Trends and disparities of hazardous heat exposure among incarcerated people in the United States

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The ~2 million incarcerated people in the United States face growing heat-related health risks. We evaluated exposure to potentially hazardous heat for 4,078 continental US carceral facilities during 2016-2020. We found that state-run carceral facilities in Texas and Florida accounted for 52% of total exposure, despite holding 12% of all incarcerated people. Further, the number of hot days per year increased during 1982-2020 for 1,739 carceral facilities, primally located in the Southern US. We highlight the urgency for enhanced infrastructure, health system interventions, and treatment of incarcerated people, especially under climate change.

Incarcerated people in the United States (US) are at high risk for heat-related morbidity and mortality due to their physical confinement, social isolation, and high rates of chronic mental and physical illnesses.[1–3] Unlike the large majority of the US population, who have access to air conditioning (central and any air conditioning equipment)[4] – the most effective individual-level intervention to mitigate heat exposure[1] – many of the 2 million incarcerated people[5] are in the 44 states that do not universally provide air conditioning in carceral facilities.[6,7]

Identifying where incarcerated people are exposed to hazardous heat conditions is fundamental to advancing environmental justice for one of the most marginalized and disempowered communities in the US.[3] Yet researchers and policymakers have largely overlooked how heat impacts incarcerated people,[3,8,9] in part due to perceptions that their physical suffering is justified.[3] As climate change accelerates, the US will experience more frequent, intense, and longer heat waves that may disproportionately affect incarcerated people.[8]

Here, we evaluate recent exposure to and the trends of potentially hazardous heat conditions during 1982-2020 for all 4,078 operational and populated carceral facilities (referring to

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While previous work has assessed how heat impacts incarcerated people in the United States,[2] there is a critical need to quantify potentially hazardous heat conditions at carceral facilities.[9,10] Without this knowledge, the impact of more frequent periods of elevated heat[11] on incarcerated people cannot be contextualized nor framed against future climate projections. Identifying where incarcerated peop ... [1]

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prisons, jails, immigration detention facilities, and other carceral facilities) in the continental US (Methods, Supplementary Information). We define potentially hazardous heat as the number of days per year where the indoor maximum wet bulb globe temperature ($WBGT_{max}$) exceeds 28°C, the threshold defined by the US National Institute for Occupational Safety and Health (NIOSH) for acclimated populations to limit humid heat exposure under moderate workloads (234–349 W).[10]

During 2016–2020, there were, on average, 41.3 million person-days of heat exposure annually at carceral facilities in the US. State prisons accounted for 61% (24.5 million person-days) of total exposure (Figure 1a), followed by county jails (11.1 million person-days; 27%). The estimated 145,240 people in Texas and 98,941 in Florida housed in state-run carceral facilities in 2018 – 12% of all incarcerated people in the US – accounted for 52% of total exposure (Figure 1a). At 118 carceral facilities, largely in southern California, Arizona, Texas, and inland Florida, experienced on average, 75 days or more per year where $WBGT_{max}$ exceeded 28°C (Figure 1b). Air conditioning in carceral facilities in these states is spotty or relies on a less effective cooling system like evaporative cooling[11] where air conditioning even exists.[6,7] Across all US carceral facilities, the Starr County Jail, a county facility in Rio Grande, TX, that held 249 people in 2018, experienced the largest number of day per year $WBGT_{max}$ exceeded 28°C on average during 2016–2020 (126.2 days per year). We include additional analyses by further carceral facility types in the Supplementary Information (Supplementary Figures 3 – 4).

During 1982–2020, carceral facility locations were, on average, exposed to 5.5 more days per year where $WBGT_{max}$ exceeded 28°C annually compared to locations without carceral facilities (Figure 2a). However, there was a considerable amount of variation by year, with a maximal

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disparity of 9.8 more days at carceral facilities than locations without carceral facilities in 1998 and a minimal disparity of 3.5 days in 1994. Arizona, California, and Nevada ranked as the top three states with the greatest exposure disparities (Figure 2a). Carceral facilities in Arizona experienced 13.1 more days per year than the rest of the state and 40.9 more days compared to the entire continental United States during 1982-2020 on average. Statistics comparing the characteristics of incarcerated and non-incarcerated people are found in Supplementary Tables 1 and 2.

In 2018, 915,627 people in the United States, 45% of the estimated total incarcerated population, were housed in 1,739 carceral facilities with an annual increase in the number of days per year $WBGT_{max}$ exceeded 28°C during 1982-2020 (Figure 2b). These facilities are primarily located in the Southern US, which faced the greatest number of potentially hazardous heat days per year since 1982 (Figure 2b). Carceral facilities in Florida experienced on-average 22.1 more days in 2020 compared to 1982, the greatest increase in humid heat days for all continental states, consistent with previous work finding that the largest relative increases in heat stress are expected at latitudes closer to the equator.[12] The greatest overall increase relative to the state was for Webb County Jail, TX, with 58.7 more days than the rest of Texas in 2020 compared with 1982 (Figure 2c). We also present results from Figures 1 and 2 with alternative thresholds of 26°C and 30°C (Supplementary Figures 5 - 8).

The majority of carceral facilities in the Southern US have experienced a rapid increase in potentially hazardous heat exposure since the 1980s and are located in states that do not have mandatory conditioning access for state-run institutions.[6,7] While physically this rapid increase in heat exposure is a result of anthropogenic climate change, land-cover and land-use change, including an urban heat island effect caused by the materials used to construct carceral

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facilities,[3] this geographic disparity reflects state-level criminal justice policies, as Southern states have the highest imprisonment rates in the US (though not necessarily highest jailing rates)[13] and the inherent differential effects of climate change. Throughout the country, including in the Northeast and Midwest, many locations with carceral facilities also experienced an increasing number of days WBGT exceeded 28°C compared to other locations. This continuing intensification limits the effectiveness of heat-mitigation plans (if they exist at all) at non-air-conditioned facilities.[11]

That we found carceral facilities are systematically exposed to an increasing number of potentially hazardous heat days compared to other areas of the US is plausible for several reasons. First, carceral facilities are often built where there is availability of low-cost land and limited resistance of local communities.[14] In many states, areas that meet these criteria are in sparsely populated desert or swampy environments.[5] Zoning laws in urban environments and security issues also favor construction in isolated, desert-like areas.[14] The lack of disparity we identify in Florida is an exception likely due to the north-south climate gradient, with a relative dearth of carceral facilities in the most hot-humid, but economically wealthy and densely populated southern tip. We found that the top-four most exposed states to potentially hazardous heat days per year were Texas, Florida, Arizona, and Louisiana, all of which do not provide universal air conditioning to all their prisons,[7] potentially creating a double burden of increased exposure and vulnerability.

Incarcerated people have few options to reduce the impact of hazardous heat[3,7,9] and these marginalized communities are often disproportionately susceptible to the effect of heat exposure given preexisting health conditions. An estimated 43% of the state prison population has a previous mental health diagnosis[15] and people on psychotropic medications are at

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increased risk for heat illness.[16] Exposure to elevated heat can also cause both acute health effects, such as heat stroke or mortality, and long-term damage. For example, chronic dehydration strains kidney function and those with chronic heat exposure have been shown to have higher rates of kidney disease.[17] Such vulnerabilities are especially relevant given restrictive prison policies with respect to drinking water and other potential heat-adaptation tools.[3]

Though there have been recent declines, the incarcerated population of the US has in increased by 500% over the past four decades.[18] People of color are overrepresented in carceral facilities and compose an estimated two-thirds of the total incarcerated population. The prison population is also aging, with 1 in 7 serving life in prison,[19] potentially resulting in potentially greater heat vulnerability to those incarcerated. Structural racism manifests in persistently higher proportions and rates of incarcerated people being people of color.[20] Acknowledging and accounting for the role structural racism plays in incarceration is critical to understand both key vulnerabilities to heat as well as contextualizing solutions to exposure to heat. Appropriate preparation for periods of elevated heat is also critical. For example, seasonal forecasts could help facilities prepare for summer heat waves to reduce the impacts of hazardous conditions for incarcerated communities.

Our work highlights how incarcerated populations in the US are systematically exposed to potentially hazardous heat with the greatest exposure and rates of increase concentrated in state-run institutions. Federal, state, and local laws mandating safe temperature ranges, enhanced social and physical infrastructure, and health system interventions could mitigate the effect of hazardous heat. Underlying this is the need for a fundamental overhaul to the perception and treatment of incarcerated people in environmental public health policy and

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regulatory action. Further work is critical to comprehensively characterize the vulnerability of the United States incarcerated population to heat, as well as how heat impacts health, to build reliable and validated datasets of cooling mechanisms in prisons and jails, to directly measure indoor temperatures in prisons and jails, and to deploy adaptation measures to mitigate the worst impacts of climate-related stressors. Doing so is critical to environmental justice, particularly for incarcerated people with limited social and political agency.

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Methods

We assigned daily $WBGT_{max}$ estimates to 4,078 carceral facility locations for the United States during 1982 - 2020. $WBGT_{max}$ is constructed from high-resolution (4 km) daily maximum 2m air temperatures (T_{max}) and maximum vapor pressure deficit (VPD_{max}) from the PRISM dataset.[1] T_{max} and VPD_{max} are used to construct daily maximum heat index (HI_{max}) following the US National Weather Service's procedure,[2] which is converted to indoor, or shaded, $WBGT_{max}$ using a quadratic transform that assumes fixed wind speeds (0.5 m s^{-1}) and no radiated heat (Supplementary Information). Facility location and population data is from Homeland Infrastructure Foundation-Level Data (HIFLD), produced by the Department of Homeland Security.[3]

We then define potentially hazardous heat frequency as the number of days per year where the maximum wet bulb globe temperature ($WBGT_{max}$) exceeded 28°C, the threshold used by the US National Institute for Occupational Safety and Health (NIOSH) for acclimated populations to limit heat exposure under moderate workloads (234–349 W)[4] and it is used widely in environmental epidemiological research.[5-6] Exposure during 2016 - 2020 is measured by multiplying the number of incarcerated people housed at each carceral facility in 2018 by the average number of days $WBGT_{max}$ exceeded 28°C per year during 2016 - 2020. Annual disparity between incarcerated and locations without carceral facilities is measured by taking the population-weighted difference between the number of days $WBGT_{max}$ exceeded 28°C at the location of a facility and the rest of the state. Population weighting fairly reflects the experience of a population to heat stress. To measure the annual rate of change in annual heat exposure, we fit linear regressions to the count of days $WBGT_{max}$ exceeded 28°C per year for each facility. For a more detailed explanation of methods, see the online Supplementary Information.

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Data availability

Daily 4-km PRISM data during 1982-2020 and HIFLD data are freely available at https://prism.oregonstate.edu/recent/ and https://hifld-geoplatform.opendata.arcgis.com, respectively. National Center for Health Statistics (NCHS) bridged-race dataset (Vintage 2020) is available during 1990-2020 https://www.cdc.gov/nchs/nvss/bridged_race.htm and from the US Census Bureau before 1990 https://www.census.gov/data/tables/time-series/demo/popest/1980s-county.html.

Code availability

All code to reproduce this work, as well as underlying daily $WBGT_{max}$ for each carceral facility during 1982-2020 and analytical products used here, are freely available at https://github.com/sparklabnyc/temperature_prisons_united_states_2024.

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Author contributions

C.T. and R.M.P. designed research; C.T., V.D.L., and R.M.P. performed research; C.T. and R.M.P. contributed analytic tools; C.T., V.D.L, Y.A., C.R, and R.M.P analyzed data; and C.T., V.D.L., R.S., A.E.N. and R.M.P wrote the paper with assistance from Y.A. and C.R.

Competing interests statement

The authors have no competing interests to declare.

Figure 1. Mean annual exposure during 2016-2020 to potentially hazardous heat in carceral facilities within the continental United States (N=4,078), measured by: (a) the number of person-days $WBGT_{max}$ exceeded 28°C for incarcerated people by state and carceral facility type; and (b) the number of days $WBGT_{max}$ exceeded 28°C for each carceral facility.

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Figure 2. (a) Population-weighted difference between the annual number of days $WBGT_{max}$ exceeded 28°C at the location of carceral facilities versus all other locations in the continental United States during 1982–2020, overall and stratified by state, ordered by average population-weighted difference, (b) the total change in the number of number of days $WBGT_{max}$ exceeded 28°C per year for each carceral facility in the continental United States during 1982–2020, and (c) the total change in disparity in number of number of days $WBGT_{max}$ exceeded 28°C per year for each carceral facility in the continental United States, compared with the rest of the state the carceral facility is located, during 1982–2020.

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