

Health on the Rocks: Geohealth in Kentucky

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Geohealth sits at the crossroads of geology and human health, bringing earth science into direct conversation with medicine, clinical outcomes, and public health response. When diverse geologic systems shape everything from radon exposure to flood-driven disease risk, understanding the health impacts of our landscapes isn't optional—it's essential. This publication highlights key areas where Kentucky's geology intersects with acute and chronic health outcomes, offering insights into risk, resilience, and the scientific frontiers of geohealth.

Earth Processes Impacting Human Health

Kentucky has distinct geological localities characterized by different geological processes that produce unique medical and clinical risks. In addition, the impacts of natural hazards and extreme weather (e.g., tornadoes, floods, droughts) compound health risks across these regions. These events are not just environmental; they are deeply

tied to respiratory illness, toxic exposure, public health response, and trauma care.

FLOODING & LANDSLIDES In the Eastern Kentucky Coal Field and Appalachian Plateau, steep slopes and unstable soils create high landslide risk, and many landslides are triggered by extreme rainfall that can also lead to flooding (Crawford et al., 2016). These events result in traumatic injuries, waterborne illness, respiratory disease from mold, and major delays in emergency medical response as transportation networks are impacted (Yard et al., 2014).

GEOGENIC EFFECTS OF TORNADOES Tornadoes, such as those that occur in the Mississippian Plateau and Mississippi Embayment, alter the landscape by stripping topsoil, exposing or redistributing contaminants (solid and liquid human wastes) and microorganisms, and disturbing legacy mine sites (Summers et al., 2021; Kaya et al., 2024). In addition to damage to life and property from direct contact with high-speed winds and

debris, these geologic disruptions also contribute to mental and respiratory illness and obstruct access to care (Lee and First, 2022).

SINKHOLES Common in the karstic Mississippian Plateau and Inner Bluegrass, sinkholes can collapse during intense rain or drought (Currans, 2002). These sudden events damage homes and infrastructure, causing injuries and disrupting access to utilities and emergency medical services.

EARTHQUAKES The New Madrid Seismic Zone produced a series of devastating earthquakes in the winter of 1811–1812. The zone remains active, regularly producing smaller events, indicating that western Kentucky could someday again be affected by damaging earthquakes (Crawford et al., 2016). Earthquake events could cause widespread trauma, damage hospital infrastructure, release contaminants (e.g., wastewater, heavy metals, pathogens), and interrupt power and water systems essential to clinical care (Bayram et al., 2023).



Landslides can be far more than cosmetic—they can block roads, damage utilities, and disrupt entire communities. This 2012 slide in Lewis County highlights the risks of unstable slopes in Kentucky.



Cover-collapse sinkholes form when the ground caves in, exposing openings in the limestone below. These openings can expand over time, making sinkholes a continuing hazard in karst terrain.



KGS scientists measure radon gas in soils across Kentucky to better understand where risks are highest and how radon is moving beneath the ground. Radon is a naturally occurring gas that can seep into homes, and long-term exposure can impact health.

Water and Airborne Contamination

Kentucky’s geology creates natural pathways for contaminants with direct health consequences.

RADON EXPOSURE Kentucky leads the nation in lung cancer incidence and mortality among both smokers and non-smokers (Brainson et al., 2021). A major contributor is the state’s limestone karst and black shales, which emit high levels of radon, a radioactive gas known to be

a carcinogen (Haneberg et al., 2020). Radon is the second leading cause of lung cancer in the United States (Clement et al., 2010). Poorly ventilated buildings over uranium-bearing shale or karst bedrock intensify exposure, particularly in rural and Appalachian areas lacking mitigation infrastructure (Stanifer et al., 2022).

LEGACY NUCLEAR SITE RADIATION Legacy nuclear sites in Kentucky, including the Maxey Flats disposal site and the Paducah Gaseous Diffusion Plant, have led to long-term environmental contamination with radionuclides such as plutonium, technetium-99, and uranium (Cleveland and Rees, 1981; Foye, 2025). These can pose chronic health risks through groundwater and airborne exposure pathways, including elevated cancer risks and kidney toxicity from ingestion or inhalation of these radionuclides (Thomas et al., 2017).

ACID MINE DRAINAGE & MOBILIZED METALS Sulfide oxidation in coal seams and natural geologic weathering release toxic metals like arsenic, lead, and manganese into water sources. These mobilized metals pose serious health risks—including cancer, neurotoxicity, renal damage, and developmental impacts—through chronic exposure in drinking water (Dsa et al., 2008).

NUTRIENT POLLUTION Nutrient-rich runoff from agriculture, urban sewage, and karst terrains contributes to degraded water quality and downstream toxicity. These increase the potential for harmful algal blooms (HABs) in Kentucky (de la Cruz et al., 2017), which produce hepatotoxins and neurotoxins that may cause liver failure, neurological damage, and skin irritation—often requiring

hospitalization (Backer et al., 2015). While HAB impacts are amplified by warmer temperatures, nutrient-driven water contamination also plays a role in gastrointestinal illness and dermatologic irritation (Borowski and Carroll, 2015).

AIRBORNE DUST & GAS Disturbance of geologic materials releases silica dust, coal particulates, asbestos, volatile organic compounds, and hydrogen sulfide, contributing to respiratory disease. Hydrogen sulfide exposure can cause eye and airway irritation, neurological effects, and in high doses, respiratory collapse (Batterman et al., 2023). Combined exposures increase risk for silicosis, black lung disease, and other serious pulmonary conditions.

MICROBIAL CONTAMINANTS Rapid recharge and limited filtration in karst aquifers make them highly susceptible to pathogen intrusion. Flooding or heavy rainfall can introduce fecal bacteria and protozoa into drinking water, increasing gastrointestinal illness and enteric infection rates (Gray and Engel, 2013; Yard et al., 2014).

Geohealth Solutions: From Bedrock to Breakthroughs

Kentucky is poised to lead in developing targeted, geoscience-informed health strategies.

BIOPROSPECTING Extremophile microbes from Kentucky’s caves, coal seams, and deep boreholes offer novel potential in antibiotic, antiviral, anti-cancer, and immunomodulatory drug development (Beattie et al., 2011).



Water from an abandoned coal mine in McCreary County picks up acid as it moves through shale, then flows across limestone, which helps neutralize it before reaching downstream rivers. This natural “chemical balancing act” shows how geology can both cause and reduce environmental impacts.



When heavy rain hits a karst landscape, sinkholes and underground channels can’t drain water fast enough. The flooding gets worse when development fills in natural drainage paths. In some cases, the only safe fix is moving houses out of the floodplain. Photograph by Jim Rebmann, Lexington-Fayette Urban County Government.



Bioprospecting is the search for microbes in extreme environments like caves to see what unique compounds they produce. These natural products could become new medicines, tools for cleaning up pollution, or ingredients for useful technologies. Photograph by Nicholas Belen.

BIOREMEDIATION Naturally occurring geomicrobes are already being adapted to detoxify arsenic, nitrates, and other groundwater contaminants—reducing clinical exposures and disease burdens (MacDonald et al., 1999).

PREPAREDNESS & RESPONSE Kentucky is building geologic and microbial monitoring networks, which will enable near real-time event prediction and support health forecasting, hospital surge planning, rural healthcare response, and early disease detection.

Conclusion: Why Geohealth Matters Now

Kentucky's geology isn't just a backdrop; it's a driver of clinical and public health outcomes. From radon-linked lung cancer to flood-borne infections, earthquake-related trauma, and the health impacts of nutrient runoff and extreme weather, the geology of the Commonwealth helps to shape disease risk, emergency response, and long-term care challenges. As environmental variability accelerates and health systems face increasing strain, integrating geologic insight into medicine is essential. Geohealth provides the framework to anticipate and mitigate these risks through targeted diagnostics, bioremediation strategies, disaster preparedness, and innovative therapeutic discovery. By bridging the gap between earth's processes and human health, we can better protect our communities, improve outcomes, and lead the nation in a field where geology becomes a frontline asset in medicine.

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