Examination of Social Vulnerability Factors and Disaster Preparedness of Southern Arizona Healthcare Facilities and Communities

Making Action Possible in Southern Arizona (MAP Dashboard)
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Executive Summary

The Role of Social Vulnerability in Disaster Preparedness

Social vulnerability encompasses the socioeconomic, demographic, and structural factors that influence a community's ability to prepare for, respond to, and recover from disasters (CDC/ATSDR, 2022). These factors, such as poverty levels, age distribution, disability status, housing type, language proficiency, and access to transportation and technology, can magnify the effects of hazards and impede recovery efforts, especially for populations exposed to higher levels or an unequal distribution of these factors (Bergstrand et al., 2015). It is vital to understand social vulnerability and its relationship to potential disparities in disaster impact and to better guide mitigation and preparedness strategies. For healthcare systems, this knowledge supports the development of equitable, community-tailored responses that protect the most at-risk individuals and promote resilience during disaster emergency events (ASPR, 2022).

The objective of this paper is to evaluate how social vulnerability factors can inform the disaster preparedness of healthcare facilities and their surrounding communities in Southern Arizona. This region warrants specific focus due to its unique characteristics, proximity to the U.S.-Mexico border, widespread rural and tribal communities, desert climate, and ongoing drought conditions. Southern Arizona's healthcare delivery system faces persistent workforce shortages, resource limitations, and health disparities, particularly among rural, tribal, and low-income populations. By centering on Southern Arizona, the analysis develops actionable insights relevant to regions facing similar vulnerabilities both statewide and nationally.

About Our Research

Our analysis draws on facility-level survey data collected from October – December 2023 and includes 54 healthcare organizations across Southern Arizona, stratified by rural and urban classifications, to capture on-the-ground perspectives of hazard risk (e.g., how risk of certain hazards is perceived) and preparedness capacity. This is complemented by community-level data from federal and state sources, measuring key social vulnerability factors (e.g. poverty rates, age, disability, language, housing characteristics). By integrating community-based social vulnerability indices with self-reported facility preparedness, we provide a granular picture of the intersection between social vulnerability and disaster readiness. This approach enables the identification of hazards and gaps most relevant to the communities throughout the region.

Key Findings

Surveyed healthcare organizations identified staffing shortages, extreme heat, severe weather (e.g., monsoons, dust storms, flash flooding), communication/network failures, and cyberattacks as the most significant hazards facing both rural and urban healthcare delivery systems. According to Southern Arizona-specific social vulnerability data, rural facilities serve populations with higher rates of poverty, a higher number of residents living in mobile homes, limited access to healthcare infrastructure, and longer travel distances to care (Tables 3 – 8). These communities also have higher proportions of children and more limited access to technology, such as smartphones. Urban facilities encounter higher concentrations of older adults, denser housing (including multi-unit structures), significant pockets of linguistic diversity, and greater rates of disability and crowding (Tables 3 – 8). Both rural and urban healthcare locations in Southern Arizona display high vulnerability scores in domains such as socioeconomic status, minority status, housing and transportation barriers, and health insurance gaps, though the patterns and combinations of vulnerability factors vary by setting (Tables 3 – 8).

Evidence-based examples from rural and urban healthcare settings reveal different preparedness strategies according to their highest risk hazards (Table 9). For example, rural areas often depend on mobile units, neighbor checks, and telemedicine, while urban systems focus on surge capacity, multilingual communication, and scalable infrastructure, such as cooling centers during heat events. Both settings face challenges in workforce recruitment, supply chain reliability, and maintaining communication during disasters (Table 9).

Recommendations for Healthcare

- Promote Emergency Preparedness to Leadership: Continue advocating for resource allocation, leadership engagement, and recognition of preparedness activities as critical elements of a successful organization.
- Tailor Preparedness to Vulnerabilities: Use local data to guide facility and community-specific interventions, addressing heat vulnerability, aging population needs, language access, and technology gaps.
- Integrate Social Vulnerability Data into Planning: Use validated social vulnerability indicators and hazard risk assessment tools to continuously assess risk and monitor program effectiveness in a structured approach.
- Plan for Hazard-Specific Needs: Address challenges associated with top-ranked hazards through targeted investments in infrastructure, technology, community engagement, and cross-sector collaboration.

The disaster preparedness of Southern Arizona's healthcare facilities and their surrounding communities is inextricably linked to underlying social vulnerability factors. Rural and urban areas face distinct challenges, but both require active, locally informed strategies to strengthen resilience in the face of increasingly frequent and severe disasters. By understanding community-specific vulnerabilities and adapting preparedness activities accordingly, leaders and partners across the state can build more equitable, responsive, and effective healthcare emergency systems, for Southern Arizona.

Table of Contents

Introduction

In recent years, the U.S. healthcare delivery system has faced escalating risks from hazards such as infrastructure failures, extended utility outages, cyberthreats, and severe weather events, even experiencing a combination of several hazards, further compounding the impact. In 2022 during Hurricane Ian, there were 16 hospitals evacuated and over 8,000 patients evacuated from 47 nursing homes and 115 assisted living facilities due to secondary utility and technological hazards following the storm (Muoio, 2022). The Marshall Fire in 2021, the most destructive fire in Colorado’s history, forced the evacuation of over 240 patients in a 114-bed hospital and two long term care facilities during the ongoing 2019 Coronavirus (COVID-19) pandemic, resulting in compounding challenges due to existing staffing and supply shortages (Daugherty et al., 2022). The direct impacts of hazards can lead to cascading events that amplify disaster consequences and add an extra layer of burden. For instance, a power outage that occurs during an extreme heat wave can complicate alternative cooling mechanisms or lead to a potential evacuation of patients, considered a worst-case scenario for healthcare facilities.

Recent examples from Arizona and the U.S. emphasize the need for sustained focus on preparedness. In August of 2024, an issue with the HVAC system at St. Luke's Behavioral Health Facility in Phoenix led to the relocation of 98 patients to nearby healthcare facilities. This relocation was completed with the help of multiple state organizations including the Arizona Department of Health Services (ADHS) and the Arizona Coalition for Healthcare Emergency Response (AzCHER) (Tanet, 2024). In a series of compounding events in June 2020, the Northwest Medical Center in Oro Valley, Arizona experienced an increase in asthma and other respiratory emergency department visits due to poor air quality caused by smoke from the Bighorn Fire, all while actively responding to the COVID-19 pandemic (McNeil, 2020).

Healthcare facilities are uniquely affected by disasters and play a critical role in community mitigation and recovery, making it essential to understand how hazards impact both healthcare facilities and the communities they serve to enable an effective, coordinated response.[1] Healthcare facilities are essential partners and leaders in preparedness efforts convened and directed by state and local public health agencies at the state and local level. According to a 2022 policy brief from the National Rural Health Association, communities with resource constraints, such as rural or remote geographic locations like those in Southern Arizona, have limited access to public health services, with rural-serving public health agencies operating under inadequate funding, unmet technology needs, and limited physical and human infrastructure (e.g., healthcare workforce) (Beecham et al., 2022). The rural public health

[1] A disaster is defined as a significant breakdown in how a community or society functions, occurring when a hazardous event interacts with existing levels of exposure, vulnerability, and capacity UNDRR. (2021a). *Terminology-Disaster*. Unted Nations Office for Disaster Risk Reduction. https://www.undrr.org/terminology/disaster. Disaster risk arises from the combination of a hazardous event and the specific conditions that leave people and places vulnerable and exposed to its impacts. A hazard is any process, event, or human activity that has the potential to cause loss of life, injury, or other health impacts, as well as damage to property, disruption of social and economic systems, or harm to the environment. This can include natural hazards such as weather, climate, or geological events; infectious diseases; and human-caused hazards, whether intentional or accidental UNDRR. (2021b). *Terminology-Hazard*. United Nations Office for Disaster Risk Reduction. https://www.undrr.org/terminology/hazard.

system constraints highlight the need for active preparedness participation and leadership by healthcare facilities in rural areas by strengthening their preparedness activities with a better understanding of the challenges facing their communities. In fact, understanding the community is an initial step in the National Incident Management System Preparedness Cycle (Appendix A).

Hazard risk assessment, or Hazard and Vulnerability Analysis (HVA), combined with an examination of social factors, can provide healthcare facilities with a clear data-driven picture of the community that can be integrated with other key aspects of operational and care improvement. In practice, healthcare facilities are aware of the Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI) and often include pre-designed, county-level maps as appendices to their emergency preparedness planning (ASPR, 2022). However, they may not fully take advantage of the SVI information provided at a more detailed planning level because they may lack a systematic approach to integrate this data. Healthcare emergency management is a chronically underfunded area (Cappiello, 2011). However, conducting a data-driven risk assessment that integrates use of SVI data could potentially be linked to other organizational level initiatives (e.g. Community Health Needs Assessments, Medicare cost report analyses, chronic disease prevention projects, etc.) aimed at improving care quality and financial performance (Cappiello, 2011). For example, a data-driven risk assessment using the SVI that finds a high level of vulnerability to extreme heat, due to disability and mobile home prevalence, could also inform care quality initiatives focused on post-surgical outcomes or medication adherence.

This paper will describe the most severe hazards with the highest probability of occurring in rural and urban Southern Arizona as identified by healthcare facilities and demonstrate how SVI can inform preparedness and response activities for these hazards, outlining a systematic approach that can be applied in other healthcare settings. By adopting this approach, healthcare facilities will not simply check a planning box but demonstrate the importance of integrating a robust community understanding while also strategically engaging in preparedness and response activities that benefit the entire healthcare delivery system.

Southern Arizona Healthcare Delivery System

Southern Arizona is a region marked by its striking natural beauty, cultural diversity, and a blend of urban centers and rural landscapes. The area encompasses five counties, Cochise, Graham, Greenlee, Pima, and Santa Cruz, each contributing its own unique history and character to the region (MAP, 2025). Cities such as Tucson, Sierra Vista, Safford, Clifton, and Nogales serve as economic and social anchors, while the presence of the San Carlos Apache Tribe, White Mountain Apache Tribe, Pascua Yaqui Tribe, and Tohono O'odham Nation adds to the region's rich tapestry of traditions and governance (MAP, 2025). Figure 1 identifies Southern Arizona geographical locations in a reddish-orange color.

Figure 1. Map of Southern Arizona counties and tribes (AzCHER, 2020).

Southern Arizona's healthcare delivery system faces unique disaster preparedness factors, such as its proximity to the U.S.-Mexico Border, rural geography, and a desert climate (MAP, 2025). Healthcare access is a defining issue across Southern Arizona (MAP, 2024). The region is served by 30 licensed hospitals and 30 skilled nursing facilities, with a total of 3,182 licensed beds (AzCHER, 2024). Despite this infrastructure, the ratio of one healthcare provider for every 382 residents highlights ongoing workforce challenges, particularly in rural and tribal communities where recruiting and retaining providers can be difficult (AzCHER, 2024). Tribal nations such as the San Carlos Apache, Pascua Yaqui, and Tohono O'odham face additional barriers, including higher rates of health professional shortages and cultural and linguistic needs that must be addressed to deliver effective care (MAP, 2024).

Social and economic factors shape how disaster preparedness challenges differ across Southern Arizona's counties, reflecting the region's complex mix of rural and urban communities (Bergstrand et al., 2015).In the more rural counties of Greenlee and Graham, persistent poverty, limited access to specialty healthcare, and transportation challenges pose significant barriers to effective preparedness and response (ADHS, 2024b). These factors can limit evacuation capabilities and delay access to emergency resources, leaving residents at increased risk when disaster strikes (RHI Hub, 2022). Communities with high poverty rates may have less robust infrastructure to support evacuations, especially for complicated healthcare facility evacuations (Bergstrand et al., 2015). By contrast, Pima County's urban core, anchored by the Tucson metropolitan area, offers more robust healthcare and social services but contends with issues like higher housing cost burden (31.4%), an aging population, as well as a high poverty rate (14.9%) (MAP, 2024). High housing cost burden and poverty rate negatively impact an individual's ability to evacuate during a disaster due to financial constraints leading to a lack of transportation, lack of flexible funds, and emergency supplies (Lee & Van Zandt, 2019).

Disaster preparedness efforts must prioritize equitable resource allocation to address these disparities (Yuk-Chiu Yip, 2021). In addition to the material resource constraints, practices and approaches to serving and including these communities with higher social vulnerability by systems and organizations may be lacking. Research on federal wildfire mitigation programs in Arizona reveals that socially vulnerable communities, even those exposed to high biophysical risks, are less likely to participate in preparedness initiatives due to systemic barriers like limited outreach, language gaps, or distrust in institutions (Ojerio et al., 2011).

According to publicly available Hazard Mitigation Plans in Southern Arizona, the most common hazards with a potential to impact the healthcare delivery system are described below. These plans and assessments are mostly limited to naturally occurring hazards and lack the technological or human-made hazards that may disproportionately affect healthcare facilities.

- **Extreme Heat:** In 2022, Pima County Health Department reported that 54 people died from extreme heat-related causes with the number jumping to 91 deaths in 2023 (ADHS, 2025). Heat-related causes can refer to heat-related illness and exposure to extreme heat which include, heat stroke, heat exhaustion, heat cramps, and heat rash (ADHS, 2024a)
- **Wildfires:** According to the Arizona Department of Forestry and Fire Management, from 2022-2024, there has been an increase in the total number of fires throughout the state, but also in acreage burned (AzDFFM, 2024). In 2023, the U.S. Fire Administration found that there were 88 deaths from wildfires in Arizona (USFA, 2023). Wildfire hazards can cause increased healthcare utilization, strain on resources and facilities, and also long-term impacts on one's health (ALA, 2016). Some of the risks to individual health posed by wildfire smoke can include asthma, chronic obstructive pulmonary disease, bronchitis, and chronic heart disease (ALA, 2016).
- **Severe Weather:** Severe weather in Southern Arizona can include monsoons, dust storms, and flash flooding. New research reveals significant health risks associated with dust storms, such as a 6% increase in emergency department visits for asthma, pneumonia, and congestive heart failure (Zheng et al., 2025). Monsoons include significant rainfall on dry land, resulting in flash flooding and an associated increase in motor vehicle accidents (ADHS, 2025). When dust storms and heavy rainfall occur, they can blow harmful particles into the air like those that cause Valley Fever and can create breeding grounds for mosquitoes that carry diseases like West Nile or Zika viruses (ADHS, 2024b).
- **Drought and Water Scarcity:** The Arizona Department of Water Resources defines a drought as, "a prolonged period of below-average precipitation severe enough to negatively impact the environment and human activities" (ADWR, 2025). According to

the Arizona Drought Monitor, as of May 20th, 2025, Southern Arizona is currently in Extreme Drought (ADWR, 2025). Drought can affect the healthcare delivery system by compromising quantity and quality of drinking water, worsening air quality, diminishing living conditions, and increasing the incidence of disease (CDC, 2024).

By bringing social vulnerability considerations into disaster preparedness, healthcare organizations can identify and align areas of improvement across all departments, partners, and community-wide initiatives. The HVA process can also be aligned with the facilities' quality improvement and sustainability efforts. For instance, hospitals are held accountable for readmission rates and there are social factors that can lead to increased readmissions during and after a disaster. HVA is an impactful evaluation approach when aligned with the social factors of a healthcare facility's patient population/community. By integrating social vulnerability into healthcare planning, the region can build resilience that protects its residents while strengthening the entire healthcare and emergency response ecosystem. This paper explores the health vulnerability factors related to Southern Arizona's highest-risk disasters in a series of questions outlined below.

Exploratory Questions

This paper asks two questions to help understand how social vulnerability factors can impact the disaster preparedness of rural and urban Southern Arizona healthcare facilities and their communities.

1. Which hazards *pose the greatest* risk (high probability and high severity) to rural and urban Southern Arizona, according to the healthcare delivery system?
2. How should social vulnerability factors inform the disaster preparedness and response activities of rural and urban healthcare delivery systems when considering the highest-risk hazards?

Approach

Highest Risk Hazard Identification

To identify the highest-risk hazards of rural and urban Southern Arizona healthcare facilities, we conducted secondary, quantitative analysis of the 2023 Arizona Healthcare Community Hazard and Vulnerability data using risk calculations in Microsoft Excel. We used survey data from AzCHER's 2023 report because the 2023 survey had a higher response rate and the 2024 report served as an update and hazard confirmation of the prior year's hazard assessment (AzCHER, 2024). The data were aggregated by region and then into rural and urban categories to calculate mean scores for each hazard. The mean scores were entered into the Kaiser Permanente (KP) adapted Community Hazard Vulnerability Assessment (CHVA) tool. Figure 2 calculates risk using the formula shown below. A total of 39 hazards were ranked by healthcare coalition members.

Figure 2. The KP adapted CHVA tool calculates risk based on the formula below.

Risk: Probability x Severity (Impact – Mitigation)

Mitigation
=
Preparedness Level
+
Response Capacity

Application of Social Vulnerabilities

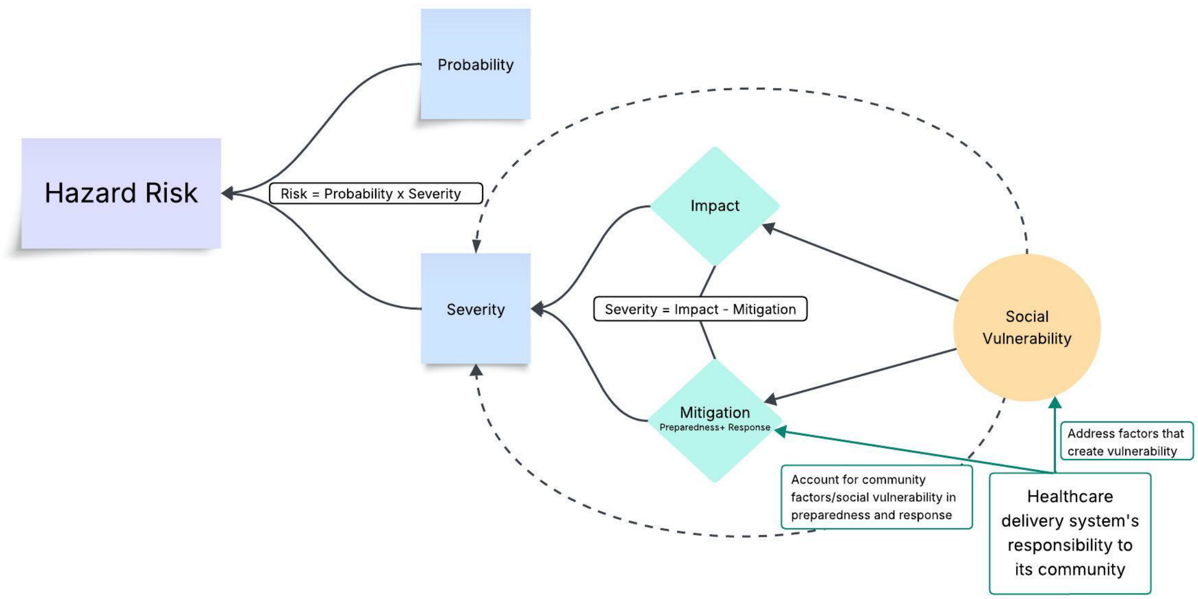
The CDC SVI identifies communities disproportionately affected by disasters due to factors such as poverty, limited transportation access, crowded housing, and language barriers. We apply the SVI themes to discuss potential planning and response considerations related to the highest-risk hazards in the region. An additional Arizona-specific theme from the ADHS SVI is examined to include factors for heat risk and healthcare access. Throughout the paper we refer to social vulnerability to describe community factors. We want to emphasize that this measure of vulnerability is only one representation of community factors. A high vulnerability score does not mean individuals in that area are inherently vulnerable, communities also have strengths and resources, such as social cohesion, that the index does not capture. It is focused on communities that could be disparately impacted and does not include representation of resiliency or other protective factors that often co-exist. Communities should not be reduced to only their vulnerabilities, but taking these into account in disaster preparedness is critically important. Lastly, these vulnerabilities are often the result of historic social, political, and policy decisions. We do not interpret these factors as inherent to individuals or to the communities to which they belong.

As shown in Figure 3 (see page 11), the interconnected relationships among hazard risk, social vulnerability, and the responsibilities of healthcare delivery systems to their communities. Hazard risk is depicted as a function of both the probability and severity of a potential event (Risk = Probability × Severity). Severity itself is further defined by the formula Severity = Impact – Mitigation (Figure 2), where mitigation refers to preparedness and response efforts that can reduce the overall impact of a hazard.

The impact of an event is influenced by underlying social vulnerability, the combination of community factors that shape who is most at risk and why. The healthcare delivery system has a responsibility to the community not only to account for these social vulnerability factors in its preparedness and response activities but also to actively address the root causes of vulnerability. In doing so, healthcare organizations help to reduce the severity and impact of hazards, thereby lowering overall risk for their populations. The diagram underscores the importance of integrating social vulnerability into all stages of disaster preparedness, response, and mitigation to fulfill the healthcare system's community obligations (Figure 3).

The use of “healthcare delivery system” in the white boxes outlined in teal refers to the array of organizations involved in delivering high-quality and safe healthcare to a community before, during, and after a disaster, such as hospitals, long-term care facilities, pharmacies, public health, emergency management, and insurance organizations (Figure 3). No single healthcare organization is solely responsible for “addressing factors that create vulnerability” or “accounting for community factors/social vulnerability in preparedness and response,” however, as part of the public health system and as part of their duty of care to patients, they do have a responsibility to use and understand the data describing their communities to inform their preparedness response.

Figure 3. Visual diagram demonstrating the relationship between the healthcare hazard risk calculation metrics and social vulnerability factors.



Classification of Rurality

To compare between rural and urban locations, we applied the Rural-Urban Commuting Area (RUCA) codes assigned at the 2020 Zip Code Tabulation Area (ZCTA) to each healthcare facility. For the purposes of this paper, we used the Health Resources and Services Administration (HRSA) definition of rural to assign rurality to each data entry representing a healthcare facility.[2] Utilizing HRSA's approach allows us to capture rural communities, which often exist alongside or within the boundaries of larger, more urbanized regions. For our analysis, we classify a healthcare facility as urban or metropolitan when it cannot be classified as rural using HRSA's criteria. This binary approach is limited because it does not capture the complexity of "mixed" census tracts; however, it allows us to analyze hazard rankings in a rural group that would otherwise be too small to subdivide into more detailed levels of rurality. After applying HRSA's definition of rural, our dataset includes 15 rural and 39 urban healthcare facilities totaling 54 facilities.

[2] HRSA defines rural areas as those outside major metropolitan centers or lacking typical urban population density (HRSA, 2025). This includes non-metropolitan counties, metropolitan counties without any city of 50,000+ residents, and census tracts within metropolitan counties classified with RUCA codes 4–10 (denoting remoteness). It also encompasses large census tracts (at least 400 square miles, ≤35 people per square mile) with RUCA codes 2 or 3, as well as smaller tracts (at least 20 square miles) with a Rural-Urban Continuum Code (RUCC) of 5 and RUCA codes 2 or 3, even within metropolitan counties.

Question 1

What are the highest-risk hazards in rural and urban Southern Arizona as rated by the healthcare delivery system?

Hazard Risk
=
Probability
x
Severity

Impact – Mitigation*

**Mitigation = Preparedness + Response Capacities*

AzCHER, a program of the Arizona Hospital and Healthcare Association (AzHHA), annually conducts a CHVA that uses an evidence-based risk calculation to estimate the overall risk, probability of occurrence, healthcare impact, level of preparedness, and existing response capacity of healthcare facilities in Southern Arizona (AzCHER, 2024). The characteristics and types of healthcare facilities that responded to their survey can be found in the CHVA Summary Report at AzCHER.org.

Table 1 describes the top ten highest risk hazards for rural and urban healthcare delivery systems in Southern Arizona, ordered f on a scale from 100% - 0% (AzCHER, 2023). These are the most severe hazards with the highest probability of occurring. For instance, there is a 56% chance that a severe staffing shortage emergency will occur in Southern Arizona, as rated by survey respondents.

Table 1. Rural and urban healthcare facility respondents identified Staffing Shortage, Extreme Heat, Severe Weather, Communications/Telephone/Network Failure, and Cyber Attack as the most severe hazards with the highest possibility of occurring in Southern Arizona, 2023.

Community Hazards Color Key	
Naturally Occurring Events	
Human Related Events	
Hazardous Materials Events	
Technological and Utility Events	
Epidemics and Pandemics	

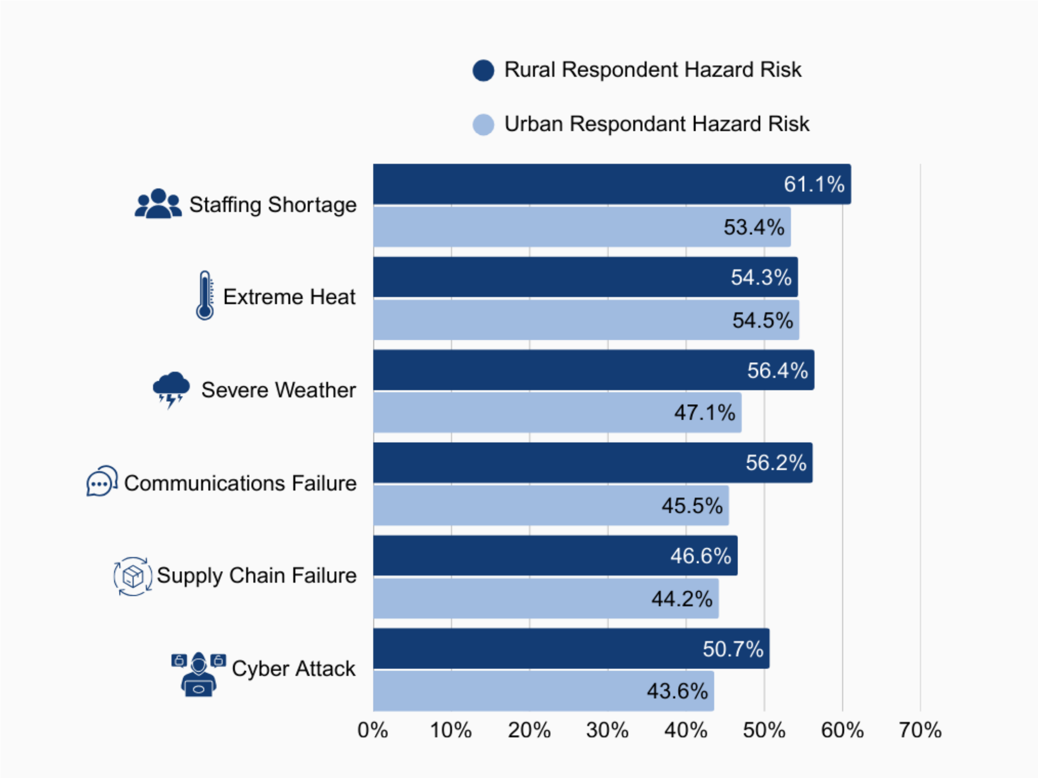
	Rural Facility Respondents - Hazards of Southern Arizona (n=15)	Risk Score		Urban Facility Respondents- Hazards of Southern Arizona (n=39)	Risk Score		All Facility Respondents Southern Arizona Hazards (N=54)	Risk Score
1	Staffing Shortage	61.1%	1	Extreme Heat	54.5%	1	Staffing Shortage	55.8%
2	Severe Weather (damaging winds, dust storm, etc.)	56.4%	2	Staffing Shortage	53.4%	2	Extreme Heat	54.2%
3	Communications/ Telephone/ Network Failure	56.2%	3	Severe Weather (damaging winds, dust storm, etc.)	47.1%	3	Severe Weather (damaging winds, dust storm, etc.)	49.9%
4	Extreme Heat	54.3%	4	Communications/ Telephone/ Network Failure	45.5%	4	Communications/ Telephone/ Network Failure	48.3%
5	Cyber Attack	50.7%	5	Supply Chain Failure	44.2%	5	Cyber Attack	45.6%
6	Active Threat	50.5%	6	Extended Power Outage	43.7%	6	Flood/Flash Flood	45.5%
7	Flood/Flash Flood	48.5%	7	Cyber Attack	43.6%	7	Supply Chain Failure	44.1%
8	Workplace Violence / Threat	48.2%	8	Pandemic (coronavirus, influenza, etc.)	43.0%	8	Pandemic (coronavirus, influenza, etc.)	44.1%
9	Outbreak of Treatable Infectious Diseases	47.7%	9	Flood/Flash Flood	41.8%	9	Information Systems Failure	41.8%
10	Supply Chain Failure	46.6%	10	Epidemic (vaccine-preventable, water-borne illness, etc.)	39.6%	10	Active Threat	41.7%

According to the AzCHER CHVA, the top five hazards are defined below (AzCHER, 2024). The full list of all 39 hazard definitions can be found in Appendix B.

1. **Staffing Shortage:** staffing shortage occurs when there is a lack of employees within an industry. Healthcare often sees staffing shortages for physicians and nurses.
2. **Extreme Heat:** a period of high heat with temperatures above 90 degrees Fahrenheit for at least two to three days. Humans may struggle to compensate and regulate their core body temperature, leading to heat-related illnesses and potentially death. Cooling systems and power supply are also tested.
3. **Severe Weather:** a weather event which may result in monsoon rain, flash floods, lightning storms, high winds, tornadoes, dust storms, haboobs, and other sudden, extreme weather changes during the summer months.
4. **Communications, Telephone, and Network Failure:** the complete or partial failure of a component or components in a network because of malfunction or natural or human-caused disasters.
5. **Cyberattack:** any offensive maneuver that targets computer information systems, computer networks, infrastructures, personal computer devices, or smartphones.

Figure 4 displays another way of visualizing the top five highest risk hazards for rural and urban healthcare respondent groups, offering a more direct comparison between rural and urban. Respondents from both rural and urban healthcare facilities/communities identified Staffing Shortage, Extreme Heat, Severe Weather, and Communications failure as the most severe hazards with the highest probability of occurring in the Southern Arizona Region. Respondents from rural healthcare facilities assigned higher risk to hazards overall with a range of scores from 3.6 – 61.1% while urban-based respondents' hazards ranged from 5.9 – 54.5% (Table 1). Rural and urban healthcare facility respondents assigned a similar risk score to the Extreme Heat hazard with a 54.3% and 54.5% chance of severely occurring and impacting the healthcare delivery system in Southern Arizona.

Figure 4. The most severe hazard with the highest chance of occurring in rural healthcare communities is Staffing Shortage (61.1%) while the most severe hazard with the highest chance of occurring in urban healthcare communities is Extreme Heat (54.5%).



Question 2

How should social vulnerability factors inform the disaster preparedness and response activities of rural and urban healthcare delivery systems when considering the highest-risk hazards?

In practice, emergency planners and healthcare administrators use social vulnerability data to guide crucial preparedness and response actions. For example, SVI data informs decisions on the number and distribution of emergency personnel, helps plan evacuation routes for those who lack transportation, and guides the locations and capacities of emergency shelters. While public health and healthcare emergency preparedness professionals understand what social vulnerabilities exist within their communities, there is not a standardized process for applying SVI themes and data to their plans and exercises. This paper outlines a systematic approach that can be applied by other emergency preparedness professionals in various settings.

Top 5 *Rural* Hazards:

1. Staffing Shortage
2. Severe Weather
3. Communications/ Telephone/ Network Failure
4. Extreme Heat
5. Cyber Attack

When examining the top five highest-risk hazards (the most severe hazards with the highest probability of occurring) in urban and rural communities of Southern Arizona, it is important to consider the social factors at play. Rural communities may need targeted investments in healthcare access, communication infrastructure, and transportation services. Meanwhile, urban areas require strategies that address diverse populations' needs (e.g., language access) and mitigate risks associated with larger and denser populations. While the most severe and most probable hazards in rural and urban areas are similar, their mitigation strategies may be different. In this section of the paper, we will examine selected AzSVI factors between rural and urban communities and relate each to the top five hazards for each group.

Top 5 *Urban* Hazards:
1. Extreme Heat
2. Staffing Shortage
3. Severe Weather
4. Communications/ Telephone/ Network Failure
5. Supply Chain Failure

Rural and Urban Community Considerations for Healthcare in Southern Arizona

Table 2 details differences in social vulnerability factors between rural and urban communities in Southern Arizona that have direct, real-world implications for disaster preparedness and response. For rural areas, high rates of poverty, a large proportion of children, widespread mobile home residency, greater heat vulnerability, and longer distances to care (as seen in Tables 4 – 8) mean that simple assumptions about resource access, transportation, or communication can lead to disastrously inadequate emergency response. If these vulnerabilities are not identified and addressed, rural populations will remain at higher risk of suffering worse outcomes during disasters and may recover more slowly. In urban areas, although resources are more plentiful, the challenges of poverty, housing crowding, reliance on public transportation, higher concentrations of older adults, and dense neighborhoods (as seen in Tables 4 – 8) create different barriers. Disasters can quickly overwhelm available services, exacerbate the spread of disease, and leave the most vulnerable, such as non-English speakers or those in structurally unsafe housing, without the help they need. Understanding and acting on these distinctions ensures that preparedness plans, resource allocation, outreach, and recovery strategies are truly equitable and effective. Ultimately, tailoring efforts to address the unique vulnerabilities of each community is essential for building resilience and mitigating the impact of disasters on those least able to withstand or recover from them.

Table 2. A sample of SVI factors can help describe key planning considerations of rural and urban communities in Southern Arizona.

SVI Factor	Rural Community Considerations	Urban Community Considerations
Persons below 150% poverty	A higher proportion of the rural population is clustered (9 of 11 ZCTAs) at higher levels of poverty (over 20% of persons below 150% poverty level) (Table 4). In rural areas, poverty often intersects with geographic isolation, limited healthcare infrastructure, and transportation barriers (RHI Hub, 2022). Many rural residents live far from hospitals or clinics, and those	A lower proportion of the urban population is clustered (13 of 19 ZCTAs) at higher levels of poverty (over 20% of persons below 150% poverty level) (Table 4). In urban settings, while healthcare facilities and resources are often more numerous, poverty presents different challenges. Low-income urban residents, particularly those living in high-density housing, may lack access to

SVI Factor	Rural Community Considerations	Urban Community Considerations
	facilities may already be understaffed or under-resourced. During disasters, evacuation is complicated by a lack of public transportation and longer distances to shelters or advanced care. People living below the poverty line in rural communities may find it particularly difficult to afford emergency supplies, maintain reliable transportation, or recover lost property. Additionally, rural hospitals are more susceptible to financial strains that could force them to close or suspend services, leaving low-income populations even more vulnerable during crises (AHA, 2019). Tailored outreach, mobile health units, coordination with community organizations, and investment in telemedicine have become critical strategies to close gaps for the rural poor (RHI Hub, 2022).	private transportation, making evacuation and access to care more difficult during disasters. Financial hardship can mean foregoing disaster insurance, chronic disease management, or required prescriptions. Populations below the poverty line are also more likely to reside in structurally vulnerable buildings susceptible to damage, and overcrowded conditions can accelerate the spread of infectious disease in emergency shelters (Robb et al., 2024).
Aged 65 and older	A lower proportion of the rural population (4 of 11 ZCTAs) is clustered with over 20% of persons aged 65 and older (Table 5). They may live farther from healthcare facilities, have more limited transportation options, and be more likely to live alone or in isolated settings. During disasters, these factors can delay timely evacuation, make it harder to refill prescriptions or reach a hospital, and increase reliance on local clinics that may themselves be under-resourced or at risk of closure. Emergency plans in rural regions must therefore include strategies for identifying at-risk seniors, coordinating transport and check-ins, and ensuring backup systems for power-dependent medical devices (RHI Hub, 2022).	A higher proportion of the urban population (9 of 19 ZCTAs) is clustered with over 20% of persons aged 65 and older (Table 5). Healthcare resources are more concentrated in urban areas, however, many seniors in cities live in high-rise buildings or densely populated neighborhoods, complicating evacuations and rescue efforts. Urban seniors may depend on public transit for medical appointments, which can be disrupted by disasters. They might also have limited social support networks, increasing risks of isolation during emergencies. Although, research has shown that households with older adults are more likely to have disaster kits and evacuation plans in place, likely because caregivers feel a heightened sense of responsibility to protect these vulnerable family members during emergencies (Bronfman et al., 2019), (O'Sullivan et al., 2012).
Aged 17 and younger	A higher proportion of the rural population (7 of 11 ZCTAs) is clustered with over 20% of persons aged 17 and younger (Table 5). Rural healthcare facilities may be limited in pediatric resources, including medicines, equipment, and providers trained in pediatric care. Schools are key centers for communication, shelter, and post-disaster support and may also be sparse or widely dispersed, making it harder to coordinate large-scale responses or outreach (Lai, 2024). For children with chronic conditions or disabilities, coordination among local clinics, schools, and social services	A lower proportion of the urban population (8 of 19 ZCTAs) is clustered with over 20% of persons aged 17 and younger (Table 5). Urban healthcare systems must be ready for spikes in pediatric visits, ensure communication is tailored for both youth and caregivers, and provide child-appropriate sheltering, mental health services, and nutritional support. The proximity of major pediatric hospitals is a benefit, but surges in demand following disasters can quickly overwhelm urban pediatric services. Schools and childcare centers act as central hubs for preparedness education, reunification, and

SVI Factor	Rural Community Considerations	Urban Community Considerations
	becomes even more critical to ensure continuity of care and access to medications, medical devices, or specialized therapies during disasters.	recovery but also present logistical challenges for safe evacuation, reunification, and ongoing care (Lai, 2024).
Mobile homes	A higher proportion of the rural population (4 of 11 ZCTAs) is clustered with over 20% mobile homes (Table 7). Mobile homes are generally more susceptible to damage from severe weather events, such as high winds, wildfires, and floods, than conventional homes (Kusenbach et al., 2010). In rural areas, where mobile homes are more common, residents may face additional challenges such as geographic isolation, limited access to transportation and technology, and longer distances to emergency shelters or healthcare facilities. Rural healthcare providers must plan for higher injury rates, increased demand for post-disaster care, and difficulties in reaching affected residents in dispersed locations.	A lower proportion of the urban population (1 of 19 ZCTAs) is clustered with over 20% mobile homes (Table 7). In urban settings, mobile home parks are often located on the outskirts of cities or in lower-income neighborhoods that may already face concentrated risks and resource limitations (Kusenbach et al., 2010). Crowding and poor infrastructure in urban mobile home communities can heighten risks during flood or extreme heat events and make it difficult for emergency services to access all residents quickly. Urban healthcare systems need to factor in the possibility of surges in patients from these communities, some of whom may have limited health insurance, pre-existing chronic conditions, or language barriers that complicate care and communication.
Heat vulnerability[3]	Among the rural census tracts, 31.5% of the population has three or more heat vulnerability factors (Table 8). In rural areas, residents may face challenges such as limited access to air conditioning, lower housing quality, and older or less energy-efficient homes, including mobile homes that are highly susceptible to extreme heat. Many rural households are also geographically isolated and may lack access to community cooling centers, reliable transportation, or timely emergency health services (ADHS, 2024a). When heat waves occur, rural healthcare providers may need to anticipate an increase in cases of heat exhaustion, dehydration, and complications of chronic diseases, especially among the elderly, children, and those with pre-existing health conditions (CDPHE, 2023).	Among the urban census tracts, 23.0% of the population has three or more heat vulnerability factors (Table 8). In urban settings, the "urban heat island" effect, caused by concentrations of concrete, buildings, and fewer green spaces, can drive temperatures much higher than in surrounding rural regions (ADHS, 2024a). Urban healthcare systems must be prepared for spikes in emergency department visits for heat-related illnesses. They must also coordinate efforts to open and staff cooling centers, deploy public health messaging, and ensure that at-risk patients, such as those with cardiovascular or respiratory diseases, have access to supportive services and check-ins (CDPHE, 2023). Densely populated neighborhoods may face power outages during peak demand, requiring rapid response to restore electricity and provide emergency aid.

[3] Heat vulnerability in the Arizona SVI is defined as the aggregated risk facing individuals and communities due to a combination of age, poverty, living situation, housing type, absence of cooling resources, and environmental exposure. Developed by the U.S. Census Community Resilience Estimates, this measure is designed to estimate the count and proportion of a population at heightened risk for adverse health outcomes during extreme heat events, providing localized estimates at the tract, county, and state levels.

Tables 3 - 8 below highlight the distribution of social vulnerability levels among rural and urban healthcare facility locations in Southern Arizona across four themes: 1) Socioeconomic status (SES), 2) Household Characteristics, 3) Racial and ethnic minority status, and 4) Housing type/transportation. All definitions and sources of data can be located on the CDC and AzSVI websites (CDC/ATSDR, 2022), (ADHS, 2024b). The AzSVI data are available at the Census Tract level which is a recommended way to examine smaller, rural communities whose data may get lost in a larger county level analysis, especially when Arizona's counties are larger than some U.S. states (ADHS, 2024b). Since our CHVA dataset includes the ZIP codes for each respondent, we analyzed the ZCTA for each respondent's primary healthcare facility location.

In rural areas, high vulnerability is most frequently found in housing type and transportation (73% of ZCTAs), followed by racial and ethnic minority status (55%), household characteristics (46%), and socioeconomic status (36%) (as seen in Table 3). Urban facilities also see high vulnerability in housing type and transportation (53%) and socioeconomic status (37%) but have a more even spread in medium-high and low-medium vulnerability across the domains, and a notably higher medium-high vulnerability for racial and ethnic minority status (53%) (Table 3). This pattern suggests that while both rural and urban communities face significant vulnerability in housing and transportation, rural areas tend to have greater concentrations of high vulnerability in multiple domains, particularly among minority groups and households with lower resources; urban areas, by contrast, display a wider range of vulnerability levels and may face more pronounced disparities within certain subgroups (Table 3).

Table 3. SVI factors can be prioritized by examining the number of ZCTAs by level of vulnerability (High, Medium-High, Low-Medium, and Low) based on the locations of rural and urban Southern Arizona CHVA survey respondents.

Vulnerability Level	Socioeconomic Status	Household Characteristics	Racial and Ethnic Minority Status	Housing Type and Transportation
Rural Facility Location: 15 respondents are located in 11 ZCTAs				
High	4/11 (36.4%)	5/11 (45.5%)	6/11 (54.5%)	8/11 (72.7%)
Medium-High	5/11 (45.5%)	2/11 (18.2%)	2/11 (18.2%)	1/11 (9.1%)
Low-Medium	1/11 (9.1%)	3/11 (27.3%)	2/11 (18.2%)	0/11 (0%)
Low	1/11 (9.1%)	1/11 (9.1%)	1/11 (9.1%)	2/11 (18.2%)
Urban Facility Location: 39 respondents are located in 19 ZCTAs*				
High	7/19 (36.8%)	6/19 (31.6%)	4/19 (21.1%)	10/19 (52.6%)
Medium-High	3/19 (15.8%)	5/19 (26.3%)	10/19 (52.6%)	5/19 (26.3%)
Low-Medium	6/19 (31.6%)	3/19 (15.8%)	4/19 (21.1%)	1/19 (5.3%)
Low	2/19 (10.5%)	4/19 (21.1%)	1/19 (5.3%)	2/19 (10.5%)
Missing	1/19 (5.3%)	1/19 (5.3%)	1/19 (5.3%)	1/19 (5.3%)

Data source: CDC SVI, 2022

*One ZCTA was excluded from analysis because it appears to be a ZCTA with a very low population <200 people associated with a ZIP code that is a nursing facility.

SVI Theme 1: Socio-Economic Data & SES SVI Ranking

Table 4. In selected rural ZCTAs, there is a higher proportion of clustered locations with over 20% persons below 150% poverty level and a 10% unemployment rate compared to selected urban ZCTAs while housing cost burden and percent uninsured is similar among both groups.

Facility Location	ZCTAs	Range % persons below 150% poverty	Range Unemployment Rate	Range % Housing Cost- Burdened	Range No High School Diploma	Range % Uninsured
Rural (n=15)	11	[9.5 - 62.9] 9 of 11 (81.8%) ZCTAs are over 20% persons below 150% poverty	[3.5 – 31] 5 of 11 (45.4%) ZCTAs are over 10% unemployment rate	[9.7 – 28.6] 8 of 11 (72.7%) ZCTAs are over 20% housing units with annual income less than $75,000	[6 – 31.1] 7 of 11 (63.6%) ZCTAs are over 15% persons with no high school diploma	[0.9 – 21.1] 4 of 11 (36.4%) ZCTAs are over 10% persons uninsured
Urban (n=39)	19*	[9.5 – 100] 13 of 19 (68.4%) ZCTAs are over 20% persons below 150% poverty	[3.3 – 100] 5 of 19 (26.3%) of ZCTAs are over 10% unemployment rate	[9.7 – 45.6] 15 of 19 (78.9%) ZCTAs are over 20% housing units with annual income less than $75,000	[2.2 – 31.1] 5 of 19 (26.3%) ZCTAs are over 15% persons with no high school diploma	[0 – 21.1] 6 of 19 (31.6%) ZCTAs are over 10% persons uninsured

Data source: CDC SVI, 2022

*One ZCTA was excluded from analysis because it appears to be a ZCTA with a very low population <200 people associated with a ZIP code that is a nursing facility.

SVI Theme 2: Household Characteristics Data & Household Characteristics Ranking

Table 5. In selected rural ZCTAs, there is a lower proportion (36.4%) of clustered locations with over 20% persons aged 65 and older but a higher proportion with over 20% persons aged 17 and younger (63.6%) compared to the same factors of the selected urban ZCTAs (47.4% over 20% aged 65 and older; 42.1% over 20% aged 17 and younger).

Facility Location	ZCTA	Range % persons aged 65 and older	Range % persons aged 17 and younger	Range % persons with a disability	Range single-parent households	Range % people who speak English less than well
Rural (n=15)	11	[7.5 – 42.7] 4 of 11 (36.4%) ZCTAs are over 20% persons aged 65 and older	[13.1 – 38.2] 7 of 11 (63.6%) ZCTAs are over 20% persons aged 17 and younger	[9.2 – 24.5] 5 of 11 (45.5%) ZCTAs are over 15% persons with a disability	[1.4 – 13.8] 4 of 11 (36.4%) ZCTAs are over 10% single-parent households	[0 – 31.7] 4 of 11 (36.4%) ZCTAs are over 5% people who speak English less than well
Urban (n=39)	19*	[9.5 – 42.7] 9 of 19 (47.4%) ZCTAs are over 20% persons aged 65 and older	[0 – 32] 8 of 19 (42.1%) ZCTAs are over 20% persons aged 17 and younger	[10.8 – 60.2] 11 of 19 (57.9%) ZCTAs are over 15% persons with a disability	[2.4 – 12.9] 2 of 19 (10.5%) ZCTAs are over 10% single-parent households	[0 – 31.7] 3 of 19 (15.8%) ZCTAs are over 5% people who speak English less than well

Data source: CDC SVI, 2022

*One ZCTA was excluded from analysis because it appears to be a ZCTA with a very low population <200 people associated with a ZIP code that is a nursing facility.

SVI Theme 3: Racial & Ethnic Minority Data & Ranking

Table 6. In selected rural ZCTAs, there is a higher proportion (72.7%) of clustered locations with over 50% racial and ethnic minorities compared to selected urban ZCTAs with a lower proportion (42.1%).

Facility Location	ZCTA	Range % Racial and ethnic minority
Rural (n=15)	11	[9.7 – 97.3] 8 of 11 (72.7%) ZCTAs are over 50% racial and ethnic minorities
Urban (n=39)	19*	[9.7 – 96.2]

Facility Location	ZCTA	Range % Racial and ethnic minority
		8 of 19 (42.1%) ZCTAs are over 50% racial and ethnic minorities

Data source: CDC SVI, 2022

*One ZCTA was excluded from analysis because it appears to be a ZCTA with a very low population <200 people associated with a ZIP code that is a nursing facility.

SVI Theme 4: Housing Type/Transportation Data & Housing Type/Transportation Characteristics

Table 7. There is a higher proportion (47.4%) of clustered households with no vehicle in urban areas and a lower proportion (27.3%) in rural areas. In selected rural ZCTAs, there is a higher proportion (36.6%) of clustered locations with over 20% mobile homes and a lower proportion (5.3%) in selected urban ZCTAs.

Facility Location	ZCTA	Range % mobile-unit structures	Range % mobile homes	Range % crowding	Range % with no vehicle	Range % group quarters
Rural (n=15)	11	[0 – 4] 0 of 11 (0%) ZCTAs are over 15% housing structures with 10 or more units	[1.8 – 43.6] 4 of 11 (36.6%) ZCTAs are over 20% mobile homes	[1.4 – 27.4] 2 of 11 (18.2%) are over 20% at a household level with more people than rooms	[0 – 25] 3 of 11 (27.3%) are over 10% households with no vehicle	[0 – 11.4] 3 of 11 (27.3%) are over 5% persons in group quarters
Urban (n=39)	19*	[0 – 34] 10 of 19 (52.6%) ZCTAs are over 15% housing structures with 10 or more units	[0.1 – 34.9] 1 of 19 (5.3%) ZCTAs are over 20% mobile homes	[0.8 – 21.2] 1 of 19 (5.3%) are over 20% at a household level with more people than rooms	[0 – 25] 9 of 19 (47.4%) are over 10% households with no vehicle	[0 – 100] 3 of 19 (15.8%) are over 5% persons in group quarters

Data source: CDC SVI, 2022

*One ZCTA excluded from analysis because it appears to be a ZCTA with a very low population <200 people associated with a ZIP code that is a nursing facility

AzSVI Theme 5: Heat Vulnerability and Healthcare Access Factors

Table 8. A higher percentage of households in selected rural healthcare census tracts (20.3%) have no Smartphone and heat vulnerability compared to selected urban census tracts (10.3%).

Facility Location	Number of CTs	Average % households without a Smartphone	Average % heat vulnerability	Range of drive-time (minutes) to nearest medical facility
Rural (n=15)	56	20.3% of households do not have a Smartphone	31.5% of the population has three or more heat vulnerability factors	[0.4 – 43.5 minutes]
Urban (n=39)	230	10.3% of households do not have a Smartphone	23.0% of the population has three or more heat vulnerability factors	[1.14 – 14.4 minutes]

Data source: Arizona SVI, 2024

Rural and Urban Healthcare Hazard Preparedness and Response Strategies

Table 9 displays the top five hazards with the greatest risk and evidence-based examples of healthcare preparedness and response strategies through the lens of the selected SVI factors for both rural and urban healthcare communities in Southern Arizona. Note, each related SVI factor is underlined. After the selected SVI factors were identified for rural and urban healthcare facility locations in Southern Arizona (as described in Table 2), we can further prioritize preparedness and response strategies for high-risk hazards. Healthcare emergency preparedness professionals can use this data-driven approach to invest in tailored activities like writing community-specific exercises to test responses or strategic partnering with local organizations like housing coalitions or insurance providers.

Table 9. There are different preparedness and response strategies among rural and urban healthcare communities for each type of hazard.

Hazard	Rural Preparedness and Response Strategies	Urban Preparedness and Response Strategies
Extreme Heat	• Screen patients for heat vulnerability factors, such as mobile home residence, presence of a cooling system, age, or disability. • Identify individuals with no vehicles or no smartphones and develop a "check on your neighbor" program to ensure patients in isolated settings have the resources to stay cool (CDPHE, 2023).	• Integrate heat-resilient infrastructure, such as expanding cooling centers and deploying mobile respite units in high-vulnerability neighborhoods, while ensuring accessibility for non-English speakers and people with disabilities into plans (ADHS, 2024a).
Staffing Shortage	• Invest in local pipeline programs and loan repayment incentives to attract and retain providers in settings with limited healthcare access. • Utilize strong local ties to recruit workers and support volunteer integration in nonclinical roles, especially in areas with high housing cost burden and a lack of home inventory (Sprung et al., 2023).	• Invest in workforce retention initiatives focusing on the high housing cost burden, such as housing stipends (Sprung et al., 2023). • Leverage healthcare system resources, such as telehealth technology to manage patient loads and reduce administrative burden and use the percentage of households with no smartphone to estimate access to technology.
Severe Weather	• Pre-position essential supplies and mobile medical units near concentrated populations of older adults, individuals with disabilities, or people relying on electricity-dependent medical equipment in the event of a weather-related power outage or infrastructure failure (ASPR, 2024a).	• Prepare for the increased complexity that comes with higher population density, interdependent infrastructure, and evacuation needs. • Develop comprehensive surge plans for hospitals and EMS, employing scalable alternative care sites (considering older patients, children, and those with disabilities), and using real-time data and traffic monitoring (e.g., drive time to facilities) to manage patient and staffing flow (ASPR, 2024a).
Communications/ Telephone/ Network Failure	• Build robust communication networks to maintain contact with geographically or technologically isolated patients (e.g., no smartphones or drive-time to nearest healthcare facility) and staff, even during outages or infrastructure failures. • Upgrade out-of-date software and hardware, and whenever feasible, transition to virtual data centers and	• Tailor communication to diverse and multilingual populations, planning for mass transit disruptions, and ensuring accessible evacuation and shelter options for older patients, children, and those with disabilities (ASPR, 2021).

Hazard	Rural Preparedness and Response Strategies	Urban Preparedness and Response Strategies
	cloud-based services (ASPR, 2021).	
Cyber Attack 	• Plan to notify patients of a potential breach of protected health information with pre-scripted messaging for limited English speakers and varying levels of education (HHS, 2023).	• Regularly drill and prepare paper workflows and manual processes if systems are compromised. • Translate paper documents, especially for prescription medication instructions, for limited English speakers in case translation services are impacted (ASPR, 2022).
Supply Chain Failure 	• Provide tailored information to older patients, children, those with disabilities, and limited English speakers about planning for a healthcare supply shortage, including delivery interruptions, medication access or cost, and storage requirements (ASPR, 2024b).	• Track the types of medications used by specific patient populations to plan for potential shortages. For example, in an area with poor air quality and a higher proportion of children, there may be a greater need for asthma medications (ASPR, 2024b).

Policy Implications

Past disasters emphasize how policy decisions about emergency preparedness and response allocations, as seen in the COVID-19 pandemic, can be influenced by political context and partisan perspectives. Preparedness funding can wax and wane according to political priority and perceived threat and value. For instance, additional funding was allocated to the Pandemic and All-Hazards Preparedness Act (PAHPA) in 2013 as a direct result of the lessons learned during the 2009 H1N1 influenza pandemic (Pinn, 2023). However, shortly after, the U.S. Congress saw less value in pandemic preparedness and failed to authorize additional funding until the COVID-19 pandemic (Pinn, 2023). Policymakers tend to focus on the immediate needs during their time in office, rather than planning for long term sustainable emergency preparedness funding structures. This underscores a historic trend of funding preparedness once the pressure of an ongoing response has been initiated and is widely discussed in media. Additionally, there is no centralized funding source, rather funding for disaster preparedness, response, recovery, and mitigation is spread across multiple agencies including the Federal Emergency Management Agency (FEMA), the Administration for Strategic Preparedness and Responses (ASPR), and CDC, as well as state and local budgets. The Arizona State Legislature does not allocate state funding to emergency preparedness activities, observed as best practice in other states, adopting the approach of only funding response activities after an event occurs (Pew, 2025). Therefore, local county and city health officials must rely solely on federal or city council funding to conduct emergency preparedness activities, providing them with an increased responsibility in decision making. This approach undermines preparedness as part of the continuous, ongoing emergency management cycle and will fail the most under-resourced healthcare communities in Southern Arizona.

All Medicare participating providers and suppliers are required to have an established emergency preparedness program according to the Centers for Medicare and Medicaid

Services' (CMS) State Operations Manual, Appendix Z enacted in the rule titled, *"Emergency Preparedness Requirements for Medicare and Medicaid Participating Providers and Suppliers,"* issued on September 8, 2016 (CMS, 2019). Healthcare facilities are issued a citation when their emergency preparedness programs lack crucial compliance elements (CMS, 2026). In March 2026, CMS described the five most frequently cited emergency preparedness citations and their potential impact, one of which is the all-hazards risk assessment (CMS). As outlined in this paper, the all-hazards risk assessment is a foundational component to a healthcare facility's emergency preparedness program and it "must account for the patient population served." Collecting disaster risk data, such as through an HVA tool, helps emergency preparedness programs demonstrate effectiveness and advocate for funding to support their initiatives. However, this requires experienced healthcare emergency managers with sufficient time and resources, demonstrating a significant burden and barrier to emergency preparedness. The application of SVI data, as described in this paper, can help Southern Arizona facilities meet their CMS requirements and better understand their unique, local community.

Limitations

Throughout this research there were no substantial limitations or barriers that compromised the validity of our findings. However, it is intended as a starting point for planning and discussion, not as a replacement for engaging directly with communities to understand their specific needs, rather it is one of many tools and is not predictive of current conditions.

Because the SVI uses census data, certain populations, such as undocumented immigrants, people experiencing homelessness, or transient groups, are often undercounted or omitted, resulting in the systematic underrepresentation of some of the most vulnerable residents (ADHS, 2024b). Furthermore, social vulnerability is a dynamic condition, but census data are static snapshots in time and may not keep up with rapid changes due to disaster migration, economic shifts, or emerging hazards (ADHS, 2024b). Therefore, local data and context may provide a more accurate picture.

Data limitations are especially pronounced in rural and Tribal areas, where some census tracts or ZCTAs may be excluded due to missing information or large margins of error, and cultural or resilience factors are not reflected (CDC/ATSDR, 2022). Similarly, small population sizes, sampling variability, and high relative standard errors can affect the reliability and precision of estimates, especially in less densely populated rural areas (CDC/ATSDR, 2022). Because of these gaps and potential for misinterpretation, particularly in Tribal communities, the data should not be used to represent trends. To better understand SVI data in rural and Tribal areas, it is best to partner with local public health and community organization to ensure an accurate and respectful understanding.

Recommendations

The following recommendations are designed to strengthen disaster preparedness across Southern Arizona's healthcare system by addressing the diverse needs and hazards found in both rural and urban communities. Drawing on an analysis of social vulnerability factors and the highest risk hazards facing the region, these actionable steps are tailored for public health professionals, healthcare emergency managers, healthcare leadership, and policymakers.

Healthcare Coalition Staff and Public Health Professionals

- As part of preparedness activities, regularly examine the SVI at the census tract or ZCTA levels, rather than the county level, for additional sector-specific and location-based planning. Note that the SVI relies on American Community Survey estimates which are released every 5 years. While there are limitations to the SVI data, it is still a good indicator of community level factors that can drive preparedness actions.
- Partner with healthcare and community organizations to deliver targeted risk communication and resources in communities of focus, including materials geared towards language, disability, age, and technology access needs.
- Participate in community-based coalitions to coordinate preparedness, especially around heat events, disease outbreaks, and healthcare access barriers. For instance, Tucson's Urban Heat Island workshops demonstrate the value of uniting utilities, public health agencies, and community groups to co-produce solutions like tree-planting initiatives in heat-vulnerable census tracts (Roy et al., 2024).
- Ensure preparedness plans, exercises, and risk assessments use vulnerability data, not just as appendices, but directly in planning functional exercises, training scenarios, and community outreach.
- Develop and implement a unified risk assessment process, ensuring that hazard and vulnerability data are consistent, comparable, and easy to share and track between healthcare facilities, coalitions, public health, and emergency management partners.
- Use standard tools (like a regionally adapted Hazard Vulnerability Analysis) and benchmarks for periodic (e.g., annual or biannual) review across all relevant institutions.

Healthcare Facilities

- Integrate SVI and heat vulnerability data directly into HVAs, exercises, and preparedness and response plans.
- Build partnerships with local housing agencies, schools, transportation authorities, utility providers, and community organizations to address interconnected vulnerabilities, especially for evacuation and sheltering planning.
- Continue to demonstrate the importance of emergency preparedness efforts to organizational leadership and decision-makers using data and evaluation to promote sustainability.

- Use data-driven outcomes (such as reduced readmissions or improved surge response) to make the case for prioritizing preparedness in annual budgets.
- Track preparedness improvements and gaps at fine geographic scales, updating risk assessments and plans annually or after major local incidents.
- Identify grant opportunities, shared cost savings, or collaborative ventures that can address the chronic underfunding of disaster preparedness.

Healthcare Leadership

- Invest in preparedness as a core organizational value, supporting sustainable, long-term funding, and staff time, even when not driven by short-term revenue or regulatory incentives.
- Prioritize recruitment, retention, and local training pipelines for healthcare workforce shortages, especially in rural or under-resourced urban areas.
- In rural areas, prioritize investments in telehealth, transportation, mobile medical units, and targeted outreach to isolated and high-poverty populations. Support capacity-building for local volunteer and pipeline workforce programs.
- For urban areas, focus on surge capacity, translation services, access for linguistically diverse populations, and scalable support for populations in dense or multi-unit housing.

Policymakers

- Target funding and emergency resources directly to communities with overlapping vulnerabilities (poverty, minority status, poor housing, transport gaps, heat risk), especially at the census tract or ZCTA level.
- Foster cross-sector policy collaboration, encouraging partnerships among public health, emergency management, education, housing, and utilities to address interconnected vulnerabilities.
- Establish sustainable, dedicated funding streams for disaster preparedness, moving beyond sporadic crisis-driven allocations to continuous investments that build capacity in both rural and urban areas.

By centering these actions around granular SVI data and local context, each group can collectively strengthen preparedness, resilience, and health for Southern Arizona's communities.

Conclusion

Overall, the findings underscore the critical role of understanding the social factors and how they can inform healthcare disaster preparedness in Southern Arizona. This analysis specifically advances the current knowledge of what disaster preparedness looks like for this community and addresses the gaps in not only the lack of resources, but also infrastructure and funding. Healthcare disaster preparedness in Southern Arizona should move beyond not only hazard-centric approaches but also address the root causes of vulnerability (Adini et al., 2012). This requires aligning emergency management funding with social goals, prioritizing communities where poverty, limited education, and health disparities intersect with high hazard exposure. This paper highlights the intersection of hazard and social vulnerability in Southern Arizona. It aims to guide the healthcare and emergency preparedness community in considering how longstanding community factors shape planning for future hazards.

Author Positionality

The authors of this research represent a multidisciplinary group of individuals who come from different social, cultural, professional, and political backgrounds. As a team, we have maintained transparency and have openly discussed potential biases when writing this paper. We use the term “Paper” throughout this document as a more inclusive term. Moving towards such terminology is a meaningful step toward fostering a more welcoming environment for all.

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Appendix A: Understanding Systems

To better understand the federal systems in place for emergency preparedness, this appendix outlines the Emergency Preparedness Cycle developed by FEMA, as well as the National Incident Management System (NIMS) Cycle, established by the Center of Excellence for Homeland Security. The FEMA Cycle's audience is geared to the general community, local governments, schools, community organizations, and emergency management officials, whereas the NIMS Cycle's audience is more tailored to Emergency Preparedness professionals, Public Health Agencies, First Responders, Homeland Security officials, and Incident Command Teams.

FEMA Cycle of Emergency Preparedness Cycle:

As a part of FEMA's National Preparedness goal, outlined below is a cycle to show the steps in preparing for emergencies (FEMA, 2020).

https://www.fema.gov/emergency-managers/national-preparedness/mission-core-capabilities

Type	Description
Prevention	Prevent, avoid or stop an imminent, threatened or actual act of terrorism.
Protection	Protect our citizens, residents, visitors, and assets against the greatest threats and hazards in a manner that allows our interests, aspirations and way of life to thrive.
Mitigation	Reduce the loss of life and property by lessening the impact of future disasters.

Response	Respond quickly to save lives, protect property and the environment, and meet basic human needs in the aftermath of a catastrophic incident.
Recovery	Recover through a focus on the timely restoration, strengthening and revitalization of infrastructure, housing and a sustainable economy, as well as the health, social, cultural, historic and environmental fabric of communities affected by a catastrophic incident.

National Incident Management System (NIMS) Cycle of Emergency Preparedness:

The National Incident Management System (NIMS), "defines preparedness as "a continuous cycle of planning, organizing, training, equipping, exercising, evaluating, and taking corrective action in an effort to ensure effective coordination during incident response." The cycle is one element of a broader system to prevent, respond to, recover from, and mitigate natural disasters, acts of terrorism, and other man-made disasters" (FEMA, 2017).

Type	Description
Plan	Effective planning serves as the foundation for managing all phases of crisis response. It involves developing both broad strategies and specific operational procedures that define performance expectations, resource needs, and organizational responsibilities. Planning creates comprehensive standard operating procedures and emergency response plans that ensure preparedness for major disasters. The National Response Framework provides the overarching structure that coordinates all response entities to deliver consistent, nationwide disaster management from minor incidents to catastrophic events, establishing a unified approach to emergency response across all hazard types.

Organize/Equip	This phase focuses on assembling the necessary human resources and technological infrastructure to build effective emergency response capabilities. It involves determining the specific skills and expertise required for various roles, ensuring proper staffing levels, and securing essential equipment and resources that organizations will need during emergency situations.
Train	Training develops the competencies of all emergency response personnel, including first responders, security officials, emergency managers, and community partners. This component ensures that individuals acquire the specific knowledge and practical skills necessary to execute their assigned responsibilities during crisis situations.
Exercise	Emergency exercises serve as testing grounds for preparedness plans and capabilities. These simulated scenarios allow organizations to identify their operational strengths and weaknesses, refine their procedures, and address any gaps in their emergency response systems before facing actual disasters.
Evaluate/Improve	This final phase centers on continuous enhancement of emergency preparedness through systematic review and refinement. Organizations analyze outcomes from exercises and real emergencies, document key insights, create action plans for addressing identified deficiencies, and implement improvements. FEMA's continuous improvement program facilitates knowledge sharing and best practice development across emergency management professionals at all levels of government.

Source: https://www.fema.gov/sites/default/files/2020-07/fema_nims_doctrine-2017.pdf

Appendix B: Full List of Hazard Definitions

Hazard	Definition
Naturally Occurring Events	
Drought	A prolonged period of abnormally low rainfall, leading to a shortage of water.
Dust Storm	A strong, turbulent wind which carries clouds of fine dust, soil, and sand over a large area.
Earthquake	A sudden and violent shaking of the ground, sometimes causing great destruction, because of movements within the earth's crust or volcanic action.
Flood/Flash Flood	An overflowing of a large amount of water beyond its normal confines, especially over what is normally dry land.
High Winds	Winds with sustained speeds of 40 to 57 miles per hour.
Landslide	The sliding down of a mass of earth or rock from a mountain or cliff, often occurring after a flood.
Severe Thunderstorm	A thunderstorm that produces one inch of hail or larger in diameter and/or winds equal or exceed 58 miles an hour.
Extreme Heat	A long period (2 to 3 days) of high heat and humidity with temperatures that are much hotter than the average.
Extreme Cold	A long period (2 to 3 days) when temperatures drop below normal and wind speed increases.
Tornado	A mobile, destructive vortex of violently rotating winds having the appearance of a funnel-shaped cloud and advancing beneath a large storm system.
Wildfire	A large, destructive fire that spreads quickly over woodland or brush.
Human Related Events	
Active Threat	A dynamic, quickly evolving situation involving an individual (or individuals) using deadly physical force, such as firearms, bladed weapons, or a vehicle. An active threat incident typically involves an individual (or individuals) presenting an immediate threat or imminent danger to people by displaying a weapon, having made threats, and/or shown intent to cause harm or perform violence.
Act of Terrorism	Violent, criminal acts committed by individuals and/or groups who are inspired by, or associated with, designated terrorist organizations or nations.
Civil Disturbance	An incident which disrupts a community and requires intervention to maintain public safety.
Mass Casualty (Trauma)	An event that overwhelms the local healthcare system, where the number of casualties vastly exceeds the local resources and capabilities in a short period of time.
Patient Surge	The ability to evaluate and care for a markedly increased volume of patients—one that challenges or exceeds normal operating capacity.
Staffing Shortage	When there is a prolonged lack of employees within the healthcare industry that impacts patient care.

Hazard	Definition
Supply Chain Failure	An event in the supply chain that disrupts the flow of materials on their journey from initial suppliers through to final customers.
Workplace Violence / Threat	Any act or threat of physical violence, harassment, intimidation, or other threatening disruptive behavior that occurs at the work site.
Hazardous Materials Events	
Biological Incident	Occurs with an accidental or intentional (bioterrorism) release of a biological agent. These agents may be relatively harmless or may cause serious illness and/or death. Biological agents can affect humans, pets, livestock, and/or the environment.
Chemical Incident	The uncontrolled release of a toxic substance, potentially resulting in harm to public health and the environment. Chemical incidents can occur because of natural events, or as a result of accidental or intentional events. These incidents can be sudden and acute or have a slow onset when there is a 'silent' release of a chemical.
Explosives Incident	All incidents where explosive materials, chemicals, or ignitable mixtures were determined to be the primary cause of an explosion.
Nuclear Incident	Involves a blast, detonation, or a nuclear explosion (fission). Victims can have contamination and/or exposure. Examples include nuclear weapon detonation and improvised nuclear device detonation.
Radiological Incident (External)	Incident that produces radiation without detonation of a nuclear device. Examples include a radiological dispersal device or a hidden radioactive source.
Technological and Utility Events	
Communications/Telephone Failure	When there is internal or external interruption of communications by either party that results in difficulty transporting the intended message.
Cyber Attack	An attempt by hackers to damage or destroy a computer network or system.
Dam Failure	An uncontrolled release of water from a reservoir through a dam as a result of structural failures or deficiencies in the dam.
Information Systems Failure	A system that either does not perform as expected, is not operational at a specified time, or cannot be used in the way it was intended due to software issues, design, or faulty data.
Mass Electrical Failure	A loss of power typically caused by a fault on a power line.
Medical Gas Failure	An incident where there are interruptions to medical gas service or a leak in the lines.
Natural Gas Leak	A leak of natural gas, either from a pipe or another contained area, into any area where gas should not be.
Network Failure	Complete or partial failure of any network component such as a router, switch, firewall, repeater, connection cable, etc., due to human error, malfunction or natural disaster.

Hazard	Definition
Transportation Disruption (includes roadway, railway, air transport failures)	Means any significant delay, interruption, or stoppage in the flow of transportation caused by a natural disaster, heightened threat level, an act of terrorism, or any transportation security incident.
Water Disruption	An incident or incidents that cause discoloration, off flavors or odors in the potable water supply. Disruption also includes water outages to part or all of a building or facility.
Water Contamination	Occurs when harmful substances, often chemicals or microorganisms, contaminate the water supply.
Wastewater Treatment Failure	An incident impacting a wastewater treatment plant and ability to provide treated water.
Epidemics and Pandemics	
Epidemic (vaccine-preventable, water-borne illness, etc.)	Widespread occurrence of an infectious disease in a community at a particular time.
High Consequence Infectious Disease Outbreak	An acute infectious disease, which typically has a high case-fatality rate, may not have effective prophylaxis or treatment, may have the ability to spread in the community and within healthcare settings, and requires an enhanced population and system response to ensure it is managed effectively, efficiently and safely.
Pandemic (coronavirus, influenza, etc.)	A widespread occurrence of an infectious disease over a whole country or the world at a particular time.

Appendix C: Full Data for Table 1

Rural Facility Respondents - Hazards of Southern Arizona (n=15)		Risk Score	Urban Facility Respondents- Hazards of Southern Arizona (n=39)		Risk Score	All Facility Respondents Southern Arizona Hazards (N=54)		Risk Score
1	Staffing Shortage	61.14%	1	Extreme Heat	54.50%	1	Staffing Shortage	55.80%
2	Severe Weather (damaging winds, dust storm, etc.)	56.44%	2	Staffing Shortage	53.40%	2	Extreme Heat	54.20%
3	Communications/Telephone/Network Failure	56.17%	3	Severe Weather (damaging winds, dust storm, etc.)	47.10%	3	Severe Weather (damaging winds, dust storm, etc.)	49.90%
4	Extreme Heat	54.28%	4	Communications/ Telephone/ Network Failure	45.50%	4	Communications/Telephone/Network Failure	48.30%
5	Cyber Attack	50.74%	5	Supply Chain Failure	44.20%	5	Cyber Attack	45.60%
6	Active Threat	50.46%	6	Extended Power outage	43.70%	6	Flood/Flash Flood	45.50%
7	Flood/Flash Flood	48.48%	7	Cyber Attack	43.60%	7	Supply Chain Failure	44.10%
8	Workplace Violence / Threat	48.17%	8	Pandemic (coronavirus, influenza, etc.)	43.00%	8	Pandemic (coronavirus, influenza, etc.)	44.10%
9	Outbreak of Treatable Infectious Diseases	47.70%	9	Flood/Flash Flood	41.80%	9	Information Systems Failure	41.80%
10	Supply Chain Failure	46.64%	10	Epidemic (vaccine-preventable, water-borne illness, etc.)	39.60%	10	Active Threat	41.70%
11	Wildfire	45.79%	11	Drought	39.34%	11	Epidemic (vaccine-preventable, water-borne illness, etc.)	41.30%
12	Pandemic (coronavirus, influenza, etc.)	45.56%	12	Active Threat	37.89%	12	Extended Power outage	41.30%
13	Epidemic (vaccine-preventable, water-borne illness, etc.)	44.66%	13	Mass Electrical Failure	37.74%	13	Outbreak of Treatable Infectious Diseases	39.90%
14	Chemical Incident	42.90%	14	Outbreak of Treatable Infectious Diseases	36.09%	14	Drought	39.40%
15	Information Systems Failure	42.17%	15	Workplace Violence / Threat	33.42%	15	Wildfire	38.50%
16	Dust Storm	41.83%	16	Wildfire	33.22%	16	Mass Electrical Failure	37.90%
17	Drought	38.77%	17	Water Disruption	32.98%	17	Workplace Violence / Threat	37.50%
18	Mass Electrical Failure	38.02%	18	Water Contamination	29.10%	18	Water Disruption	34.00%
19	Extended Power outage	37.96%	19	Information Systems Failure	28.82%	19	Chemical Incident	32.50%
20	Water Disruption	36.05%	20	Natural Gas Leak	28.70%	20	Dust Storm	32.40%
21	Water Contamination	33.83%	21	Dam Failure	28.36%	21	Patient Surge	30.60%
22	Mass Casualty (Trauma)	33.68%	22	Patient Surge	28.16%	22	Water Contamination	30.10%
23	Patient Surge	32.33%	23	Dust Storm	28.05%	23	Mass Casualty (Trauma)	28.30%
24	Civil Disturbance	31.25%	24	Act of Terrorism	27.99%	24	Act of Terrorism	27.50%
25	Transportation Disruption (includes roadway, railway, air transport failures)	29.14%	25	Chemical Incident	27.93%	25	Transportation Disruption (includes roadway, railway, air transport failures)	26.70%
26	Explosives Incident	26.85%	26	Mass Casualty (Trauma)	25.04%	26	Natural Gas Leak	25.40%
27	Act of Terrorism	26.12%	27	Transportation Disruption (includes roadway, railway, air transport failures)	24.94%	27	Civil Disturbance	24.70%
28	Natural Gas Leak	25.10%	28	Wastewater Treatment Failure	22.44%	28	Wastewater Treatment Failure	23.20%

Rural Facility Respondents - Hazards of Southern Arizona (n=15)		Risk Score	Urban Facility Respondents- Hazards of Southern Arizona (n=39)		Risk Score	All Facility Respondents Southern Arizona Hazards (N=54)		Risk Score
29	High Consequence Infectious Disease Outbreak	24.29%	29	Explosives Incident	21.59%	29	Explosives Incident	22.90%
30	Wastewater Treatment Failure	23.89%	30	Biological Incident	21.36%	30	High Consequence Infectious Disease Outbreak	21.90%
31	Radiological Incident (External)	22.15%	31	Civil Disturbance	21.26%	31	Biological Incident	21.40%
32	Biological Incident	21.35%	32	High Consequence Infectious Disease Outbreak	19.84%	32	Radiological Incident (External)	15.60%
33	Medical Gas Failure	19.58%	33	Radiological Incident (External)	13.44%	33	Medical Gas Failure	14.00%
34	Nuclear Incident	17.78%	34	Temperature Extreme (Cold)	12.44%	34	Extreme Cold	12.90%
35	Landslide/Sink Hole	16.00%	35	Medical Gas Failure	12.01%	35	Nuclear Incident	12.60%
36	Temperature Extreme (Cold)	13.61%	36	Nuclear Incident	10.90%	36	Landslide/Sink Hole	11.60%
37	Earthquake	11.43%	37	Landslide/Sink Hole	9.32%	37	Earthquake	9.20%
38	Tornado	10.04%	38	Earthquake	7.73%	38	Tornado	7.50%
39	Dam Failure	3.63%	39	Tornado	5.87%	39	Dam Failure	1.60%

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