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OPINION

The labour force in a changing climate: Research and policy needs

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Heat stress and the labour force preamble

Labour is one of the sectors most affected by heat stress. Labour supply (number working hours) and labour productivity (output during these hours) are all affected by warming. A growing body of literature finds that heat affects labour in multiple ways, with predominantly negative impacts on economic growth and workers' health, that are heterogeneous across regions and sectors. However, there are significant gaps in the literature, making it hard to inform effective policy, including labour protection regulations. With improved understanding of the complex links between labour, health, and output, policies can be better designed to protect workers, especially vulnerable groups of workers, such as outdoor workers, and enhance economic output and economic growth [1, 2].

Evidence

Warming is already having a negative effect on labour in most parts of the world, particularly in tropical regions, and will continue to do so. Warming affects the number of hours worked (labour supply) [1–5], output during these working hours (labour productivity) [6], and labour capacity [7–9]. This in turn has implications for economic output, and general and occupational health [10, 11], absenteeism [12], and labour rights. There is evidence that outdoor and indoor manual/manufacturing workers are particularly affected by heat stress, with the impacts being highest on outdoor workers (agriculture and construction [1, 2, 7, 8, 13]. At present there is little evidence of the effects on workers in the services sector. As well as being detrimental to the individual, these impacts have implications for firm profitability and economic growth at the country-level.

Those areas where labour is at highest risk under future warming include parts of sub-Saharan Africa, south Asia, and South East Asia. In contrast, in cooler countries, such as those in northern Europe, there are currently benefits from warming, though these benefits may be short-lived as the planet warms further [1, 3, 14]). Warming is therefore likely to exacerbate inequalities, especially among more vulnerable working groups such as women and low-income workers in high-exposure sectors such as agriculture and construction.

Gaps in knowledge and understanding

A basic yet fundamental issue in this literature is the absence of agreed definitions. The terms labour productivity, work productivity, work capacity, worker performance, and worker productivity are often used interchangeably [1]. As a result findings have been biased, and

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incorporating these findings into economic models such as Computable General Equilibrium CGE (CGE) and Integrated assessment modelling (IAM) has proved challenging.

Wet-bulb globe temperature (WBGT) has frequently been used as a proxy for heat stress. However, there are well documented limitations of this indicator. For example, it often underestimates the thermal stress conditions and assumes that workers are wearing light clothing. In addition, most of the literature uses WBGT based on reanalysed data or climate model projections. Yet accurate measurements of WBGT require heat monitoring devices. As such, there have been suggestions in the literature that only WBGT measurements using monitoring devises be used. Given these concerns, findings using WBGT should be treated with caution [15].

Another practical reality is that many of the impacts of heat, both short and long-term, may not be fully understood by workers and employers; there may be asymmetric information on the health impacts between workers and employers; and worker and employer incentives may not align [14]. Specific under-studied aspects include absenteeism due to heat-induced ill health, and chronic conditions such as kidney diseases that are increasingly being found in outdoor workers.

One reason for these knowledge gaps is the lack of comprehensive empirical analyses on labour outcomes, especially labour productivity. A large part of the literature relies on numerical exercises that combine regional/downscaled climate models with one-size-fits-all response-functions. These response-functions are often based weak empirical analysis and small sample sizes from specific locations and/or a single country, to compute the impacts of future climate change on the labour force (usually labour capacity) at the global-level. The use of these location-specific response functions based on limited number of observations has often resulted in biases and errors that are not always sufficiently clarified when the outcomes of economic models and analyses are used for policy-related work.

Most of the literature has treated heat-labour impacts as a biophysical relationship, disregarding the socioeconomic dimensions. This has, for example, resulted in lack of nuanced analyses that take into account that some workers are more vulnerable than others. It has also led to there being little incorporation of adaptation, which has likely resulted in the effects of heat stress being overestimated, and the effectiveness of policies being mis-estimated. Contextualising the role of adaptation has the potential to improve assessment of economic consequences of future climate change impacts on labour.

Spatial coverage of the evidence on heat stress on labour is patchy. For example, very few if any studies focus on Latin America and the Caribbean (LAC) region. There is a lack of deep-dive case studies. These are important for understanding country-specific links between heat and labour, and therefore for informing policy. These studies will also improve our understanding of how workers in different occupational settings are affected differently by heat.

Priorities for future policy-relevant research

There is considerable scope for focused research that can contribute to, for example, assessing the impact of existing heat regulations in the workforce; reducing heat-stress induced work-related injuries and deaths; improved labour protection policies; strengthening of labour unions; providing the evidence base for regulations concerning limiting hours worked in intense heat; and identifying vulnerable groups.

Research is more likely to contribute to improved labour outcomes through generating the evidence required to improve the design of effective regulations to protect worker rights if it is undertaken in collaboration with labour unions (e.g. how trade unions organise around the issue of climate change), occupational safety and health institutions, and regulators. An

example of such a collaborative initiative is the ILO Vision Zero Fund. Such collaborations can enable the better design of specific plans for the protection of the working population from heat events, including implementing maximum temperature thresholds at which work can take place.

A clear priority is to ensure there is sufficient data, geographical coverage, and analysis for research to guide policy makers in a sufficiently granular and therefore useful way. Estimating robust exposure-response functions using observed data (for example, sourced from labour force surveys), especially on labour productivity, will reduce uncertainty and inaccuracies in existing findings. Improved response-functions are also required to compute policy relevant projections using updated CMIP6 scenarios, which can help to identify *hotspots* where future heat stress will have the highest effects on labour and vulnerable working populations.

The design of locally-relevant labour protection policies requires local scale data and an understanding of local contexts. Deep-dive case studies focusing on individual countries can provide an improved understanding of the interaction between socioeconomic, sociodemographic, and climatic stressors, and therefore inform better local policies.

More research is needed for the design of early warning systems that, combined with heat health action plans, can protect workers from extreme heat. Research into sector-specific temperature thresholds and meteorological forecasts can contribute to these early warning systems being more effective [14]. More broadly, such research could also be the basis for developing sector specific plans for worker protection from extreme heat events, including implementing maximum temperature thresholds at which work should take place.

Climate change is expected to impact the labour force by increasing the incidence of certain diseases and worsening the working conditions of outdoor workers. Examining the effects on workers' health such as incidence of kidney diseases among outdoor workers will be required to not only improve the design of policies to protect labours but also to estimate the additional burden on the healthcare system.

There remains insufficient understanding of whether there is adequate thermoregulatory infrastructure and the extent to which physiological acclimatisation mitigates some of the impacts of heat stress. Research can combine a better understanding of these processes with cost-benefit analyses of adaptation strategies, such as shift working and air conditioning. The potential unintended consequences of policies also need to be better understood. For example, policies to protect labours such as shifting working hours can harm sleep patterns or increase exposure to vector-borne diseases.

As the structure of societies change, contributing to research on green transformation of the labour force and providing evidence as to how to minimise labour market disruptions will become increasingly important. These could also examining the impacts of climate change mitigation policies on employment and policies likely to facilitate the transition to a low-carbon economy.

Finally, incorporating empirical findings from the heat stress and labour impacts research into economic models such as CGE and IAM will enable improved assessment of the economic consequences of future climate change impacts on labour.

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