n=71) and interviews (e.g., focus groups, key-informant interview) (n=75), which assessed a wide range of topics: community resources, HE barriers/facilitators, healthy food access, acceptability/affordability/accommodation of local food outlets, and suggestions/ideas for environmental

improvement. Other widely used tools to subjectively measure environmental supports for HE included photovoice (n=3), qualitative field notes (n=1), card sorting exercises (n=1), and free listing exercises (n=1).

Breastfeeding

A total of three peer reviewed research articles were identified that subjectively-measured breastfeeding environments (Supplemental Tables 1-4) (Flood, 2017; Flower et al., 2008; Majee et al., 2016). Subjectively-measured environments or settings for breastfeeding included workplaces (n=3) and hospitals (n=1). Within rural workplace environments, supports for breastfeeding included practices or spaces that allow for breastfeeding during the workday. Workplace environment barriers to breastfeeding included unresponsive accommodations (e.g., supervisor's office or bathroom as lactation room), misaligned practices, language, or culture for breastfeeding, and/or the need to return to the workplace environment during critical postpartum periods. Rural hospital or healthcare environment barriers to breastfeeding included perceived lack of healthcare resources (e.g., Baby Friendly Hospitals) in rural areas and a lack of referrals to other healthcare specialists for breastfeeding.

Two types of subjective tools or methods were used in the identified peer-reviewed research to capture environmental factors related to breastfeeding in rural U.S. communities (Supplemental Table 5), including ethnographic interviews (n=2) and semi-structured focus groups (n=1). These interview methods specifically assessed mother or healthcare worker perceptions of workplace supports for breastfeeding and health services/factors that predict breastfeeding initiation/continuation.

Discussion

This scoping review compiled a breadth of research on subjectively-measured environmental factors that influence PA, HE, and/or breastfeeding practices in rural communities across the U.S. Overall, results demonstrated the importance of rural recreational facilities, parks, playgrounds, streets, trails, and other pedestrian infrastructure for promoting PA. Adding to this, results demonstrated most rural public health research and practice in this scope focused on opportunities in workplaces and hospitals to promote breastfeeding and food retail environments to promote HE. Further, as demonstrated by a paucity of sources focused on environmental support for breastfeeding in rural areas, this area is underinvestigated compared to HE and PA. This review collected information on subjective measurement techniques employed to assess rural environments and PA, HE, and/or breastfeeding resource access. Importantly, there was great diversity in the measurement tools used, which creates clear barriers to comparing research findings on environmental resources in rural and under-resourced environments.

Although previously published reviews on environmental influences on PA have only examined peer-reviewed research, our study, which included both peer-

reviewed and grey literature, identified similar supportive behavior settings (e.g., recreational facilities, parks, playgrounds, pedestrian infrastructure, school/childcare environments). For example, research by Frost and colleagues found that recreational facilities, sidewalks, crime/safety, and traffic were most important for improving PA outcomes in rural communities. As another example, research by Umstadtd Meyer and colleagues found that enhancing infrastructure supporting walking and increasing opportunities for extracurricular PA were the most important strategies for improving PA outcomes in rural communities. Existing reviews on environmental influences on PA have also highlighted the importance of using objective measurements of PA outcomes to identify unbiased estimates of the effect of environmental interventions or changes. Most articles in our findings (especially qualitative research papers) noted their lack of generalizability.

Similar to past research on rural environmental influences on PA, there have been no scoping reviews published on environmental influences on HE to our knowledge. Despite this, our results highlighting the importance of food retail environments, schools, and childcare settings are similar to findings from past *systematic* reviews in this field. For instance, research by Calancie and colleagues found that programs and interventions focused on increasing access to nutritious foods/beverages and/or decreasing access to less nutritious options were most common for improving HE behaviors in rural communities. This research also concluded that accommodating distances to food sources, tailoring to local food cultures, and building community partnerships was crucial in rural environments. Our review similarly showed that the distance/proximity of healthy outlets, presence of culturally appropriate and locally sourced food, and partnerships between local food producers and food retail were crucial for promoting HE in rural areas. As another example, research by Pinard and colleagues found that rural communities face different challenges with healthy food access compared to urban settings. Specifically, small, rural food stores lacked healthy food options because store owners feared that customers would not purchase healthier items and faced challenges with distribution. Similarly, articles identified in our search highlighted that the perishability of healthier foods may serve as a barrier to selling fruits and vegetables in rural stores, yet many food retail outlets employed advertising techniques to increase healthy food sales and ensure healthy food sales were profitable. In addition, articles in our search noted that improving connections between local producers and distributors was effective in increasing healthy food availability in rural areas.

Results from our review showed that research on breastfeeding environments has mostly focused on workplaces and hospitals. While workplace breastfeeding supports often included practices or spaces that allow for breastfeeding during the workday, hospital or health-care environment breastfeeding supports were more focused on the presence of healthcare resources (e.g., Baby Friendly Hospitals) in and referrals to other breastfeeding healthcare specialists. To our knowledge, there are very few existing

reviews on breastfeeding environments or supports, and no reviews focusing on rural environments specifically. Despite this, reviews on breastfeeding support in rural and urban locations have focused on hospital and community-based breastfeeding resources and support. As an example, a scoping review by Hadisuyatmana and colleagues found that educating mothers and improving the rate of early breastfeeding initiation was successful for improving maternal and child health outcomes, yet may be tempered in rural settings where traditional values are strongly held or when environmental resources (e.g., health insurance, health care, breastfeeding support resources) are limited.

Implications for public health research & practice

Results from this scoping review should be used to inform public health research and practice by considering the following recommendations. First, given the notable engagement by local stakeholders, like Extension and SNAP-Ed agents, rural policy, systems, and environmental data collected by SNAP-Ed and Extension could be leveraged by local practitioners for surveillance purposes. Second, public health researchers should examine ways to partner with rural schools to collect both school and broader community policy, systems, and environmental effort data. Results indicated that schools were important settings for health promotion, and can specifically provide HE and PA opportunities for children. Adding to this, public health researchers and local health departments should monitor school nutrition environments (specifically federal child nutrition program implementation, and school nutrition policies in support of HE), school garden and farm-to-school nutrition initiatives, monitor community and consumer food retail environments, environment changes for pedestrian-friendly characteristics for walking and bicycling environments, and presence, maintenance, and persistent barriers of PA environmental supports for rural schools, parks, recreation facilities, trails, natural environments, and churches. As seen in our review, local stakeholders were often engaged in interviews and surveys with researchers to help uncover barriers and facilitators for PA, HE, and breastfeeding in rural communities. For this reason, many recommendations listed above relate to improving surveillance efforts by leveraging existing partnerships. Recommendations related to settings that were not identified in our scoping review, like rural community centers and fishing areas, should be explored in the future and incorporated into these recommendations.

Limitations and Strengths

This study has important limitations to note. While our study identified measurement methods used in past research on subjectively-measured environmental change approaches, our results showed limited survey and interview methods to date and low standardization of measurement techniques across studies. Therefore, results should be interpreted with the knowledge that surveillance must be improved in rural areas of the U.S. to create more directed recommendations. Next, due to the large number of articles found on policy, systems, and environmental factors or changes to increase PA, HE, and breastfeeding, this review was split into several papers for publication

(with Policies, Systems, and Environments published independently). Recognizing that policy, systems, and environmental change approaches frequently intersect and overlap, further research is necessary to gain a deeper understanding of these intricate dynamics. Despite this, these papers should be read and interpreted together to provide a holistic understanding of policy, systems, and environmental factors or changes to promote health in the rural U.S. Lastly, given this was a scoping review, we did not conduct reliability checks during article selection or results synthesis phases or provide confidence or bias ratings of selected articles. While the scope and focus of this project limited our ability to report these types of metrics, we made sure to adhere to a strict protocol, provided training for all team members, and held regular meetings to ensure our inclusion/exclusion criteria and results synthesis process were clearly defined.

This review also has notable strengths. First, this was the first scoping review (to our knowledge) that investigated rural-specific policy, systems, and environmental level factors that are related to PA, HE, and breastfeeding. While some past research has conducted systematic reviews of peer-reviewed research, it is important to incorporate grey literature and dissertation research that provide rich information about rural health promotion opportunities that can be used to inform policy, systems, and environmental change strategies. Next, as previously published, this scoping review was conducted using rigorous methods to ensure the validity of our results. Specifically, we included a scientific research librarian on our team to ensure our search terms were comprehensive, we used strict protocols to train those who conducted screening efforts, and we included multiple reviewers to identify review articles. Most importantly, we made sure to conduct our review with a focus on policy, systems, and environmental factors that allowed the research team to accurately review a burgeoning body of literature and practice focused on community and population level change. The PSE change framework is increasingly used to address health behavior and outcome disparities and the compilation of these review papers synthesizes the growing body of literature on this topic. Lastly, this study identified survey and interview methods being used in rural contexts. Compiling subjective tools that are being used in rural settings is crucial for informing qualitative research, theory development, and other initiatives in under-resourced settings.

Conclusions

To summarize, this scoping review identified subjectively-measured environmental factors or interventions related to PA, HE, and breastfeeding in rural settings across the U.S. Our results demonstrated key settings where interventions and programs may be most effective (e.g., parks/recreational facilities, food outlets, workplaces), and highlighted factors (e.g., access/proximity to PA, HE, breastfeeding opportunities) that should be more intentionally measured and incorporated into existing initiatives to improve health behaviors among rural residents. Finally, methods and measurement techniques for

subjectively assessing rural environments have been compiled in our results as a resource to public health researchers and practitioners working to improve PA, HE, and breastfeeding in rural settings. Our synthesis of academic research, graduate theses, and grey literature in this field shows that there are clear opportunities for improving environmental resources and engaging local partners in data collection in rural settings. Moreover, results from this scoping review were used to create recommendations to help improve surveillance of breastfeeding, HE, or PA environments in rural U.S. settings, specifically identifying the need for improvements and standardization in surveillance methods of schools, food retail, parks/recreational facilities, pedestrian infrastructure, churches, and natural environments in rural areas.

Declarations

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Conflicts of Interest

None.

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Authors' Contributions

MEW synthesized review articles, drafted the manuscript, and edited, finalized, and approved the submitted manuscript. MRUM contributed to the conceptualization and design of the study methodology, interpreted study findings, drafted results, and edited, finalized, and approved the submitted manuscript. BH contributed to the conceptualization and design of the study methodology, interpreted study findings, drafted results, and edited, finalized, and approved the submitted manuscript. RLM contributed to the design of the study methodology, acquisition of data, and reviewed and approved the submitted manuscript. KJK contributed to the conceptualization and design of the study methodology, interpreted study findings, drafted results, and reviewed and approved the submitted manuscript.

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Ethics Approval and Consent to Participate

Not applicable in this study. This review has been registered in the Open Science Framework Registration [DOI:10.17605/OSF.IO/VXMDC](#).⁹⁹

Availability of Data and Materials

The complete search strategy and all data generated or analyzed from articles meeting inclusion criteria for this study as it pertains to this manuscript, are included in this published article and its supplementary information files.

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