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Health implications of the rapid rise of data centers in Virginia: an exploratory assessment

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Driven by advances in cloud computing, cryptocurrency, and artificial intelligence, the rapid proliferation of data centers may pose severe human and planetary health risks. This paper, to the best of our knowledge, is the first-of-its-kind assessment of the potential health implications associated with data centers. Here, we examine the case of Virginia's Data Center Alley, the world's largest concentrated data center hub, and argue that data centers can cause public health harms, harms that can be at least partially mitigated through improved planning and design. We assess the health risks associated with data centers, including air pollution, extensive water use, noise pollution, and detrimental land use's risk of disrupting natural ecosystems and community well-being. We also address how rising energy costs can worsen social determinants of health. To mitigate these risks, we recommend transitioning data centers to renewable energy, implementing strict regulations to minimize water consumption, and optimizing site planning with acoustic treatments and green zoning to reduce noise pollution. Additionally, we advocate enforcing responsible site selection and zoning regulations to curb adverse land use changes, equitable energy pricing to alleviate economic burdens, and strengthening health communication for informed public and governmental decision-making, action-oriented advocacy, and policy changes. Finally, we emphasize the need for transdisciplinary research integrating physical sciences, engineering, and public health to quantify specific health outcomes linked to data centers.

KEYWORDS

advocacy, climate change, data centers, public health, sustainable development

Introduction

The surge in demand for computing infrastructure, driven by advancements in cloud services, cryptocurrency, and artificial intelligence, has led to extensive data center construction globally (Masanet et al., 2020; International Energy Agency, 2024). There is a small but growing body of research on societal problems associated with data centers (see Al Kez et al., 2022; Lei et al., 2023) but to the best of our knowledge, research has not yet been done on the human health effects of data centers. Here, we make the case that data centers can cause public health harms, harms that can be at least partially mitigated through improved planning and design.

In this paper, we present evidence arguing that data centers may pose significant health risks, including diseases associated with air pollution from fossil fuel combustion, waterborne illnesses resulting from excessive water usage, and both mental and neurological health concerns related to noise pollution. We further discuss how data center construction drives large-scale land use changes, degrading natural ecosystems and community well-being, and how rising energy costs can worsen social determinants of health. Finally, we emphasize that children, the elderly, and low-wealth groups can be particularly susceptible to the health impacts associated with data centers.

Although data centers are expanding globally, here we focus primarily on Northern Virginia because it is one of the largest concentrations of data centers anywhere in the world, using it as a case study to draw broader public health insights. This area is often referred to as the "Data Center Alley", handling an estimated 70% of the world's internet traffic (Samuelson, 2024). The region's proximity to Washington, D. C., coupled with early investments in fiber-optic networks and energy infrastructure, affordable land, low-cost energy, and minimal natural disaster risks, has made Northern Virginia a prime location for data centers since the 1960s (Kidd, 2023). State policies, such as the 2009 sales tax exemption for data center equipment, have further strengthened Virginia's leadership in the data center industry.

Figure 1 illustrates the geographical distribution and scale of both existing and proposed data centers in Northern Virginia, showing that nearly 80% are located in three counties: Loudoun, Prince William, and Fairfax. Data on existing and proposed data centers suggests that this geographic distribution will only get more concentrated in the region, with data center footprints expected to more than double in the region as more and larger installations go online. Other areas where data centers are currently concentrated include counties surrounding Virginia's capital, Richmond (e.g., Henrico and Hanover counties).

While Virginia's data centers generate economic benefits, which can be an asset in strengthening the region's social determinants of health, it is important to determine whether these gains are equitably distributed or whether they merely exacerbate existing economic and health disparities. Moreover, addressing the subtle yet growing climate threat from data centers, which poses a risk to Virginia's climate progress, is essential. Below, we discuss the potential health implications of data centers related to air pollution, excessive water use, noise pollution, land use changes, and economic burdens on low-income households.

This exploratory assessment draws on peer-reviewed and grey literature published from the early 2000s through 2025, identified through targeted searches of academic databases (Google Scholar, PubMed, Web of Science, and Scopus) using search terms including data centers, digital infrastructure, energy demand, air and water pollution, noise, land use change, climate change, and public health. Given the rapidly evolving nature of data center development and regulation, we also included grey literature such as government and regulatory reports, established environmental organizations reports,

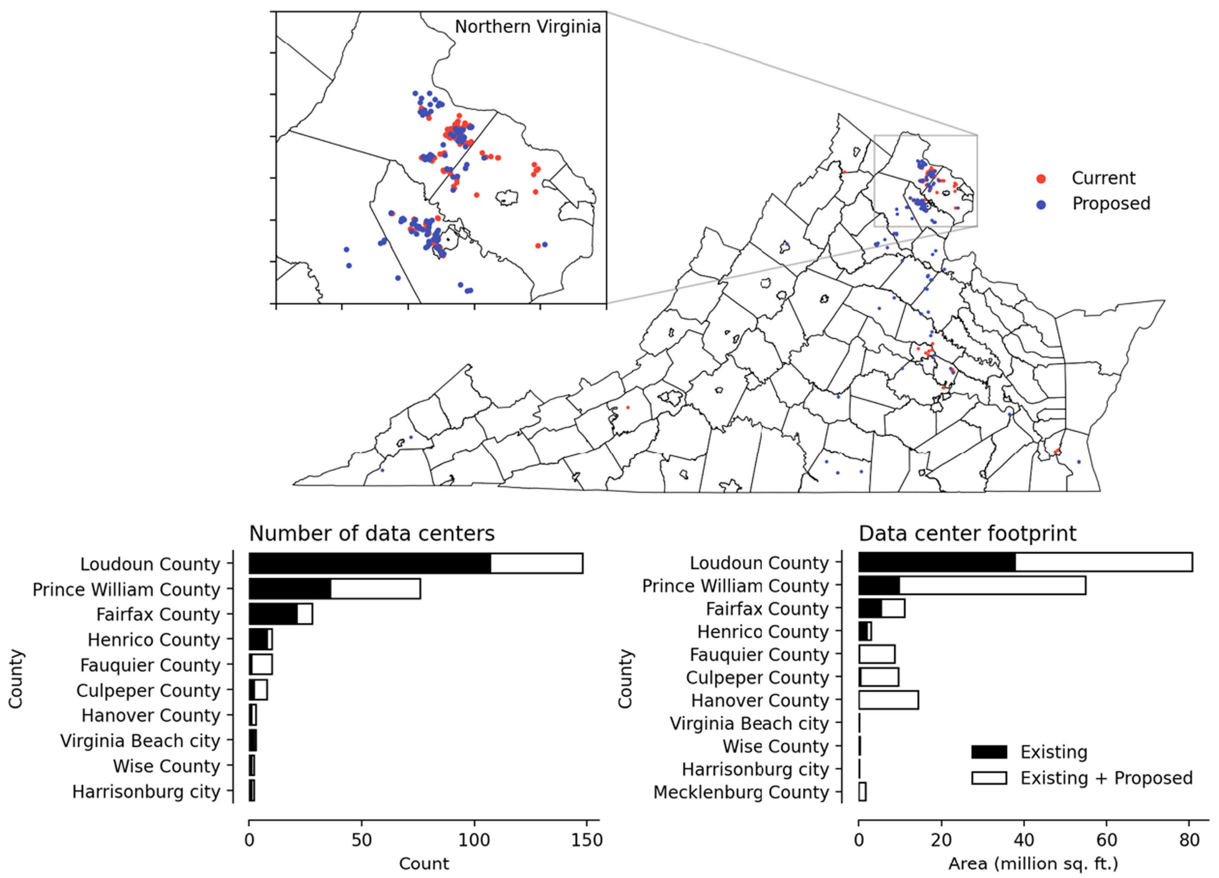

FIGURE 1
Distribution and scale of existing and proposed data centers in Northern Virginia. Data source: Piedmont Environmental Council (2024) (The Piedmont Environmental Council has pulled together this information on existing data center facilities (that they are aware of), along with pending data center proposals they have found on various town and county websites, as well as through various news outlets. It is their best approximation given the information available and is subject to change as more data centers are proposed, approved, or denied), Accessed March 2024.

and coverage from reputable media outlets, which were evaluated based on institutional authorship, transparency of sources, and consistency with peer-reviewed evidence. Sources were selected to synthesize converging evidence across disciplines and to identify plausible health pathways, knowledge gaps, and policy-relevant concerns.

Likely health impacts of data centers

Air pollution

Data center operations increase electricity demand and reliance on fossil fuel–based power generation and backup diesel generators, contributing to increase in air pollutant emissions [Cohen et al., 2017; Joint Legislative Audit and Review Commission (JLARC), 2024]. These emissions may contribute to both short-term exposures (e.g., acute respiratory and cardiovascular effects) and long-term health risks, including chronic disease, adverse reproductive outcomes, and premature mortality (Di et al., 2017; Rajagopalan et al., 2018; Conforti et al., 2018).

Data centers in Virginia are a major source of air pollution attributable to their round-the-clock energy-intensive operations, a critically strained electric grid, and backup diesel generators (Piedmont Environmental Council, 2024). Despite their essential role in the digital economy, data center sites in Virginia consume a substantial portion of the state's electricity, with an estimated power use of 5,050 megawatts [Joint Legislative Audit and Review Commission (JLARC), 2024]. The rising electricity demand from data centers, which accounted for 21% of Virginia's major utility company Dominion Energy's sales in 2022 and is projected to double by 2040 (Piedmont Environmental Council, 2024), drives higher greenhouse gas emissions and air pollution, thereby increasing chronic health risks.

Virginia's electricity generation heavily relies on fossil fuels, with 54% from natural gas and 4% from coal (U.S. Energy Information Administration, 2024b). Virginia imports a significant share of its electricity (36% in 2024), making it the largest net importer in the US, and because much of this power comes from coal-heavy states like West Virginia (where 86% of generation is coal-based), the state's demand shifts pollution burdens across its borders (U.S. Energy Information Administration, 2024a,c). This reliance on fossil fuels, primarily natural gas—which consists of 70–90% methane—contributes to greenhouse gas emissions and air pollutants such as sulfur dioxide, nitrogen oxide (NO_2), particulate matter (PM), and carbon dioxide (CO_2) exacerbating climate change and worsening air quality-related health risks (Cohen et al., 2017; Mailloux et al., 2022; Lelieveld et al., 2019; Vohra et al., 2021). These gaseous and particulate pollution are linked to serious health harms including respiratory and cardiovascular diseases, various cancers, neurological disorders, and conditions such as stroke, dementia, diabetes, and childhood asthma (Lelieveld et al., 2023; Peeples, 2020; Markandya and Wilkinson, 2007; Shah et al., 2015; Wang et al., 2022; Rajagopalan et al., 2018). Moreover, air pollution has been linked to reduced fertility, lower live birth rates, and increased risks of miscarriage and stillbirths, highlighting significant concerns for female reproductive health (Conforti et al., 2018).

Data centers' extensive use of diesel generators causes air pollution which may further exacerbate the health issues noted above. Virginia's data centers have more than 4,000 backup diesel generators. Used primarily during power outages, which Federal Energy Regulatory Commission (FERC) estimates to have been 6.78 h per year for the average customer in Virginia in 2022 and 2023, these generators also undergo routine testing 10–30 min per month [Joint Legislative Audit and Review Commission (JLARC), 2024], yielding an estimated number of hours in use statewide of approximately 35,000 to 51,000 h.[1] When in use, these diesel generators can emit harmful pollutants like NO2, particulate matter, and carbon monoxide (Tsai et al., 2011; Liu et al., 2005; Liang et al., 2005; Saiyasitpanich et al., 2005). Exposure to these pollutants has been associated with respiratory and cardiovascular diseases and neurological problems, particularly among older adults and children (Hesterberg et al., 2012; Peeples, 2020; Loh et al., 2007; Zhang, 2017).

Moreover, rising temperatures from climate change increase cooling demand and together with the rapid growth of data centers, add additional strain to the grid, raising the likelihood of power outages, particularly during heat waves (Do et al., 2023). Virginia has experienced increasingly frequent and severe heat waves over the past decades, with average summer temperatures rising by nearly 2 °F since 1970 (NOAA National Centers for Environmental information, 2025). Cooling degree-days have increased across all climate divisions in Virginia, rising by 11 to 25 °C days per decade over the past 60 years (First Virginia Climate Assessment, forthcoming 2025), which directly increases summer cooling demand—a key driver of data center energy use (Ruess et al., 2025). In June 2025, a record heat wave caused 828 heat-related emergency visits statewide in 4 days (Natural Resources Defense Council, 2025). The urban heat island effect, particularly pronounced in densely built regions like Northern Virginia, further increases local temperature extremes and cooling demands. These conditions heighten the energy needs of data centers, worsen air quality, and compound cardiovascular and respiratory risks, while also increasing the likelihood of power outages that impact individuals with existing health conditions.

Additionally, the reliance on diesel generators during power outages, particularly by hospitals and data centers, can worsen air pollution, further increasing health risks during these hot periods. Studies have shown that extreme heat can significantly increase cardiovascular mortality and, when combined with high PM 2.5 levels, can also elevate the risk of mortality from myocardial infarction, especially among women and the elderly (Khatana and Groeneveld, 2023; Xu et al., 2023).

Beyond air quality and health effects, data centers are also an emerging driver of climate change. U. S. data centers emitted 105 million tons of CO_2e in 2023–2024, accounting for 2.2% of national emissions (Guidi et al., 2024). While data centers currently account for a smaller share of global emissions than fossil fuel industries, their rapid growth and geographic concentration make them a rising climate and health risk. For perspective, Heede (2013) showed that just 90 fossil fuel producers

1 Calculations are based on an average annual outage of 6.78 h per customer (6.78 × 4,000 = 27,000 h) and aggregate monthly testing of 10–30 min per generator (10–30 min x 12 months x 4,000 generators = 8,000–24,000 h).

are responsible for nearly two-thirds of historic global emissions, underscoring the urgency of addressing emerging sources like data centers.

Water consumption and pollution

Data centers affect health indirectly through intensive water use and wastewater discharge associated with cooling systems, which can strain local water supplies and degrade water quality (Mytton, 2021). These changes can increase risks of water scarcity, waterborne diseases and poor maternal and infant health outcomes, with effects that may intensify over time under drought and climate stress (Currie et al., 2013; Stanke et al., 2013).

Data centers require significant resource consumption, with water playing a crucial role both directly in cooling systems and indirectly through electricity production. Globally, data centers significantly contribute to the water footprint, with projections indicating usage between 4.2 and 6.6 billion cubic meters by 2027—exceeding the annual water consumption of countries like Denmark (Li et al., 2025). In the U. S., they rank among the top 10 industrial water users, consuming roughly 513 million cubic meters in 2018 alone (Siddik et al., 2021). A medium-sized data center (15 megawatts) consumes as much water as three hospitals or two 18-hole golf courses, while hyperscale data centers (100 + megawatts)—the largest and most efficient type of public cloud facilities could use even more (Mytton, 2021; Wren, 2024; Powell, 2024). For perspective, Microsoft's data center used 700,000 liters of water to train GPT-3, while generating just one 100-word email using GPT-4 requires approximately 519 milliliters of water (Verma and Tan, 2024).

In Virginia, these pressures are particularly acute because water is already heavily allocated to thermoelectric power generation, agriculture, public supply, and industrial operations (McCarthy et al., 2022). Rapid growth in the data center sector, a 250% increase in water use over four years, now competes directly with these existing demands, intensifying stress on rivers and groundwater, particularly in warmer months [Sierra Club, n.d.; Joint Legislative Audit and Review Commission (JLARC), 2024]. This proliferation in drought-prone regions is worsening local water scarcity (S&P Global, 2025). Collectively, data centers in Northern Virginia consumed nearly 2 billion gallons (7.57 billion liters) of water in 2023—a 63% increase since 2019—underscoring how this new demand compounds longstanding pressures on Virginia's water system. Adding to these pressures, Virginia has spent much of the past decade in at least "Abnormally Dry" conditions as classified by the U. S. Drought Monitor, further straining already limited water supplies (U.S. Drought Monitor, 2024).

Beyond water quantity, data center cooling systems can affect water quality through the discharge of saline wastewater, or blowdown, from evaporative cooling towers (Siddik et al., 2021; Copley, 2022). Cooling water blowdown contaminants such as sodium, magnesium, sulfate, and potassium can contaminate groundwater supplies, posing serious health risks when their concentrations increase (Soliman et al., 2021). For example, high sulfate levels in groundwater can cause skin irritation and diarrhea, especially in infants (Miao et al., 2011). Exposure to contaminated drinking water during pregnancy has also been associated with adverse fetal outcomes, including low birth weight and preeclampsia (Currie et al., 2013; Thompson et al., 2022).

The reliance on water-scarce basins for data center operations may further worsens health risks, particularly in regions like Virginia, which is already experiencing droughts and water stress due to climate change. Drought conditions reduce water availability and flow, leading to stagnant, warm environments that promote the growth of pathogens, increasing the risk of waterborne diseases such as diarrheal illnesses, eye and ear infections, and *E. coli*, among others (Bell et al., 2018; Stanke et al., 2013). Drought has also been linked to increased wildfire risk, with downstream impacts on cardiovascular and respiratory health among children (Berman et al., 2017). In water-stressed agricultural regions, prolonged drought may additionally contribute to mental health risks, including heightened stress, anxiety, and psychological distress among affected populations (Polain et al., 2011; Berman et al., 2021).

Noise pollution

Continuous operation of cooling systems and generators produces persistent noise exposure near data centers, creating a direct environmental stressor. Short-term effects include sleep disturbance and annoyance, while long-term exposure is associated with cardiovascular, cognitive, and mental health impacts (Babisch et al., 2013; Thompson et al., 2022).

Data centers contribute to local noise pollution through their cooling systems, backup diesel generators, and other machinery (Judge, 2022). Operating 24/7, data centers in Virginia generate a persistent humming noise, described as an industrial-scale 'drone' or 'hum' similar to amplified house air conditioning, with levels ranging between 40 and 59 decibels [Joint Legislative Audit and Review Commission (JLARC), 2024]. While the U. S. Environmental Protection Agency (EPA) recommends a 24-h average outdoor noise limit of 55 dBA (day–night average) or 45 dBA indoors to protect public health (U.S. Environmental Protection Agency, 1974), data center operations in residential areas often approach or exceed these thresholds.

The health impacts of noise pollution include long-term risks such as heart disease, permanent hearing loss, and tinnitus; chronic effects such as hypertension and endocrine disruption; and acute effects like decreased sleep quality and temporary hearing changes (Babisch et al., 2013; Hammer et al., 2014). Noise pollution has also been linked with an increase in mental health concerns, such as stress-related disorders and increased annoyance, particularly in sensitive individuals (Meerlo et al., 2008; Sandrock et al., 2008). Past research has shown that noise pollution is particularly concerning for children, as exposure can lead to poor cognition (Thompson et al., 2022). For instance, studies have found that children in noisy environments, defined by the U. S. EPA as chronic exposure above 55 dBA (day–night average), exhibit poor school performance, increased stress, and behavioral issues, with noise pollution also being linked to decreased learning, lower reading comprehension, and concentration deficits (Lercher et al., 2003; Stansfeld and Clark, 2015). For children residing near data centers, the constant noise from 24/7 operations could further exacerbate these developmental and cognitive risks, potentially impacting their long-term health outcomes.

Land use changes

Large-scale land conversion for data center development alters local ecosystems and built environments, indirectly affecting health through loss of green space, increased heat exposure, air pollution, and psychosocial stress. These effects are cumulative and long-term, with disproportionate impacts on rural and historically marginalized communities (Aerts et al., 2018; Johnson-Jennings et al., 2020).

Data centers require vast amounts of land, often converting areas near natural green spaces and agricultural lands into data center sites. Data from the Piedmont Environmental Council (2024) show that existing data centers in Northen Virginia currently occupy about 6,200 acres of land, while proposed projects would add nearly 21,000 acres, more than tripling the current footprint in Northern Virginia alone, where roughly 80% of data centers are located.

Our analysis of existing and proposed data centers in Northern Virginia found that the 152 proposed facilities are, on average, five times larger than the existing 191 data centers. The rapid data center expansions in Northern Virginia are increasingly targeting rural land near national parks and agricultural land into industrial zones, posing risks to public health. For example, Prince William County is facing its largest land-use transformation in decades, with developers targeting 2,400 acres of undeveloped land in the Rural Crescent for data center construction. This area contains two federally protected national parks, Prince William Forest National Park and Manassas Battlefield National Park, which together attract over a million visitors annually (Regelbrugge, 2022). Moreover, over 100 additional projects are currently planned in Northern Virginia, collectively adding roughly 180 million square feet of data center space, equivalent in area to 1,000 Walmart Supercenters (Sierra Club, n.d.). Moreover, residents have raised concerns about vehicle traffic from data center construction, citing road damage, congestion, and blocked access for school buses and emergency vehicles [Joint Legislative Audit and Review Commission (JLARC), 2024]. This can increase local air pollution (e.g., particulate matter and diesel exhaust), indirectly contributing to respiratory and cardiovascular health risks, especially among vulnerable populations.

This rapid transformation threatens rural populations, contributing to increased psychological stress, exacerbated by limited healthcare access. The loss of farmland can disrupt local economies and erode cultural and historical ties, particularly for Indigenous people and farmers who see the land as central to their identity and psychological well-being (Johnson-Jennings et al., 2020; Reed and Claunch, 2020; Yazd et al., 2019; Brigance et al., 2018).

Importantly, the proximity of data centers to green spaces degrades ecosystems by replacing vegetation with impervious surfaces, fragmenting habitats, and disrupting hydrology, thus reducing their capacity to filter air, regulate temperature, and sustain biodiversity [Joint Legislative Audit and Review Commission (JLARC), 2024; Nguyen et al., 2021]. Combined with air, water, and noise pollution from data centers, this ecological degradation can weaken green spaces' protective functions and increase health risks in nearby communities. Conversely, green spaces are linked to health benefits by reducing air pollution and the urban heat island effect, encouraging physical activity, and enhancing mental health, contributing to overall better health and increased life expectancy (Nowak et al., 2006; Jones, 2018; Shanahan et al., 2016). For example, increased tree cover has been shown to enhance natural air pollutant absorption, reducing the incidence of respiratory illnesses like asthma, Chronic Obstructive Pulmonary Disease, and cardiovascular diseases, especially among children (Liang et al., 2019; World Health Organization, 2016; Ruokolainen et al., 2015). Past research has also emphasized the importance of green spaces in improving the health of pregnant women and people with existing illnesses (Dzhambov et al., 2014; Ray and Jakubec, 2014). Research also emphasizes that proximity to green spaces is linked to better mental well-being and social support (Wigand et al., 2022; Aerts et al., 2018).

Economic harms and social inequality

Rising electricity demand from data centers places upward pressure on energy prices, indirectly affecting health through increased energy insecurity. Short-term impacts include heat- and cold-related illness due to inadequate household energy access, while long-term effects include chronic stress, food insecurity, and widening health disparities (Ballesteros-Arjona et al., 2022).

While data centers generate notable economic benefits, these gains are often concentrated among a select few, neglecting the broader public. Data centers are significant consumers of electricity, substantially increasing local energy demand and associated costs (Pipkin, 2024). According to Goldman Sachs (2024) Research, the data center's global power demand is projected to grow by 160% by 2030. In Virginia, the current energy need of data centers is estimated at about 5,050 MW of load and 11,000 GWh annually (Howland, 2024). Dominion Energy anticipates that Virginia data centers will be the primary driver of increased energy demand over the next 15 years, forecasting a need for about 13.3 gigawatts by 2038 (Vogelsong, 2024). While these data centers currently pay the full cost of service under existing rate structures, their rising energy demand strains Virginia's grid and could raise typical residential bills by $14–33 per month by 2040 [Joint Legislative Audit and Review Commission (JLARC), 2024]. Wholesale electricity prices near major data center hubs have already increased sharply, rising by up to 267% over the past 5 years (Bloomberg News, 2025). These rising energy costs disproportionately affect lower-income households and marginalized communities, exacerbating existing social inequality and health disparities (Ballesteros-Arjona et al., 2022).

Past studies have shown that energy poverty forces vulnerable families to choose between paying for energy and meeting essential needs such as food, healthcare, and education (Pitt et al., 2022; Riva et al., 2023; Harrington et al., 2005). Because climate change is increasing the frequency of hot days, there is also a rising demand for residential cooling systems like air conditioning units (Colelli et al., 2023; Sherman et al., 2022). Rising energy costs may prevent low-income households from accessing adequate cooling, raising the risk of heat-related illnesses, such as heat exhaustion and heat stroke, and worsening pre-existing conditions (Pitt et al., 2022; Hernández, 2013). Moreover, some low-income families may prioritize cooling units over purchasing healthy food, resulting in malnutrition and food insecurity, particularly among children, which can negatively affect their physical growth, cognitive development, and academic performance (Frank et al., 2006; Cook et al., 2008).

Conversely, on colder days, inadequate heating can increase health risks such as respiratory conditions and cardiovascular stress, including heart attacks and strokes (Thomson et al., 2017). Elevated energy costs can also contribute to poor mental health among adults, leading to increased anxiety, stress, and depression (Harrington et al., 2005; Oliveras et al., 2020). Therefore, addressing the rising energy demands and costs associated with data centers is critical to mitigating social inequality and safeguarding the health and well-being of vulnerable communities (Figure 2).

Potential strategies to mitigate the health harms of data centers

The rapid expansion of data centers, fueled by the rising demand for digital infrastructure, poses serious health risks that require coordinated mitigation across energy, water, noise, land use, governance and communication domains. The strategies below are organized by thematic risk pathways identified earlier in the paper and distinguish between policy-level, industry-level, and community-level interventions.

Energy-related strategies (policy and industry level)

Transitioning from fossil fuels to renewable energy for data centers can substantially reduce air pollution and related health issues, as well as lower energy costs. Ortiz et al. (2023) estimate that shifting to renewables for electricity production in Virginia could prevent deaths, reduce hospital admissions, decrease work-loss days, and save up to $350 million annually in health costs by 2045. Several technology companies have already demonstrated the feasibility of such transitions. For example, Microsoft's Project Natick tested underwater data centers powered by offshore renewables, showing improved reliability and reduced environmental footprint (Roach, 2020). In 2024, Google powered its data centers with 100% renewables and added 2.5 GW of clean energy, cutting emissions by 12% despite a 27% rise in electricity use (Google, 2024). These examples highlight the potential for cleaner and healthier digital infrastructure.

Water use and water quality strategies (policy and industry level)

Beyond cutting emissions, reducing data centers' water consumption and water contamination is critical to mitigating public health. Using non-potable water, like Amazon's use of recycled cooling water in Virginia, can ease pressure on drinking water supplies. Targeted cooling methods, such as shifting from whole-room to focused server-row cooling, can cut water use and boost energy

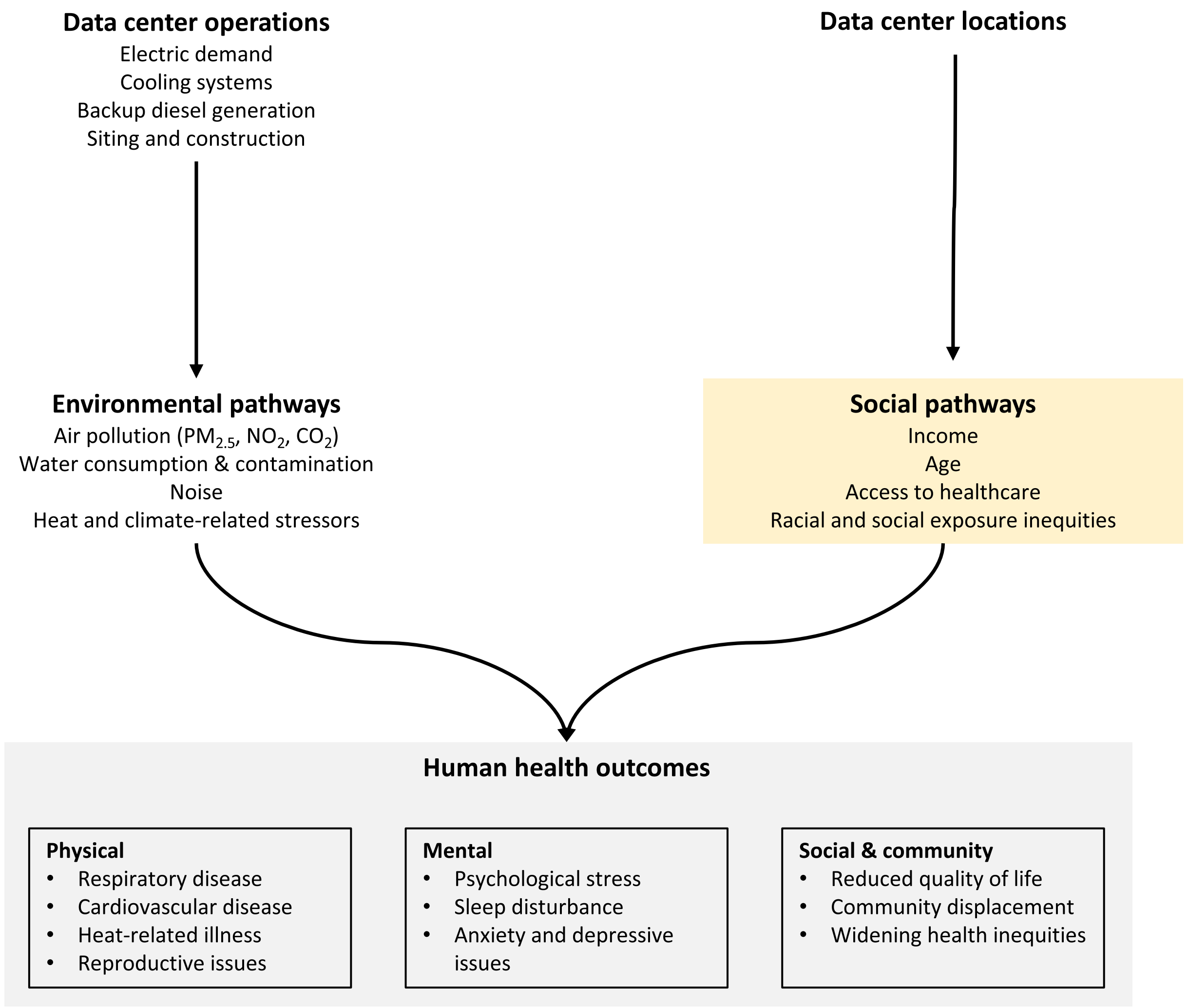

FIGURE 2
Conceptual pathways linking data center operations to human health outcomes.

efficiency by 29% (Moazamigoodarzi et al., 2019). Advanced water recycling and filtration, such as nanofiltration and reverse osmosis, can prevent contamination (see Envirogen, 2023). Moreover, to drive industry-wide change, local governments should enforce water limits during droughts and mandate data centers to adopt alternative cooling methods, such as air cooling, closed-loop systems, or hybrid models with water-side economizers to minimize freshwater dependence and reduce water contamination health risks (Silva-Llanca et al., 2023; Wang et al., 2018). Currently, however, Virginia data centers are not subject to direct regulations on their energy efficiency, emissions, or water use, relying only on general air, stormwater, and wetland permits [Joint Legislative Audit and Review Commission (JLARC), 2024].

Noise and land-use strategies (policy and community level)

Further, mitigating noise pollution is essential, especially in residential areas near data centers. Effective strategies can include locating data centers away from densely populated regions and implementing noise reduction measures such as acoustic treatments and green zoning. Proactive site selection and thoughtful design, considering urban layout and building density, can significantly reduce noise-related health issues (Chan, 2023; Dzhambov and Dimitrova, 2014). For example, a Leesburg Virginia data center reduced noise pollution by re-engineering fan mounts and cutting low-frequency tonal noise by 20% (Compass Datacenters, 2024). Additionally, to limit adverse impacts from land use changes, policymakers should mandate responsible site selection and enforce zoning regulations that prioritize building data centers on existing industrial sites. Engaging local communities through public hearings and transparent decision-making processes can also help address residents' concerns about environmental and health consequences.

Equity and governance strategies (policy level)

Moreover, rising energy costs associated with data center operations disproportionately burden low-income households. When demand exceeds supply, Virginia follows PJM (originally the Pennsylvania–New Jersey–Maryland Interconnection) curtailment rules prioritizing homes and critical services, but no current policy requires data centers to switch to backup power [Joint Legislative Audit and Review Commission (JLARC), 2024], increasing the risk of AC interruptions and related health issues during heat waves for heat-sensitive people. Policymakers should also establish equitable energy pricing by introducing a dedicated data center rate class to shield vulnerable communities from escalating costs. Utility rates, which are currently adjusted every one to two years, need to be revised more frequently to accurately reflect cost growth [Joint Legislative Audit and Review Commission (JLARC), 2024]. Promoting a diversified energy portfolio, such as integrating renewable energy sources can help stabilize electricity prices and reduce dependency on fossil fuels. Additionally, local governments should mandate Community Benefit Agreements to ensure economic benefits from data centers directly support vulnerable populations through infrastructure enhancements, workforce training, and community reinvestment.

Health communication and public engagement strategies (policy and community level)

Finally, raising awareness about the health impacts of data centers is crucial for informed public and governmental decision-making. While community opposition to data centers, often labeled as NIMBYism (Not in My Backyard), frequently centers around concerns about noise, air and water pollution, these concerns reflect legitimate public health risks that demand policy attention (see Paullin, 2025; Paddison and Marsh, 2025). Through strategic health communication, public understanding can be improved, and government action encouraged toward health-focused regulation and more sustainable data center practices. Importantly, engaging trusted stakeholders, such as healthcare professionals, policymakers, and other opinion leaders, is key to this effort (Maibach et al., 2007; Campbell et al., 2025). Primary care doctors, trusted by 69% of American voters for information on global warming (Campbell et al., 2023), are particularly well-positioned to address public concerns about data centers, which raise similar health risks. Simple, clear, and repeated messaging from physicians and other health professionals can build credibility, support action-oriented advocacy, and help drive policy change (Maibach et al., 2014).

Limitations and possible future research directions

While this paper underscores the substantial health risks associated with data centers, it is primarily an exploratory assessment. As such, some limitations should be acknowledged.

First, there is the lack of data center specific epidemiological evidence directly linking data center operations to measured health outcomes. Most existing research examines related environmental exposures, such as air pollution, water use, noise, and heat, without attributing data centers as a distinct source. Second, attributing observed health impacts specifically to data centers is challenging in regions such as Northern Virginia, where multiple industrial, transportation, and power-generation sources coexist. Disentangling data center related exposures from other regional contributors requires high-resolution environmental monitoring and spatially explicit exposure assessment, which remains limited given the novelty of data centers as a public health research domain.

Third, this review also relies on grey literature, reflecting the emerging nature of the topic and the current scarcity of peer-reviewed studies focused explicitly on data centers and health impacts. Finally, this assessment is conceptual rather than quantitative and identifies plausible exposure pathways and health risks without estimating effect sizes or population-level disease burdens.

Future research should conduct quantitative, interdisciplinary studies that integrate physical sciences, engineering, and public health to directly measure emissions, exposures, and health outcomes linked to data center operations. Such work could assess pollutant emissions from increased electricity demand and their respiratory and cardiovascular impacts, as well as unresolved questions related to water demand, regional water management, noise exposure, and climate-related environmental and health effects. Moreover, expanding analyses beyond Virginia to other regions experiencing rapid data center growth would enable comparative assessment across regulatory and geographic contexts and help refine mitigation strategies. In addition, future studies should examine the role of trusted opinion leaders such as healthcare professionals, policymakers, and government officials and effective communication strategies, including message framing, to enhance issue awareness and positively influence public attitudes and behaviors.

Conclusion

As data centers expand, both existing and proposed facilities pose significant health and environmental challenges that demand urgent action. Policymakers must mitigate harms from operational data centers by enforcing stricter environmental regulations, monitoring emissions, and mandating mitigation measures to protect surrounding communities. Transparency is essential. Residents have the right to know the risks associated with data centers and should be actively informed about industry practices. Conversely, developers must engage the public to address their concerns, especially as opposition grows under NIMBY movements. Moreover, for proposed new data centers, public input must guide decision-making—do residents want them, and if so, under what conditions? Developers must adhere to clear design and operational safeguards, including renewable energy integration, water conservation, noise pollution control measures, and responsible land siting. By prioritizing sustainability, data centers can achieve responsible growth without compromising public health.

Author contributions

NG: Conceptualization, Writing – original draft, Writing – review & editing. LO: Conceptualization, Visualization, Writing – review & editing. EM: Conceptualization, Writing – review & editing.

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Conflict of interest

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