Extreme heat and reduced cognitive performance in adults in non-air-conditioned buildings

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Students who lived in dormitories without air conditioning (AC) during a heat wave performed worse on a series of cognitive tests compared with

students who lived in air-conditioned dorms, according to new research led by Harvard T.H Chan School of Public Health. The field study, the first to demonstrate the detrimental cognitive effects of indoor temperatures during a heat wave in a group of young healthy individuals, highlights the need for sustainable design solutions in mitigating the health impacts of extreme heat.

"Most of the research on the health effects of heat has been done in vulnerable populations, such as the elderly, creating the perception that the general population is not at risk from heat waves," said Jose Guillermo Cedeño-Laurent, research fellow at Harvard Chan School and lead author of the study. "To address this blind spot, we studied healthy students living in dorms as a natural intervention during a heat wave in Boston. Knowing what the risks are across different populations is critical considering that in many cities, such as Boston, the number of heat waves is projected to increase due to climate change."

The study will be published online July 10, 2018 in *PLOS Medicine* as part of a special issue dedicated to climate change and health.

Extreme heat can have severe consequences for public health and is the leading cause of death of all meteorological phenomena in the U.S. Temperatures around the world are rising, with 2016 marking the warmest year on record for the past two centuries. While the health impacts of extreme heat are well documented, most studies to date have focused on vulnerable populations, including the very young or the elderly, and tend to be epidemiologic studies that use outdoor temperature records. Understanding the effects of indoor temperatures is important given that adults in the U.S. spend 90% of their time indoors.

For this new study, researchers tracked 44 students in their late teens and early 20s living in dorm rooms. Twenty-four of the students lived in adjacent six-story buildings that were built in the early 1990s and had

central AC. The remaining 20 students lived in low-rise buildings constructed between 1930 and 1950 that did not have AC. Researchers outfitted each student's room with a device that measured temperature, carbon dioxide levels, humidity, and noise levels, and tracked their physical activity and sleep patterns with wearable devices.

The study was conducted over 12 consecutive days in the summer of 2016. The first five days consisted of seasonable temperatures, followed by a five-day-long heat wave, and then a two-day cooldown. Each day the students took two cognition tests on their smartphones right after waking up. The first test required students to correctly identify the color of displayed words and was used to evaluate cognitive speed and inhibitory control—or the ability to focus on relevant stimuli when irrelevant stimuli are also present. The second test consisted of basic arithmetic questions and was used to assess cognitive speed and working memory.

The findings showed that during the heat wave, students in the buildings without AC performed worse on the tests than students in the air-conditioned dormitories and experienced decreases across five measures of cognitive function, including reaction times and working memory. During the heat wave, students in buildings without AC experienced 13.4% longer reaction times on color-word tests, and 13.3% lower addition/subtraction test scores compared with students with air-conditioned rooms. Combined, these data show that students in rooms with AC were not just faster in their responses, but also more accurate.

Interestingly, the most significant difference in cognitive function between the two groups was seen during the cooldown period, when outdoor temperatures began to subside but indoor temperatures remained elevated in the dormitories without air conditioning.

"Indoor temperatures often continue to rise even after outdoor

temperatures subside, giving the false impression that the hazard has passed, when in fact the 'indoor heat wave' continues," said Joseph Allen, assistant professor of exposure assessment science and co-director of the Center for Climate, Health, and the Global Environment (C-CHANGE) at Harvard Chan School and one of the study's senior authors. "In regions of the world with predominantly cold climates, buildings were designed to retain heat. These buildings have a hard time shedding heat during hotter summer days created by the changing climate, giving rise to indoor heat waves."

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