

The TERRA Framework

Conceptualizing Rural Environmental Health Inequities Through an Environmental Justice Lens

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The deleterious consequences of environmentally associated diseases are expressed differentially by income, race, and geography. Scientists are just beginning to understand the consequences of environmental exposures under conditions of poverty, marginalization, and geographic isolation. In this context, we developed the TERRA (translational environmental research in rural areas) framework to explicate environmental health risks experienced by the rural poor. Central to the TERRA framework is the premise that risks exist within physical-spatial, economic-resources, and cultural-ideologic contexts. In the face of scientific and political uncertainty, a precautionary risk reduction approach has the greatest potential to protect health. Conceptual and technical advances will both be needed to achieve environmental justice. **Key words:** *environmental health, intervention studies, public health, rural health, social justice*

CONCEPTUAL frameworks addressing environmental health (EH) inequities in rural communities are few and far between. As a result, nurses examining the social determinants of EH in underserved and rural communities have had few choices to conceptually ground their work. Because of the challenges in finding conceptual frameworks that reflect a nursing lens, some studies have been conducted atheoretically; others have adapted frameworks from other disciplines.

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This work is supported by NIH NINR R01NR009239, Reducing Environmental Risk to Rural Low-income Families, and NIH NINR, T32NR07039, The Women's Health Nursing Research Training Grant.

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To address this deficit, to capture nursing's multifaceted perspective, and to provide a conceptual foundation for our own studies with rural low-income families, we developed the TERRA (translational environmental research in rural areas) framework. With a dual emphasis on risk (from multiple agents) and risk perception, the framework is intended to strengthen nursing's rapidly evolving body of science addressing EH and environmental justice. Sequentially, this article includes a summary of (1) advances in exposure analysis, (2) issues shaping rural EH inequities, (3) TERRA's development, (4) concepts and practice examples from the TERRA framework, (5) similarities and differences among other social-cognitive EH frameworks, and (6) the importance of conceptually driven EH inquiry.

MEASURES BEFORE MEANING: A SUPERFICIAL HISTORY OF ANALYTIC EH

The past 10 years has been a remarkable time for the conceptualization and measurement of EH exposures. The Institute of Medicine reports addressing medical

curricula, nursing competencies, environmental justice, and EH indicators included specific recommendations addressing curricular insertion points.¹⁻⁴ Advances in analytic techniques gave scientists the ability to obtain reliable low-cost estimates of exposure to prevalent agents such as pesticides and metals.⁵ Armed with a new generation of extremely sensitive tests that were able to calculate contaminants at the parts per billion level, scientists were often challenged in interpreting analytic test results in meaningful ways for clinicians, policy makers, and grassroots activists.

WHY RURAL MATTERS

The vernacular of EH science comes from toxicology and epidemiology and is couched in the language of scientific uncertainties (eg, confidence levels, *P* values). While EH scientists understand the merits of this perspective, citizens do not. Citizens want to know how to fix problems in their homes and get help from local officials. Those living in rural areas face additional challenges in obtaining EH risk reduction advice. Away from city-level municipal services, such families may rely on equally uninformed neighbors for advice about septic systems, drinking water, well maintenance, and household hazards.^{6,7}

Rural health services are frequently underfunded, understaffed, and/or undermined by local officials, with some areas receiving almost no services.^{8,9} As a consequence of perpetual underfunding, public health officials may become aware of EH problems only after the "cow is out of the barn," forced at that point to focus on secondary rather than primary prevention efforts. Many small towns lack safety net programs intended to mitigate problems associated with substandard housing, agricultural runoff, and improper waste disposal. This dynamic can leave citizens with the impression that they need to solve problems on their own; an impression that may or may not be well founded. Hence, the need to develop and test the impact of EH inter-

ventions compatible with the realities of rural public health systems.

In many rural areas, attitudes toward EH issues are strongly influenced by economic factors (eg, finding and keeping a job) and a pervasive distrust of government oversight. As rural communities transition from old (ie, extractive industries) to new (ie, service industries, construction) economic realities, they often experience wide variations in employment, a phenomenon that Bashir refers to as a "feast or famine economic cycle"^{10(p738)} Low-income families are frequently caught up in local economic downturns, resulting in the loss of insurance benefits, extended periods of un- or underemployment, the economic necessity of multiple part-time jobs, or both. The proximity of residential to agricultural property, coupled with lax zoning, lower property values, and less sophisticated local resistance has meant that poorer residents often live adjacent to a variety of point source polluters, ranging from confined animal feeding operations to underregulated small businesses (eg, automotive shops), illicit methamphetamine laboratories, or both.¹¹⁻¹³

TERRA: CONCEPTUAL INSIGHTS FROM EMPIRICAL ROOTS

Our research focuses on testing the impact of environmental risk reduction (ERR) interventions on health indicators in rural Montana and Washington families. Similar to the rural southwest,¹⁴ the performance sites are located in communities strongly influenced by gentrification, with housing costs driving the relocation of both wealthy and low-income families. In both communities, low-income families who move "out of town" in search of less expensive housing often end up with problems (eg, septic failures) they neither understand nor have the resources to fix. Like many places in the intermountain West, we work in communities that are predominately white but rigidly stratified by income and class distinctions. Hispanic and Native American persons in our communities often

express feelings of linguistic isolation, cultural isolation, or both. “Main street” represents a culture in transition, with feed stores and automotive repair shops located near high-end boutiques. In our communities, “trust funders” shop at the organic grocery store; young “minimum wage” families shop at Wal-Mart.

Two small qualitative studies informed preliminary development of the TERRA framework; an initial study with low-income rural mothers and a second study of local leaders’ perceptions of EH risks.^{6,7} These studies helped structure rural citizens’ involvement in the formulation of the framework. Findings from this work provided evidence of the dialectic tension between mothers’ feelings of being “trapped” in poverty and leaders’ beliefs that Westerners wanted to live as regulatory free as possible. This evidence compelled us to build a framework that explicated what EH actions were rationally at the disposal of families and what actions were not accessible to families because of poverty, public health service gaps, and/or prevailing political/economic ideologies.

Our work was further informed by the World Health Organization’s ME-ME (multiple exposures—multiple effects) model, which emphasized the need to look holistically at

EH threats rather than adopting a piecemeal single-agent approach to EH.¹⁵ This holistic approach is echoed in Native and Mexican American perspectives on environmental decision making and management.^{16,17} Subsequent efforts yielded a framework that captured the dilemmas as well as the opportunities for families to act in response to multiple risks.

The scope of the TERRA framework is narrow enough to provide guidance for our intervention research (Environmental Risk Reduction Through Nursing Intervention and Education [ERRNIE] study^{6,7,18}), yet broad enough for us to see the influence of micro- and macroeconomic factors on health behavior. Although relatively young in the theory development process, we have found that the TERRA framework is able to accommodate a multifaceted approach to inquiry, thus allowing us to concurrently examine children’s EH exposures and parents’ capacity to prevent or respond to EH risks.

SUMMARY OF FRAMEWORK

Information addressing the TERRA framework is provided in Figure 1 and Table 1.

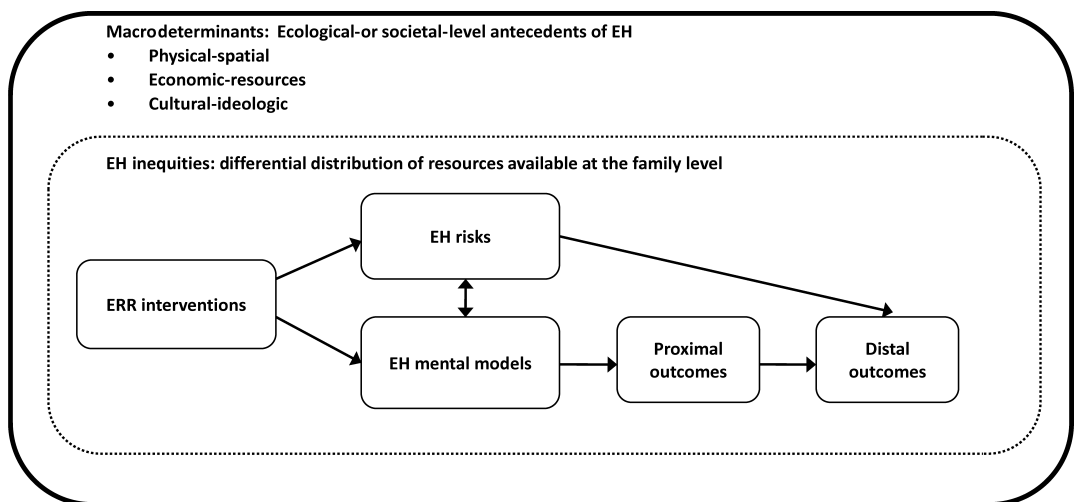


Figure 1. TERRA framework: Key concepts and examples. Abbreviations: EH indicates environmental health; ERR, environmental risk reduction; and TERRA, translational environmental research in rural areas.

Table 1. TERRA framework: Concept descriptions and examples

Concept description	Example
<i>Macrodeterminants: Ecological- or societal-level antecedents of EH</i>	
Physical-spatial: Variations in geographic and spatial characteristics of a region	Contamination of drinking water from application of fungicide on fields; geographic isolation
Economic-resources: Variations in a region's economic vitality	Increased housing costs associated with gentrification
Cultural-ideologic: Variations in citizen's belief systems	Prevailing norms addressing self-reliance, sense of space
<i>Family-level determinants and outcomes</i>	
EH inequities: Differential distribution of resources available at the family level	Choices families have to make in relation to paying rent or fixing leaky roof
EH risks: Potential harm from biologic, chemical, physical, or social agents	Multiple agents in home setting: water contaminants, lead, airborne radon, environmental tobacco smoke, carbon monoxide, mold/moisture, methylmercury
EH mental models: Social-cognitive constructions of risk	Perceptions that one's children are or are not at risk for health problems from airborne radon
ERR interventions: Education, guidance, and mitigation addressing EH risks	No-cost/low-cost options to reduce EH risks; interactive educational tools
Outcomes: change in risk, risk perceptions, or both	
Proximal: Changes in social-cognitive constructions of risk	Families' knowledge, self-efficacy
Distal: Changes in ERR actions; reductions in exposures, disease	Behaviors adopted to reduce children's exposure

Abbreviations: EH, environmental health; ERR, environmental risk reduction; TERRA, translational environmental research in rural areas.

Figure 1 addresses key concepts and relationships; Table 1 includes a description of concepts and respective examples. Concepts in the framework include the following: (1) *Macrodeterminants* of EH, are multifaceted and include *physical-spatial* (eg, topography, climate, proximity to services), *economic-resources* (eg, power base of local businesses, social safety net), and *cultural-ideologic* elements (eg, property rights and land use norms). (2) *EH inequities*, refer to the differential distribution of resources available to reduce exposure to environmental risks. Best viewed as gaps between the rich and poor about income, housing, neighborhood entrée, and job opportunities, EH inequities reflect the unequal

playing field about health protection options. Making them explicit allows more accurate insights into risk reduction actions by families that may seem short sighted from an outsider's perspective. While macrodeterminants are just that—macro- and societal-level influences—EH inequities reflect resource availability at a family level and provide a more immediate context for ERR interventions. Understanding EH inequities can help guide the delivery of public health interventions for families that do not own a reliable vehicle or live in a weather-proof home. (3) *EH risks*, refer to the potential for exposure to biologic, chemical, physical, and social agents with deleterious health consequences. (4) *EH mental models*, refer to beliefs about

risks. People decide to act (or not) on the basis of a social-cognitive construction of a risk; this “mental model” may or may not reflect current scientific views about EH.¹⁹ (5) *ERR interventions*, are delivered by health providers, can either directly mitigate EH risks or indirectly alter the mental models pathway, such that citizens act to change their risk. (6) *Proximal outcomes*, such as knowledge, risk interpretation, and/or self-efficacy, are the tools that families need to have both the information and confidence to act. These outcomes may or may not result in a change in risk reduction behavior. (7) *Distal outcomes*, refer to families’ ERR actions, reductions in exposure, and decreases in disease incidence, severity, or both.

EXPLICATION OF KEY CONCEPTS

Macrodeterminants

The natural and anthropogenic world sets the stage for EH risks and citizens’ perceptions of those risks. The TERRA framework focuses on physical-spatial, economic-resources, and cultural-ideologic determinants, not because they encompass all EH risks (they do not), but rather because they influence the options that rural citizens have to respond to EH risks. For example, citizens living by agricultural fields are impacted by the physical-spatial characteristics of the site (eg, pesticide dispersion patterns) as well as the area’s economic vitality (eg, housing affordability). Ideologic themes in public hearings often reflect a variety of themes, ranging from the attribution of blame to viewing EH hazards as a quid pro quo for local high-paying jobs. It is common for us to hear workers attribute local job losses to “government interference” or “environmentalists” rather than market forces or business decisions. Ideologic determinants vary by community and agent of concern; however, like Native American and southwestern Hispanic communities, the communities in which we work both influence and are influenced by strong beliefs

about self-reliance and a sense of place.^{6,16,20} This conceptualization, which presupposes that macrodeterminants play a key role in the generation of EH risks, is similar to related conceptualizations addressing environmental justice, the built environment, and EH indicators.

Inequities

In an examination of rural hospitals in the United States, DeVries concluded that “when you’ve seen one, that’s all you’ve seen.”^{21 (p38)} Such a conclusion is equally apropos in trying to understand the subtle and multiplicative effects of inequities faced by rural families. In addition to well-documented differences in income between urban and rural citizens, race/ethnicity, economic vitality, and health access issues also impact families.^{22,23} Both our research sites have had a recent influx of affluent retirees and telecommuters into the area. Low-income families in these communities now face a de facto competition for resources with families who do not need a local paycheck to make ends meet. Rather than urban gentrification patterns that typically displace low-income citizens, Yagley and colleagues²⁴ noted that the rural poor are more likely to be “locked out” by gentrification, discovering one day that they no longer have access to riverfronts or open space. Only 50% of Montana residents’ income comes from within the state, so that economically and professionally connected citizens live in a different world than those relying on the local economy.²⁵ In our studies, EH inequities often “look like” a family living in a trailer with no insulation, a leaky roof, and well water they do not trust. In this context, overt and immediate demands for resources (eg, rent) often take precedence over desired but less pressing needs (eg, home repairs). Finally, rural EH inequities are only one facet of a broader constellation of disparities that impact families of color, those on tribal nations, and those isolated by language, culture, or with beliefs outside the prevailing norm.^{22,26}

EH risks

Environmental health risks refer to the potential of an agent to induce a health problem. Our study addresses household risks such as radon, carbon monoxide, mold/moisture, water contaminants, methylmercury, lead, and secondhand smoke. EH risks vary remarkably across hydrogeographic regions and in relation to unique local features (eg, agricultural crops, geology). Unfortunately the aggregation of EH data at state and regional levels often homogenizes such differences, further enhancing the invisibility of local yet severe problems.²² This problem is exacerbated by our limited understanding of genetic polymorphisms and variations in individuals' susceptibility to exposures. Both issues decrease the signal-to-noise ratio in EH, making it even more difficult to link exposures with disease consequences.

Rather than focusing on a single agent-outcome relationship, many EH scientists, including ourselves, are quantifying risks to multiple agents within a specific setting, such as a home or school. From running multiple tests in a home, we have noted patterns in our laboratory test results as they come in; the presence of one positive test was a strong predictor of subsequent positives.²⁷ It makes sense that a home that is substandard in one way (eg, elevated carbon monoxide levels) is likely to be substandard in multiple ways (eg, leaky toilet seals and mold growth). Such a "confluence of environmental risks" characterizes the pervasive influence that poverty imposes on rural children. An "examination of the health consequences of singular risks may underestimate the true environmental risk profile of low-income children."^{28(p1942)} This conceptualization of risk is consistent with a social ecological perspective, which challenges the merit of theories that quantify causation in "a thicket of decontextualized factors."^{29(p148)} The work of May et al³⁰ exemplified this broader perspective. Working with a rural Texas colonia, she notes that EH information should be "laced with local meanings and is produced from, rooted in, and connected to the local context."^{30(p1573)}

EH mental models

Risks are perceived dynamically, with thoughts and feelings contributing to citizens' conclusions about EH risks and the impact they can have on them. Cognitive psychology and neuroscience provides evidence that people develop personalized risk understandings through 2 interacting systems; a cognitive analytic system and an intuitive experiential system.³¹ Applied studies of human behavior provide evidence that people are most concerned about tangible EH risks in their community.¹⁹ Information from one's experience is integrated into personal understandings that fall on a continuum from being absent to well developed. These beliefs, which may differ widely from established knowledge, form the basis for decisions and actions. For example, participants in our study were asked to rate their level of concern about a number of local issues. Not surprisingly, tangible risks were ranked higher than intangible risks, with higher levels of concern noted for mold and Hantavirus, than for airborne radon, despite widely disseminated information that local radon levels were frequently found to be above the EPA action level.

ERR interventions

Environmental risk reduction interventions are based on the premise that mental models can be reformed through the provision of salient health information. Dixon and Dixon³² noted the limitations of EH education materials and proposed a broader approach to the epistemology of risk reduction information. The TERRA framework is consistent with this approach and based on the belief that the provision of agent-specific information is insufficient to improve public health. Rather, health is considered as a whole within the context of multiple EH risks. For example, actions to mitigate lead exposure, such as hand washing and damp-mopping, will reduce risks from other agents as well. It is not uncommon in our study to see well water results that reflect a pattern of potential risks, even though each

individual agent (eg, arsenic, nitrates, lead) is slightly below the threshold value. In such situations, the intervention nurse discusses the ambiguities of well testing and may use the test results to explain that, taken as a whole, there may be additive rather than single risks to children.

Consistent with the mental models perspective, TERRA is based on an informed decision-making approach that casts persons as active problem solvers. Motivational interviewing strategies are used by the nurses to elicit individuals' risk beliefs and frame the intervention using participants' own arguments for change. This approach enables ERR recommendations to be "compatible with regional and political identity" versus those framed in outsiders' language.^{6(p109)} In keeping with the clinical principles upon which motivational interviewing is based, participants' ambivalence is accepted, argumentation is avoided, and resistance is explored.³³ Action items, such as ways to decrease children's exposure to secondhand smoke, are negotiated between participants and the intervention nurse.

Our goal is to facilitate an iterative process that promotes co-understanding about EH issues and concerns between researchers, nurses, and communities in which we work. This process is akin to the social capital conceptualization of rural nursing proposed by Lauder and colleagues,³⁴ whereby rural nurses are both integral members of rural healthcare systems and rural communities.

Timing and elements of ERR interventions

Lindell and Perry noted that risk reduction information is frequently provided in a piecemeal manner. They maintain that in many health departments different issues (eg, agents) fall under the jurisdiction of different departments, with each area framing information from their service perspective. The result is that, although families may end up with a handful of pamphlets, they "lack the time and energy to sort through the mass of informa-

tion produced by all these agencies."^{35(p121)} While people may receive information about various EH agents, safety judgments are typically based on information integration. Our intervention book incorporates photos of each intervention family's children in the book itself and is intentionally jargon free. The book is highly interactive and uses cutouts that allow a participant to open a window, see his or her test results, and compare his or her results with threshold values. There are spaces to fill in contact information for local service providers (eg, household hazardous waste collection, county extension agent), specific questions for health department personnel, and personalized action plans. ERR recommendations are low cost and practical for resource-poor families. For example, running the tap for 5 minutes can help clear old pipes of standing water that may contain heavy metals. Setting up rain gutters to divert water away from the home can help prevent expensive home repairs later.

Outcomes

Improvements in health are based on a series of complex and time-dependent events. People must see an issue as salient if they are to use information about that issue.³⁶ For example, changes in asthma severity may (or may not) be based on antecedent changes in parental beliefs, behavior, and levels of in-home allergens. Some of the "healthy homes" studies exemplify this approach and judiciously select outcomes that capture changes in health status (eg, number of days of β_2 -agonist medication use) as well as the consequences of those changes (eg, number of workdays parent missed within the past month).³⁷ Commensurate with a process-oriented approach, the TERRA framework differentiates between proximal and distal outcomes.

Proximal outcomes of interest include accurate beliefs about EH, self-efficacy in enacting risk reduction behaviors, and advancement on the precaution adoption continuum. Instruments have been either adapted³⁶ or

developed and pilot tested to measure these outcomes.³⁸ Distal outcomes include an increase in ERR actions and a decrease in the number or level of abnormal exposures. Objective (direct observation) and subjective (self-report) instruments document a change in ERR actions. Exposure data are collected by measuring levels of household radon (3-day kit), carbon monoxide (monoxer), wood moisture equivalent (Protimeter), and water contaminants (full well screen). Blood lead, salivary cotinine, and hair methylmercury samples measure changes in the level of exposure. This delineation considers the temporal sequence of risk reduction changes and can help guide the selection and timing of study measures (eg, risk perception change scores). Although this approach is not unique in its relevance to rural populations, the differentiation between proximal and distal outcomes allows for the inclusion of place-based outcomes that promote a more comprehensive understanding of rural EH problems. It can also generate knowledge about how information impacts health outcomes through specific belief patterns.

WHERE TERRA FITS: RELATED CONCEPTUALIZATIONS ADDRESSING ENVIRONMENTAL HEALTH

Several frameworks have emphasized EH disparities, highlighting spatial concentrations of poverty/affluence and neighborhood cohesion. Race and place figured prominently in Gee and Payne-Sturges³⁹ stress-exposure-disease framework. The authors differentiated between individual- and community-level vulnerabilities, noting that both contribute to a cumulative burden of stressors, which can amplify the deleterious consequences of EH exposures. Similar themes were apparent in the work of Schulz and Northridge,⁴⁰ who examined social antecedents of environmental inequalities. The ecological stress model by Parker et al incorporates stressors and intervening factors at multiple levels of an ecological framework. Used primarily to guide in-

terventions in urban populations, the authors state that "the contextual nature of exposure to stressors suggests that research and interventions will be more effective if they are context specific."⁴¹(p505) Other models emphasize the role of community and partnership capacity in promoting environmental health and justice, paying particular attention to the role partnerships play in promoting relevant public policy.^{42,43} Overall, these contributions explicate the dynamic nature of EH and the continued need for a response to EH risks through context-based ERR interventions applicable for family- or community-level research in rural areas.

Nurses have historically conceptualized EH through a social justice lens, emphasizing advocacy and prevention.⁴⁴ Dixon and Dixon proposed a translational EH framework based on 4 conceptual domains: the physiologic, vulnerability, epistemological, and health protection domains. They noted the limited impact of public health actions that focus exclusively on the physiologic domain (eg, toxic potential of agents) stating that an understanding of the physiologic domain is necessary but insufficient to inform successful risk reduction programs.³² Equally important to translating EH is understanding how hazards are distributed among groups such as the rich and the poor (the vulnerability domain), how citizens find out about hazards, (the epistemological domain), and how people engage in EH (the health protection domain). Recently, Postma summarized 3 relevant dimensions of the environmental justice movement for translational EH nursing research. These include (1) reconceptualizing the "environment" to include the sociocultural context in which EH risks occur, (2) recognizing preexisting social networks as a strengths-based approach to working with politically marginalized groups, and (3) engaging community-based organizations and citizens alongside scientists in the research process.⁴⁵

Via their position at the intersection of public policy and people's personal lives, nurses are "ideally situated and morally obligated"

to promote health through political advocacy and efforts to influence public policy.^{46(p212)} The TERRA framework begins to address this call by building on previous conceptualizations of EH in the context of social justice to explicate EH risks experienced by the rural poor and appropriate risk reduction strategies.

THE VIEW FROM ABOVE: USING TERRA TO INFORM POLICY

The TERRA framework focuses on family-level interventions in a rural public health context. Successful interventions inform policy development. For example, our analyses to date suggest positive associations between the level of information that parents have and the number of unsafe exposures found in the home. Such findings provide evidence of the need for public health policy changes at the state and local level (eg, requiring more comprehensive disclosure of EH risks [eg, radon] by landlords and realtors).

There is flexibility in the framework to use community-based participatory research approaches to incorporate citizens' voices into the inquiry process (eg, by identifying relevant macrodeterminants in a particular community) and integrating research findings with political action. Similar ERR partnerships, for example, have instituted routine lead testing at the local health department and Indian Health Service and helped stop the use of chat (mine tailings) in construction and on roads without proper containment.⁴² Community partners play a critical role in interpreting findings locally and "taking knowledge into the political change arena," especially when institutional constraints make direct advocacy difficult.^{47,48(p318)}

Use of the framework may also lead to the development of more efficient public health-care systems. By focusing on actions aimed at mitigating risks to multiple agents, health departments may be able to "de-silo" agent-based programs (eg, lead) and incorporate broad-based risk reduction into multiple programs,

including those that are not typically considered within the purview of EH (eg, Women, Infants, and Children). Compared with the frameworks of EH disparities proposed by Schulz and Northridge and Gee and Payne-Sturges, which both address a broad range of macrolevel antecedents, our framework includes social-cognitive factors that shape how information is interpreted and applied in the context of translational interventions.^{39,40} These cognitive processes may be moderated by inequities and EH risks; however, our goal is to target specific parental behaviors that have the greatest potential to reduce exposures to children.

Our future work will explore the boundaries of the framework, its relative fit or lack thereof in more ethnically diverse communities, and the extent to which its US-centric lens may or may not work in other parts of the world. We also plan to drill into the relationships between each concept, differentiating between sequential and iterative mechanisms of change. Thus, in an effort to understand how persons address EH risks in their daily lives, the TERRA framework paints on a small canvas, yet can help inform broader and related discussions addressing EH policy and the scope of nursing practice.

CONCLUSION

Rural communities face new challenges from confined animal feeding operations, groundwater depletion, and agricultural runoff. Recent initiatives addressing hazardous waste cleanup and sustainable growth are laudable; however, the resources needed to diagnose and remediate past problems vastly outstrip those available. Complex problems require strategic solutions and EH scientists have shown remarkable flexibility in reconciling toxicological and behavioral health perspectives to this end. Embracing that complexity means that, once again, "frameworks matter" because they "determine the research questions that are posed and investigated."^{49,50(p212)}

The TERRA framework proposes a broad conceptualization to inform EH research and is poised within its lifecycle to transition from constructivist roots to empirical testing.

The TERRA framework adds to the repertoire of conceptual tools designed to advance a reflexive agenda for the next generation of EH research.

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