Record-breaking heat waves, the hottest global temperatures to date[1] - 2023 showed devastating glimpses into the consequences we all must continue to grapple with due to the changing climate. Further, the warming of the Earth's temperature does not happen in a vacuum: we bore witness to the past year's active hurricane seasons[2] and historic floods battering the neighborhoods of Los Angeles[3] just this past month. On a more microscopic scale, the implications for rising global temperatures directly impact vulnerable workers who are already exposed to hazardous working conditions. From the migrant farm workers[4] to the concrete construction contractors,[5] many workers must contend with not only an uncontrollable outdoor work environment but also with hostile work environments' failures to provide adequate shade and resting hours. In 2021 alone, there were 36 work-related deaths due to environmental heat exposure; from 2011 to 2021, there were 436 heat-related deaths caused by workplace environmental exposure.[6] Though the sheer number of deaths is low compared to workplace transportation-related injuries, the lives lost due to heat-related injuries still underscore the importance of continuing to build upon the historical strides made in protecting workers from excruciating and fatal injuries.[7]

One historical advance made to protect workers from heat-related injuries is the development of the wet-bulb globe temperature (WBGT), which is a measure of environmental health as it relates to human health. Specifically, the development of the WBGT allowed for a quantified calculation of environmental heat factors, protected workers in terms of quantifying risks and setting permissible levels, and now holds important future implications for the protection of workers.

WBGT was developed due to the experiences of soldiers within the United States military, as military recruits during the 1940s and 1950s were disproportionately affected by heat

stroke during their deployment and in training camps.[8–10] Young soldiers from all walks of life were drafted, placed into uniforms, and thrust into the rigors of military training amid heat waves; there were minimal regulatory measures to help soldiers train for the battlefield overseas in a safe manner. Before this observation of soldiers suffering from heat strokes, a different index called the "effective temperature scale" was used; however, it was inconvenient for routine monitoring as it required wind speed measurements. This requirement made the effective temperature scale inaccessible and inefficient for measuring environmental heat indices. In contrast, the WBGT was a convenient replacement for measuring the heat indices; obtaining WBGT measurements did not need access to trained personnel who could operate the complex tools required to measure wind speed.[8,11]

The novelty of the WBGT development lies in how the measurements were immediately applied in policy and practical application. When WBGT levels were measured, military training camps adopted "flag policies." A certain color flag was raised above the training camp once the measured WBGT reached a threshold value. The raising of the flag would then signal for the training camp to cease training drills and allow the soldiers to rest, protecting them from heat stroke. Further, military training camps adapted their training programs to accommodate soldiers of varying athletic abilities and implemented policies that slowly acclimated newly recruited soldiers into the training environment as well as the physical demands required of them. The two-fold development of using WBGT measurements and prompt application of WBGT threshold levels to modify training/working conditions resulted in decreased heat casualties in the late 1950s.[12]

From the Internet to GPS, innovations that originally formed their roots in the need to address a gap in military ventures have been made available for the use by and general

convenience for the general public. Similarly, the WBGT is another one of the military's innovations that has grown to have a much broader impact than its original intent: the WBGT evolved from a convenient environmental marker, originally meant to train more soldiers safely for the war efforts, to a broad environmental index quantifying hazardous work environments across many industries. Today, the use of a WBGT monitor device is recommended by the Occupational Safety and Health Administration as the method for monitoring workplace environmental heat.[13] As WBGT monitoring instruments of today are now calibrated with convenient technology to efficiently account for temperature, humidity, radiant heat, and wind, WBGT measurements are accessible for employers to monitor working conditions and has allowed for a quantifiable method of setting permissible heat-related stress levels in the modern workplace. While there are no specific guidelines or mandates that require WBGT monitoring, Minnesota is one example of a state that has included explicit monitoring of WBGT levels as part of the legal language in their state laws to protect workers from workplace-related adverse heat conditions.[14] Further, though some modern studies have proposed alternative measures such as physiological heat stress variables, other contemporary studies have continued to validate the use of WBGT in quantifying heat stress among workers.[15–17] As such, the WBGT continues to hold significant relevance for the current protection of workers employed in heat-sensitive conditions and for the workers of the future.

Most importantly, what we can and should learn from the development of WBGT is the prompt application of scientific development. The step-wise, logical sequence in which the United States military observed a problem (heat strokes causing harm to new recruits) preventing the institution from reaching a certain goal (producing larger numbers of trained military recruits for the war effort), developed a scientific way to quantify the risks associated with the problem

and subsequently applied the findings in an expeditious manner (coupling WBGT with the aforementioned flag policies within training camps). The results of these historic ventures speak for themselves with a documented reduction in the number of heat strokes.[12] Similarly, the copious amount of research on the rising global temperatures should be coupled with stricter regulations on both industrial activities contributing towards climate change and enforcement of worker protection rights laws. Endorsing individual consumer behaviors such as promoting public transportation and reducing plastic waste is all well and good, but why does the same collective responsibility fail to apply to the wealthy who produce more tons of CO2 emission in a handful of hours of their convenient private jet flight than a single, average consumer produces in a year?[18,19] Where are the enforcements curbing inappropriate heat stress that disproportionately affects low-income workers?[20]

Today, workers who are exposed to harmful heat stresses are often the most vulnerable demographic in the United States; historically, low-income workers have also been the least protected. Take, for example, the government actions that followed the publication of Upton Sinclair's *The Jungle*. Though the exposé written by Sinclair details the abuse suffered by migrant workers under industries and the squalor they lived inside the enclaves they were quarreled into, more public and government attention was given to the cleanliness of meat packing industries rather than the plight of workers. The Pure Food and Drugs Act of 1906 was passed to enforce stricter regulations on the sanitation of food, yet no sympathies were forthcoming for the working conditions or the provision of livable wages of meat packing industries workers; Sinclair later wrote, "I aimed for the public's heart, and by accident hit it in the stomach."[21] If the United States government is to provide more protection for these historically under-protected and underserved communities, the effective safeguarding of workers'

health and rights must lie in the coupling of science and policy. While the WBGT may give way to more modern measurements of environmental heat stress as science and technology continue to develop, important lessons should be drawn from the prompt response of the government and the efficient and expeditious application of the WBGT.

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