

POLICY FORUM

CLIMATE CHANGE

Intergenerational inequities in exposure to climate extremes

Young generations are severely threatened by climate change

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Under continued global warming, extreme events such as heat waves will continue to rise in frequency, intensity, duration, and spatial extent over the next decades (1–4). Younger generations are therefore expected to face more such events across their lifetimes compared with older generations. This raises important issues of solidarity and fairness across generations (5, 6) that have fueled a surge of climate protests led by young people in recent years and that underpin issues of intergenerational equity raised in recent climate litigation. However, the standard scientific paradigm is to assess climate change in discrete time windows or at discrete levels of warming (7), a “period” approach that inhibits quantification of how much more extreme events a particular generation will experience over its lifetime compared with another. By developing a “cohort” perspective to quantify changes in lifetime exposure to climate extremes and compare across generations (see the first figure), we estimate that children born in 2020 will experience a two- to sevenfold increase in extreme events, particularly heat waves, compared with people born in 1960, under current climate policy pledges. Our results highlight a severe threat to the safety of young generations and call for drastic emission reductions to safeguard their future.

Meteorological extremes, hazards, or climate change impacts are mostly studied as they evolve over time under varying emission scenarios and socioeconomic pathways (2, 4, 8). For example, applying a heat wave indicator (see table S1) (9) to four bias-adjusted global climate models indicates that

the land area annually affected by such heat waves will increase from ~15% around 2020 to ~22% by 2100 under a scenario compatible with limiting global warming to 1.5°C, and to ~46% under a scenario in line with current emission reduction pledges (see the first figure). Recent studies extended this approach, studying aspects of climate change as a function of global mean temperature (GMT) increments, highlighting the scenario-independence of several extreme event indicators (1, 3, 8) but remaining, in essence, a comparison of time windows.

By contrast, we performed a birth cohort analysis by combining a collection of multimodel extreme event projections (3) with country-scale life expectancy information (10), gridded population data (11), and future global temperature trajectories (12) from the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C (see supplementary materials). By integrating the exposure of an average person in a country or region to extreme events across their lifetime, we encapsulate spatiotemporal changes in climate hazards, population density, cohort size, and life expectancy (see the first figure).

EXTREME EVENT EXPOSURE

Our results allow for comparing lifetime exposure to climate extremes across birth cohorts globally. For example, a person born in 1960 will on average experience around 4 ± 2 (1σ) heat waves across their lifetime according to our extreme heat wave definition (see the first figure). The lifetime heat wave exposure of this cohort is largely insensitive to the three future temperature scenarios considered here. By contrast, a child born in 2020 will experience 30 ± 9 heat waves under a scenario that follows current climate pledges, which could be re-

duced to 22 ± 7 heat waves if warming is limited to 2°C or 18 ± 8 heat waves if it is limited to 1.5°C. In any case, that is seven, six, or four times more, respectively, compared with that of a person born in 1960. Repeating this analysis for all cohorts born between 1960 and 2020 highlights clear differences in lifetime exposure to heat waves between older and younger cohorts globally (see the first figure). The effect of alternative future temperature trajectories on the lifetime exposure multiplication factor becomes discernible only for cohorts younger than 40 years in 2020, with the largest differences for the youngest cohorts.

The previous example only uses one hazard indicator and a subset of all possible future temperature pathways. We expanded this approach and considered six extreme event categories: wildfires, crop failures, droughts, river floods, heat waves, and tropical cyclones (see table S1), which we analyzed under a wide range of temperature pathways that resulted in future warming that ranges from constant present-day levels up to 3.5°C by 2100 (see materials and methods and fig. S1). To this end, we generated a total of 273 global-scale projections with 15 impact models forced by four bias-adjusted global climate models (see table S2). Inspired by the IPCC's Reasons for Concern Framework (7), we visualized the exposure multiplication factors, relative to a hypothetical reference person living under preindustrial climate conditions, as a function of the 2100 GMT anomaly and cohort (see the second figure and fig. S2). Life expectancy varies with the cohort, whereas the hypothetical reference person is given the same life expectancy as that of the 1960 birth cohort in our figures. Therefore, in contrast to the previous comparison of lifetime exposure across generations given historical and climate conditions (see the first figure), we assessed how projected lifetime exposure of birth cohorts is affected by climate change since the preindustrial era and by increased life expectancy since 1960.

Our results highlight that lifetime exposure to each of the considered extreme events consistently increases for higher warming levels and younger cohorts. Changes in extreme event frequencies have relatively little effect on lifetime exposure for cohorts above age 55 in 2020, but this rapidly changes for younger cohorts as they experience increasing extreme events in the coming years and decades (see the second figure and fig. S2). For a 3°C global warming pathway, a 6-year-old in 2020 will experience twice as many wildfires and tropical cyclones, three times more river floods, four times more crop failures, five times more droughts, and 36 times more