4 Preparing for a changing world: Promoting key skills to adapt to climate change through education and training

The COVID-19 pandemic provided important lessons on how education can be reorganised and learning supported in extreme conditions, highlighting the importance of physical infrastructures, such as indoor air quality, and the inadequacy of these in many countries. The chapter provides evidence on the effects of extreme temperatures and air pollution on skills acquisition, and on the effects of environmental conditions on individuals' willingness to prioritise environmental protection. The chapter also makes the case that adapting to climate change will require developing a wide range of skills, including physical skills. To ensure that individuals and societies are better equipped with the set of skills needed to adapt to environmental changes, the chapter suggests preparing learning environments for extreme weather events, investing in green infrastructure and sustainable practices, and considering the differential effects of environmental conditions on the acquisition of skills.

Key messages

Despite the most ambitious mitigation efforts, a certain degree of climate change is already inevitable due to past emissions. Therefore, it will be necessary to implement a variety of adaptation policies to reduce the vulnerability of individuals and societies to the impacts of climate change and environmental degradation. This chapter explores the mechanisms through which adverse environmental conditions – such as extreme temperatures and air pollution – can disrupt skills acquisition and effective skills use; how environmental conditions shape the formation of attitudes and dispositions towards climate change and environmental degradation; and the physical skills and knowledge individuals will need to adapt to climate change and promote the green transition.

Key findings include:

- Events such as wildfires, extreme temperatures and flooding can disrupt skills acquisition directly by forcing the closure of schools and increasing absenteeism, but also indirectly by reducing the potential of individuals to learn when they are in class and to achieve their full potential during high-stakes exams.
- Exposure to extreme temperatures and air pollution impairs cognitive acuity and attentional and behavioural processes. For example, complex cognitive skills and analytical problem solving that rely heavily on working memory, sustained attention or arithmetic efficiency are more impaired with increased temperatures.
- Socio-economically disadvantaged children and adults are more likely to suffer the negative consequences of adverse environmental conditions. This is because they are often more exposed to poor environmental conditions and lack the resources to invest in adaptation technologies or protective behaviours.
- Concern for climate change, and willingness to prioritise the environment over the economy, increase after the occurrence of natural disasters linked to human activity. A 1 standard-deviation difference in the number of people affected by a natural disaster is associated with around 1 percentage-point change in the likelihood that individuals will be willing to prioritise the environment over the economy if this were to be necessary.
- However, a 1 percentage-point increase in unemployment is associated with a 1.7 percentage-point decrease in the likelihood that individuals will be willing to prioritise the environment over the economy if this were to be necessary.
- Greater awareness of the natural world and physical skills (e.g. riding bicycles or swimming without assistance) will be important to adapt to new environmental conditions. However, many people around the world do not have such skills. Nor are these skills prioritised in formal education.
- Among countries with available data, 83% of adults in Poland reported being able to cycle, whereas less than 60% did in Australia, Italy and Great Britain. Similarly, in OECD countries such as Finland, Germany, the Netherlands, Norway and Sweden, over nine in ten adults report being able to swim without assistance. By contrast, less than one in two individuals report the same in Mexico.

4.1. Introduction

Estimates suggest that, compared to children born in the 1960s, children born at the onset of the coronavirus (COVID-19) pandemic in 2020 may experience twice as many wildfires and 6.8 times more heatwaves across their lifetimes (Global Commission on Adaptation, 2019[1]). Should countries be successful in limiting global warming to 1.5 degrees Celsius above pre-industrial levels, they will be able to reduce additional lifetime exposure to heatwaves by 45% and to wildfires by 10%.

On top of actions aimed at reducing global warming, it is important to consider an array of actions ranging from system-level policies to classroom-level adaptations to reduce the impact of temperatures and pollution on learning and cognitive development. An extensive review of the literature on the effects of environmental conditions on skills development, swimming skills around the world, and the role of environmental conditions and unemployment on public support for environmental policies, as well as detailed descriptions of the data used in the analyses presented in this chapter, are available in the following technical working papers: Asai, Borgonovi and Wildi (2022[2]); Borgonovi, Seitz and Vogel (2022[3]); and Horvath and Borgonovi (2022[4]).

Adaptation is a key stage of the resilience process, and in the context of policies aimed at promoting environmental sustainability, it refers to a set of actions that can reduce the vulnerability of individuals and societies to the impacts of climate change. Adaptation is critical to building resilience at the individual and societal level to climate change because even with the most ambitious mitigation efforts, some level of climate change is already locked in due to past emissions. Even assuming that the commitments countries have made in recent years to halt global warming by reducing greenhouse gas (GHG) emissions and reducing other forms of environmental degradation, such as air pollution, will be effective, adaptation and mitigation policies and behaviours will be crucial in the short and medium terms.

For example, communities world wide will have to find new ways to live in a world with more extreme weather events and higher average temperatures. Changing environmental conditions will require changes in the organisation of schooling and education systems so that learning will be as little disrupted as possible due to extreme weather events. Education and training systems will also be tasked with equipping all learners with the skills needed in a changing world.

In the context of education and skills policies, adaptation includes infrastructural measures directed at reducing the impact of environmental conditions on the ability of schools and training systems to promote learning; changes in how learning is organised to ensure learning occurs despite environmental changes; and changes in the set of skills that individuals should master to be able to thrive in an overall warmer environment and an environment characterised by an increased frequency of extreme weather events.

To this end, the chapter looks at a variety of adaptation policies to reduce the vulnerability of individuals and societies to the impacts of climate change and environmental degradation. It begins with a review of the evidence on the extent to which skill acquisition is promoted or inhibited by two key environmental conditions: temperatures and air pollution. The chapter then details some of the potential adaptation policies that could be implemented to reduce learning disruptions as a result of negative environmental conditions and ensure equitable learning outcomes. Second, the chapter reveals the extent to which experiencing an environmental disaster that is directly linked to human activity or experiencing adverse macroeconomic conditions, such as increases in unemployment shapes public support for adaptation policies aimed at halting environmental degradation. Third, the chapter considers what new sets of skills could become crucial to adapt to a changing climate and provides evidence on the distribution of one such skill – swimming – both across countries and within countries across different population groups. Finally, conclusions and implications for policy are discussed.

4.2. Environmental conditions shape skills and human capital accumulation

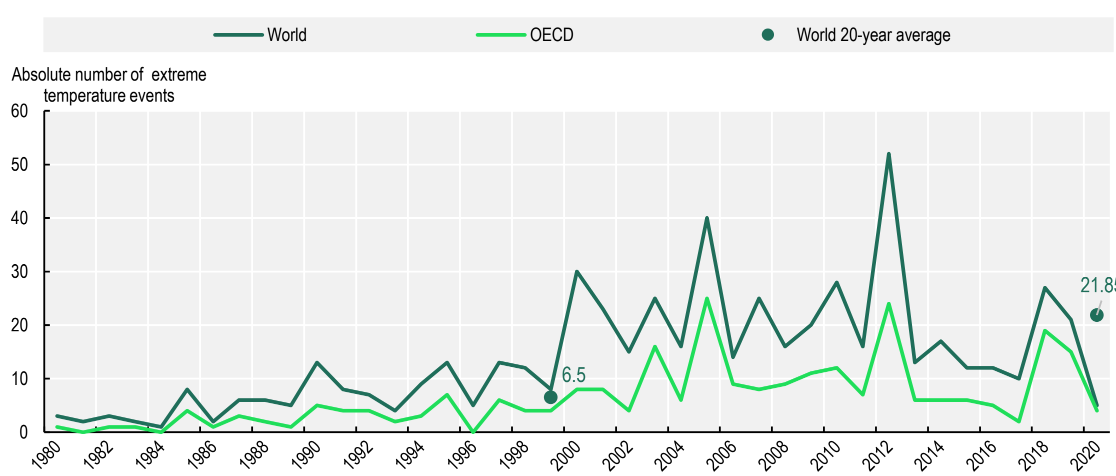
4.2.1. Exposure to extreme environmental conditions is increasing

Increases in global surface air temperatures have intensified population exposure to at least one extreme heat day per year with levels above thresholds set for human safety. Research has found that people are increasingly exposed to heatwaves, which are increasing in temperature and length, and that cities carrying more than half of the world's population are facing a severer threat of extreme heatwaves (Wang et al., 2023[5]; Chambers, 2020[6]). Given current population numbers, an increase of 1°C from pre-industrial levels has increased the number of people exposed from 97 million to 275 million. Should temperatures increase further, for example, to 3°C, this number is set to increase to 1.22 billion (Li, Yuan and Kopp, 2020[7]). Increases in global temperatures and heat extremes also threaten to offset the progress made in lowering pollution emissions in developed countries, as high temperatures incur chemical reactions with gaseous pollutants and can trap surface-level ozone.

The health burden of increasing temperatures and air pollution is considerable, as air pollution and high temperatures increase the incidence and severity of respiratory and cardiovascular diseases, including asthma, bronchitis, lung cancer and heart disease. But beyond their impact on health, environmental conditions also have an impact on the developing brain, affecting people's capacity to acquire information and use it to achieve their goals (see Horvath and Borgonovi (2022[4]) for a review of this literature).

Average temperatures have been rising consistently worldwide at an unprecedented rate since 1970 (Gutiérrez et al., 2021[8]). In 2020, global mean surface air temperature over land had risen 1.7°C above the climate normal, which references the period between 1951 and 1980, with the largest increases found in Europe (UNFAO, 2021[9]). In addition to higher average temperatures, hot temperature extremes have risen in frequency and intensity. In 2020, natural disasters classified as extreme temperature events averaged approximately 22 per year globally over the past 20 years, compared to an average of 7 per year recorded between 1980 and 1999 (Figure 4.1). Extreme temperature events are expected to continue increasing, with scientists estimating that very extreme heat events that occurred only once in 50 years will likely occur about 14 times more under a 2°C warming scenario (Gutiérrez et al., 2021[8]).[1]

Figure 4.1. Absolute number of natural disasters due to extreme temperature events per year in OECD countries and globally, 1980-2020



Note: A natural disaster event is included in this data if it fulfils at least one out of the following four criteria: 1) 10 or more people were reported killed; 2) 100 or more people were reported affected; 3) a declaration of a state of emergency was issued; or 4) a country called for international assistance. Extreme temperature events consist of either: 1) a cold wave; 2) a heat wave; or 3) severe winter conditions.
Countries included in the OECD country group are those that were OECD countries in 2021.
Source: EM-DAT (2021[10]), *International Disasters Database 2021*, www.emdat.be.

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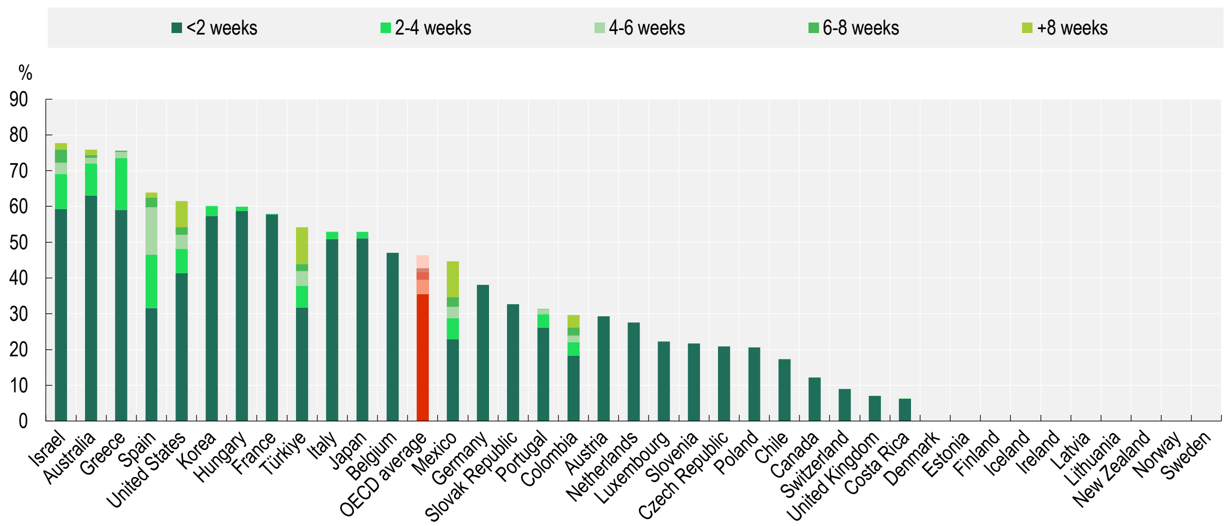
Not all countries are similarly exposed to climate-related hazards [see (Maes et al., 2022[11]) for an overview of key indicators regarding a range of climate-related hazards and country exposure]. For example, Figure 4.2 illustrates that whereas on average across OECD countries 11% of the population is exposed to days with daily maximum temperatures above 35°C for over two weeks per year, in the Republic of Türkiye (hereafter 'Türkiye') and Mexico, 10% of the population is exposed to such temperatures for over eight weeks per year.

Figure 4.2. Share of exposure to very hot days in OECD countries, 2017-21

Average percentage of a country's population exposed to days with a daily maximum temperature exceeding 35°C



Note: The figure shows the percentage of a country's population exposed to "hot days", i.e. days exceeding 35°C for fewer than two weeks, between two to four weeks, between four to six weeks, between six to eight weeks and more than eight weeks averaged over the period 2017-21. Countries are sorted in descending order of the population being affected by hot days.
Source: IEA/OECD (2022[12]), "Climate-related hazards: Extreme temperature", https://oe.cd/dx/4TF.

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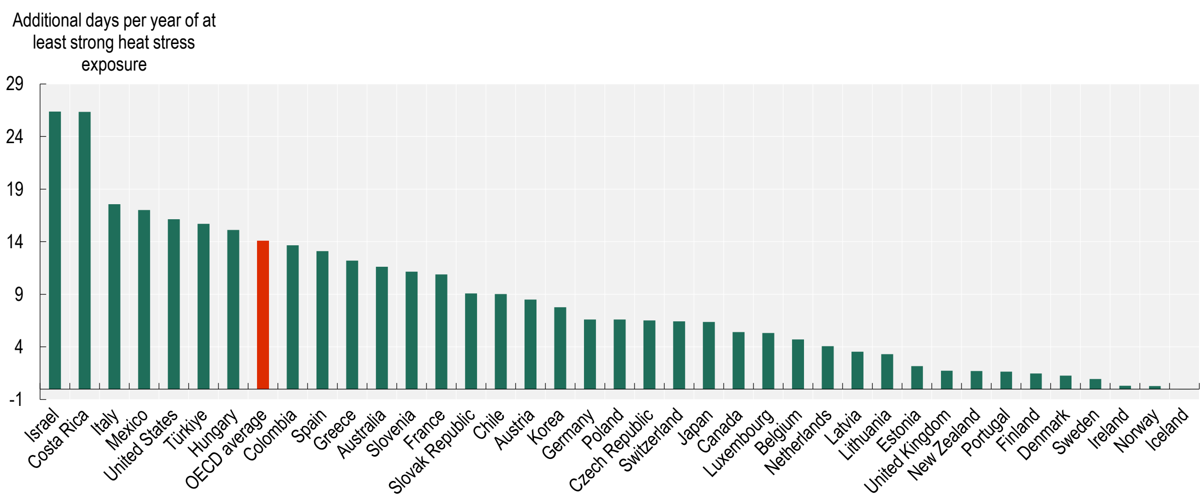
Exposure to climate-related hazards has increased as a result of human-induced climate change. For example, Figure 4.3 indicates that, on average, individuals in OECD countries had to endure 14 additional days with strong heat stress exposure, defined as Universal Thermal Climate Index (UTCI) exceeding 32°C, over the 2017-21 period compared to the reference period (1981-2010). In Israel and Costa Rica, populations had to endure almost an additional month per year of strong heat stress exposure (26 additional days). In Italy, populations had to endure 18, in Mexico 17, in the United States and in Türkiye 16, and in Hungary 15. In as many as 18 (out of 39) countries with available data, populations had to endure at least one additional week per year (i.e. seven extra days) with strong heat stress exposure in the 2017-21 period compared to the reference period.

Figure 4.3. Increase in heat stress exposure in OECD countries, 2017-21 compared to 1981-2010

Additional days per year of at least strong heat stress exposure (UTCI > 32°C) over 2017-21 compared to the reference period 1981-2010



Note: The figure provides the additional days per year of at least strong heat stress exposure (UTCI > 32°C), which accounts for other meteorological effects besides air temperature, such as relative humidity, wind speed and solar radiation, over the period 2017-21 compared to the reference period 1981-2010. Heat stress is estimated using the Universal Thermal Climate Index (UTCI). A UTCI value between 32°C and 38°C is considered as strong heat stress, between 38°C and 46°C as very strong heat stress, and above 46°C as extreme heat stress. For more information, see Maes et al. (2022[11]).
Countries are sorted in descending order of the number of additional days with strong heat stress exposure.
Source: IEA/OECD (2022[12]), "Climate-related hazards: Extreme temperature", https://oe.cd/dx/4TF.

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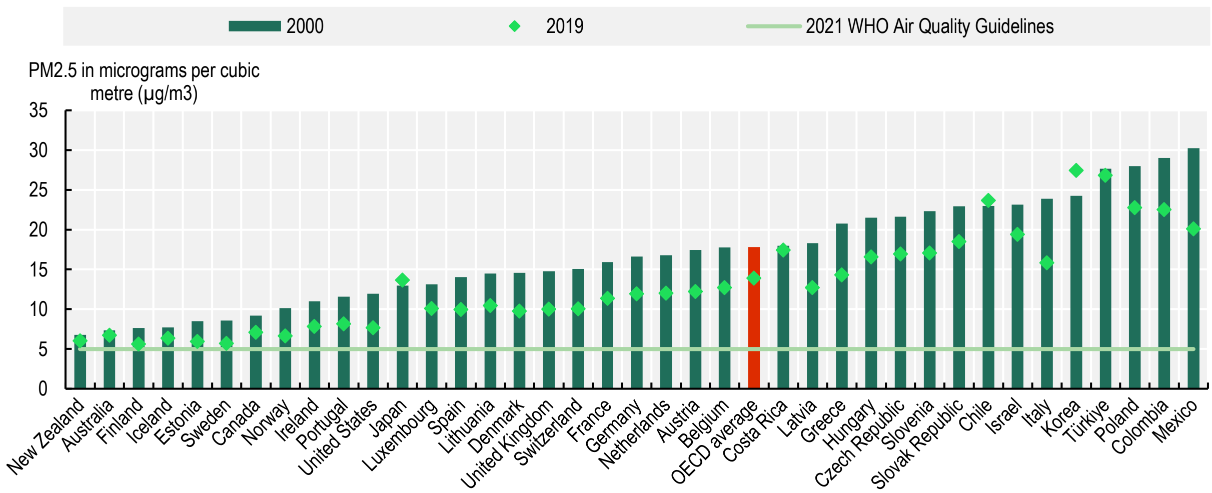
Recent evidence from the Intergovernmental Panel on Climate Change (IPCC) indicates that at least 50% of the rise in extreme temperature events is due to human-induced climate change, with carbon dioxide (CO_2) recognised as the main driver (Gutiérrez et al., 2021[8]). Other pollutants, such as black carbon, a product of particulate matter (PM) and the result of incomplete fossil fuel combustion and biomass burning, also play a significant role in accelerating warming by absorbing large amounts of solar radiation and turning it into heat (Bond et al., 2013[13]; Matthews and Paunu, 2019[14]). In addition, human activities, such as the burning of fossil fuels through vehicular transportation or electricity generation, release large quantities of CO_2, a GHG, as well as other compounds into the atmosphere (Gutiérrez et al., 2021[8]). Disasters alongside natural processes, such as forest fires and desert dust, can also contribute substantially to air pollution – a catch-all term that describes deterioration in air quality due to toxic compounds and gasses – burden in some regions (WHO, 2021[15]). National air quality guidelines typically consider six criteria based on pollutant concentrations to assess the potential harm to human health. These include: fine particulate matter (PM2.5), coarse particulate matter (PM10), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO), with additional standards for less ubiquitous pollutants. These pollutants interact chemically with each other as well as temperature, with resulting interactions determining their respective concentrations and air quality at ground level, where people breathe (Orru, Ebi and Forsberg, 2017[16]).

Unlike temperatures, Figure 4.4 shows that on average across OECD countries, mean population exposure to PM2.5 pollution decreased from 17.8 micrograms per cubic metre (µg/m^3) in 2000 to 13.93 µg/m^3 in 2019, a decrease of about 22%. Although this decline marks an important success for population health, exposure remained above recommended levels. For example, in 2019, all OECD countries had levels of exposure to PM that exceeded the updated air quality guidelines by the World Health Organization (WHO) in 2021, which were based on an improved understanding of the adverse effects of PM on human health. Moreover, outside of OECD countries, particularly in Asia, the Middle East and Africa, PM2.5 levels remain critically high (OECD, 2021[17]).

Figure 4.4. Mean population exposure to PM2.5 in OECD countries, 2000 and 2019



Note: Mean population exposure to particulate matter (PM2.5) is shown in units of micrograms per cubic metre (µg/m^3). The horizontal green line indicates the WHO global air quality guidelines updated and published in 2021 for PM2.5 at 5 µg/m^3.
Source: OECD (2021[18]), *Exposure to PM2.5 in countries*, https://stats.oecd.org/.

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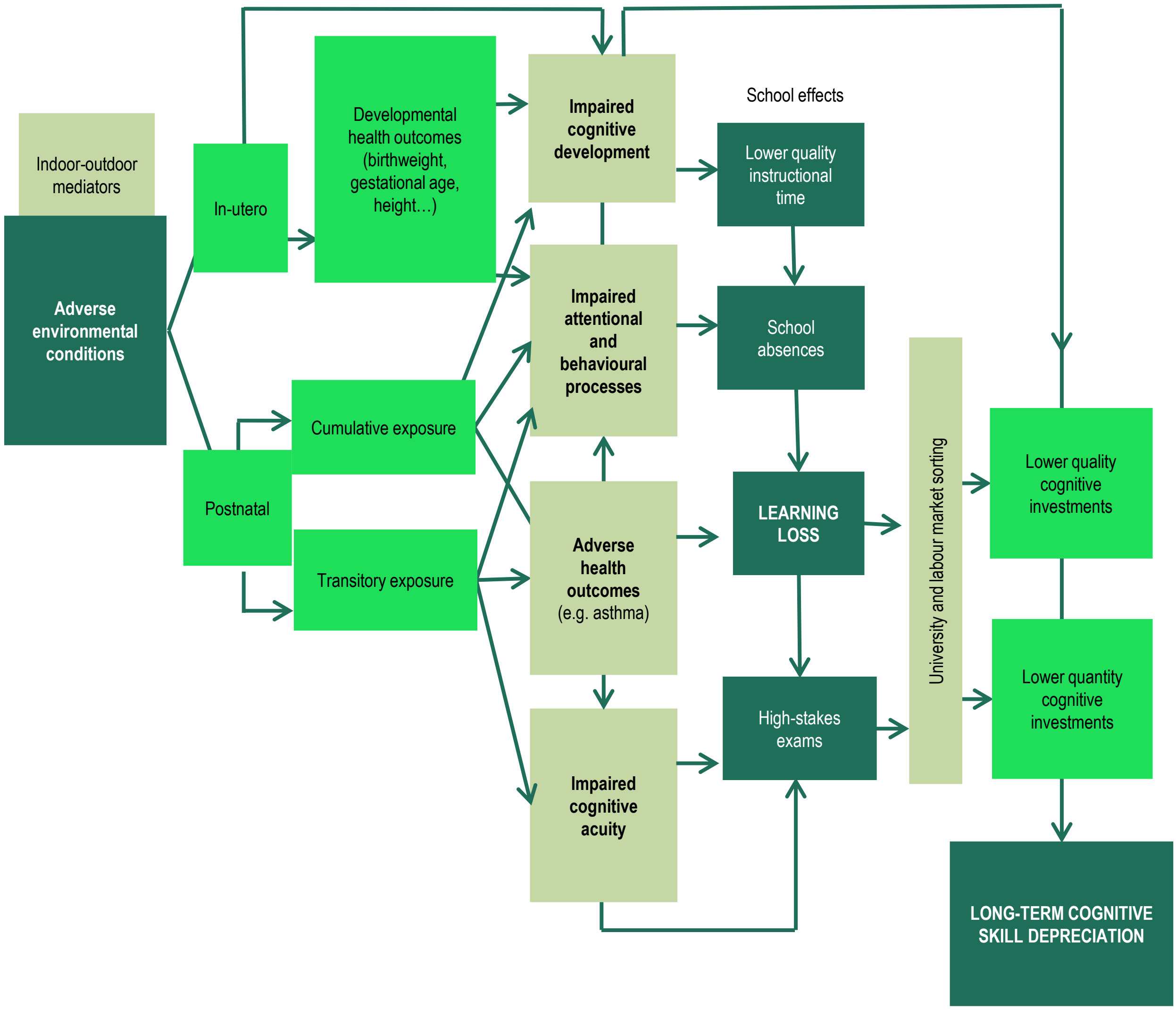
4.2.2. Environmental conditions influence learning and skill development

With regard to education, climate change affects school infrastructure. As extreme weather events become more frequent and severe, schools are at increased risk of damage from floods, hurricanes and wildfires. This can lead to school closures and interruptions in learning, which can have a negative impact on student achievement. High temperatures and levels of pollution can also influence students' learning potential without forcing schools to close but reducing young people' ability to learn while in class.

The changes described will significantly affect societies' health and human capital. Figure 4.5 summarises the mechanisms through which adverse environmental conditions such as extreme temperatures and air pollution shape cognitive skills. Table 4.1 (further below) summarises the range of estimates effects sizes detailed in the empirical literature.

Figure 4.5. Mechanisms of the effects of adverse environmental conditions on cognition over the life course



Note: This figure traces the mechanisms through which adverse environmental conditions can affect cognitive acuity and development. The focus is on indoor temperatures and increases in air-pollution/low air quality because these have been linked to worse cognitive functioning. Furthermore, these adverse environmental conditions tend to be sustained, with individuals experiencing higher temperatures and worse air quality for longer periods of time. Other disruptive events such as flooding can also negatively impact learning.

First, during gestation, exposure to air pollution and extreme temperatures can directly affect later life cognitive ability by impairing natural developmental processes that occur in the central nervous system throughout early childhood. Indirectly, children whose mothers experience adverse environmental conditions during pregnancy may also be born with low birthweight, grow up shorter than their peers, or experience impaired lung development. In turn, these development outcomes can affect academic performance when children reach school age.

Second, postnatal environmental conditions can also, directly and indirectly, affect short- and long-term cognition, amplifying any previous cognitive losses. In the short term, adverse exposure can impair cognitive acuity and attentional and behavioural processes, which can result in lower academic achievement in school. In addition, the exacerbation of respiratory and other illnesses may lead to increased school absences for students. These adverse effects on health, behavioural and attentional processes may accumulate over time to decrease the overall quality of cognitive investments during childhood, such as instructional and study time.

Third, towards the end of secondary school, high levels of transitory pollution and extreme temperatures can lower students' performance on high-stakes exams used to select students for tertiary-level education, influencing the ability of those most affected by adverse environmental conditions to attend tertiary-level education as well as the quality of that education. Because levels of air pollution and temperatures vary geographically, individuals living in areas most exposed to negative conditions just before or during selective examinations may suffer a penalty and fail to gain entrance into tertiary educational institutions or fail to enter the most prestigious institutions. Similarly, socio-economic conditions could determine the possibility that individuals and families will mitigate the negative effects of environmental conditions and therefore acquire an edge during selection processes. The resulting sub-optimal educational and labour market sorting may alter long-term skill acquisition and earnings. Once in the labour market, transitory exposure to adverse environmental conditions may further affect the willingness and ability of adults to engage in cognitively demanding activities and effective lifelong learning.

Importantly, the effects of air pollution on cognitive development have been found to occur below current international air quality standards, in both indoor and outdoor settings and across various regions around the world. Similarly, these effects have been observed when the duration, intensity and spread of extreme temperature spells were well below current projections.

In many cases, the largest effects are felt by socio-economically disadvantaged children and adults, who often have higher exposure to pollution and limited resources to protect themselves.

Table 4.1. Summary of evidence in the literature on the effects of temperatures and air pollution on skills development

Effects are expressed in percentages of a standard deviation

	Negative effects of in-utero exposure to adverse environmental conditions on child and adult cognition, as a percentage of standard deviation		Negative effects of postnatal transitory and cumulative pollution and temperature exposures on cognition in school-aged children, as a percentage of standard deviation		Negative effects of transitory and cumulative temperature and pollution exposures on high-stakes examinations, as a percentage of standard deviation	
	Childhood and adolescence	Adulthood	Transitory	Cumulative	Transitory	Cumulative
Temperature	NA	4.8	12-13.5	2-3	5.5-5.83	4.2-6.4
Air pollution	3.4-11	NA	2-6	2.4-4	4-15	NA

Note: The effect of in-utero temperature exposure on adulthood is that due to ten additional days above 29.4°C and excludes the positive effects found on later-life literacy in sub-Saharan Africa. The effect of in-utero pollution exposure on childhood and adolescent cognition is that due to a standard deviation increase in pollution exposure during gestation or being conceived within two miles of a Superfund site. The effects depicted in this table are upper and lower bounds found in the literature based on several country estimates and are likely to differ between countries. The transitory effect of temperature is that due to experiencing a transitory temperature of 32°C or above. The transitory effect of pollution is that due to a one-unit standard deviation increase in transitory pollution exposure. The cumulative effect of temperature is the effect of ten additional hot days (or hot school days) with temperatures of 26.7°C or above in the past three to four years. The cumulative effect of pollution is the annual effect due to a 25% increase in pollution exposure or that due to attending a school within one mile of a TRI (Toxics Release Inventory) site. The transitory effect of temperature on high-stakes exams is that caused by a one-unit standard deviation increase in ambient temperature during exam taking. The cumulative effect of temperature is that caused by ten additional days with a maximum daily temperature above 34°C during the summer, relative to days with a maximum temperature between 28-30°C on maths and English tests. Effect sizes of effects of in-utero exposure to adverse environmental conditions aggregated from (Bharadwaj et al., 2017[19]; Molina, 2021[20]; Peet, 2020[21]; Persico, Figlio and Roth, 2020[22]; Sanders, 2012[23]). Effect sizes of postnatal transitory and cumulative pollution and temperature exposures aggregated from (Garg, Jagnani and Taraz, 2020[24]; Marcotte, 2017[25]; Park, Behrer and Goodman, 2020[26]; Park et al., 2020[27]; Rojas-Vallejos et al., 2021[28]; Zivin, Hsiang and Neidell, 2018[29]). Effect sizes of transitory and cumulative temperature and pollution exposures aggregated from (Cho, 2021[30]; Cho, 2017[31]; Ebenstein, Lavy and Roth, 2016[32]; Graff Zivin et al., 2020[33]; Graff Zivin et al., 2020[34]; Park, 2020[35]).

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Individuals and societies can take a range of adaptations and protective measures to reduce the impact of environmental conditions on cognitive development. These include installing air filtration and air conditioning units in schools, homes and the workplace, reorganising school curricula and pedagogical formats to avoid exposure, and ensuring equal access to environmental information, which can help induce protective behaviours. Given recent projections for increased global surface warming in the next several decades, it is worth examining the empirical literature on adverse environmental exposures and their consequences on cognitive skill development over the life course to better understand the magnitude of these effects, their underlying mechanisms and distributional consequences – and the potential for mitigating them.

4.2.3. The effects of environmental conditions differ depending on where and when they occur and often magnify underlying socio-economic disparities

The effects of pollution and extreme temperatures on cognitive development can differ significantly across regions due to cross-country environmental, socio-economic and institutional differences. Moreover, the relationship between pollution levels and temperatures and cognition can be non-linear, with stronger effects observed at higher temperatures and pollution levels. For example, decreases in cognitive acuity can occur when pollution levels are moderate, but additional effects on health symptoms at higher pollution levels can further compromise achievement. Additionally, the magnitude of the effects of environmental conditions may differ significantly across countries due to the mechanisms by which they occur. For example, an additional ten days with temperatures above 26.7°C lowers performance on test scores of the Programme for International Student Assessment (PISA) tests by 2.1% of a standard deviation in poorer countries, with insignificant effects found in more affluent countries (Park, Behrer and Goodman, 2020[26]).[2] These differences may exist due to several reasons.

For example, low-income and rural settings may suffer from an additional income effect due to high temperatures. Specifically, in rural parts of the People's Republic of China (hereafter, "China") and India, the effects of temperature on cognition are more pronounced in regions that have not undertaken heat-resistant crops, the lack of which results in lower crop yields during the growing season, reducing the demand for agricultural workers and lowering the family income of agricultural households. In turn, lower family income reduces overall family resources for investment in education, such as nutrition and school attendance, lowering cognitive development in the long term. Furthermore, a high prevalence of poverty and poor state support and information infrastructures may prevent many families from making protective investments, such as air conditioning and air filters, or contribute to higher costs for exercising avoidance behaviours, such as staying at home when temperatures and air pollution are high. Additionally, some countries may be burdened with weak regulatory infrastructures due to lack of funding and expertise, as well as dependence on foreign income in pollution-intensive industries, which has made pollution control difficult.

Within countries, colder cities and counties experience larger cognitive declines because of high temperatures, demonstrating that increases in temperature do indeed have an impact on cognitive ability. Such findings, provide evidence for the successful implementation of adaptation strategies, such as air conditioning, in order to lower temperatures and improve cognitive capacity in regions with historically high temperatures. However, even in affluent countries and regions with high rates of air conditioning penetration, such as the United States, estimates under median climate change projections of 2.8°C warming suggest 3% of a standard deviation lower academic achievement due to temperatures by 2050 (Park et al., 2020[27]). Therefore, although air conditioning is a good adaptation strategy it cannot mitigate all of the cognitive declines associated with increases in temperatures and is in itself a source of energy consumption.

Young people with a socio-economically disadvantaged and minority background experience worse environmental conditions and worse outcomes

The negative effects of environmental conditions can affect some groups more than others, with important distributional consequences. First, the air and temperatures individuals are exposed to from birth onwards result from various inter-related social and economic processes. For example, in North America, disadvantaged and minority households and students are more likely to live, work, attend schools and be born in areas with higher pollution levels. Similar patterns of unequal pollution exposure have been found in Asia, Africa and the WHO European region, but may differ based on the pollutant considered. In addition to higher exposures, poor households may be less able to make protective and compensatory investments, such as additional tutoring, in response to any cognitive losses experienced due to environmental conditions.

In fact, adverse environmental conditions can have larger impacts on the test scores of students from lower socio-economic backgrounds from the day they are born, with inequalities increasing as individuals age. In Chile, the effects of exposure to CO_2 during pregnancy on cognitive ability are more than twice as large for children of mothers without a secondary school diploma. In China and India, cognitive losses due to environmental exposures operate in part via an income effect that overwhelmingly affects poor agricultural households, as mentioned above. In Israel, the impact of contemporaneous PM2.5 exposures on high-stakes exams is larger for low socio-economic status (SES) students. Each point is even “higher stakes” for low SES students due to the latter’s reduced ability to rely on social capital and financial advantages during the transition to the labour market compared to their high SES counterparts. These inequalities continue to widen as people age, as exposure to high pollution levels more significantly impacts the verbal abilities of less-educated older adults.

In addition, recent evidence suggests that environmental conditions play a non-negligible role in the racial achievement gap in the United States because of their effect on, for example, asthma and the residential locations of minorities in areas with high levels of air pollution. Additionally, it has been suggested that between 3% and 7% of the gap on standardised tests between white and Black and Hispanic students can be explained by the effects of heat on learning during compulsory school years (Park et al., 2020[27]). These effects are driven by lower school-level investments such as air conditioning and the geographical distribution of minorities in hotter regions across the United States. Estimates from Florida suggest that pollution from Superfund sites *alone* could account for at least 2% of the Black-white test score gap in the state (Persico, Figlio and Roth, 2020[22]). In fact, recent evidence suggests that the effects of pollution on reduced attainment of tertiary-level education may be intergenerational, indicating that the environment may present an additional and under-explored avenue from which intergenerational racial inequalities persist.

Gender differences in exposure and outcomes differ depending on the context

The effects of adverse environmental conditions on cognitive ability may also differ by gender. Males are thought to be more susceptible to detrimental intra-uterine environments and may therefore experience larger cognitive deficits due to high temperatures and air pollution exposure during gestation. A review of the health effects of pollution over the life course suggests that while during gestation and early childhood, boys are more susceptible to the adverse health effects of pollution, women may be more vulnerable in adulthood, potentially due to greater exposure in socially derived roles (e.g. pollutants present in cleaning products or cooking fumes). This is supported by recent findings that women experience higher rates of and more severe asthma symptoms than males after puberty but not before.

However, the distributional impacts on cognitive ability by gender are likely to differ based on the underlying mechanisms by which they exert their effects, as well as country-specific social and institutional differences. For example, school-aged girls experience larger cognitive declines in India due to contemporaneous pollution conditions. In Israel, the effects of pollution on performance on high-stakes exams are between two and four times larger for boys than girls, consistent with a significantly higher incidence of asthma in male Israeli adolescents. However, pollution-related performance losses have a greater detrimental impact on the likelihood of matriculation, enrolment and completion of post-secondary education among girls than boys. Similarly, while estimates from the Philippines and Mexico suggest that pollution in-utero and early childhood affects the cognitive ability of boys and girls equally, the effects on women in terms of reduced schooling and income are more salient during the transition to the labour market.

Effects are larger for skills that rely on working memory, sustained attention and arithmetic efficiency

Complex cognitive skills that rely heavily on working memory, sustained attention or arithmetic efficiency are more impaired during heat stress than tasks such as visual orientation, reaction time and simple arithmetic. In fact, the short-term effects of high temperatures on cognition in school children and adults tend to be most pronounced when performance in math is considered and are weakest for verbal performance. These findings provide further support for a neurological mechanism that suggests the brain regions responsible for solving math and analytical problems are more sensitive to heat.

School absence rates are also driven by respiratory illnesses, suggesting low avoidance behaviour. Reduced attendance due to environmental conditions can affect learning and academic achievement by decreasing class time and teacher-student interactions, causing students to fall behind and perform worse on tests. Chronic absenteeism, defined as missing 10% or more of the school year, is associated with approximately 10% and 8% standard deviation decreases in math and reading scores, respectively, among elementary school-aged children in the United States (Gottfried, 2015[36]). Absenteeism also leads to negative externalities: the classmates of children who are chronically absent can experience a reduction in test scores approximately half the size of the reduction experienced by the absent children themselves.

4.2.4. Indoor air quality matters too

Most of the evidence on ambient environmental conditions considers the aggregate impact of ambient conditions on learning activities that occur primarily indoors (i.e. schools and training centres) and thus estimates the net effects of such conditions, including any adaptation strategies adopted by different populations to respond to such conditions. Estimates indicate that individuals in developed economies spend approximately 90% of their time in work buildings, school classrooms or at home (EPA, 2021[37]). However, the indoor environment in itself can have an additional impact on learning and cognitive skill development depending on indoor air quality (IAQ). Although indoor-outdoor pollution levels are correlated, factors such as ventilation, air conditioning, air filters and building characteristics can mediate the interaction and effects of ambient temperature and pollution levels that are found indoors. Thus, this interaction is a mediating channel by which ambient environmental conditions can affect cognitive development.

Few studies have estimated the effects of IAQ on skills development and effective skills use, largely because before the COVID-19 pandemic, IAQ was rarely monitored. In the United Kingdom, a one-unit standard deviation increase in indoor PM10 levels of university classrooms can lower exam scores by as much as 6.4% of a standard deviation. Evidence from German chess players also suggests a one-unit standard deviation (13.19 $\mu g/m^3$) increase in indoor PM2.5 during competitive tournaments is associated with approximately a 10% standard deviation increase in meaningful errors (Künn, Palacios and Pestel, 2019[38]).

By contrast, a wider set of studies have considered the effects of indoor temperatures on cognition in school and office environments. Meta-analytic evidence from such studies indicates that lowering the temperature from 30°C to 20°C is associated with a 20% improvement in school tasks involving earning and cognitive exertion (Wargocki, Porras-Salazar and Contreras-Espinoza, 2019[39]). For adults, the performance of office workers is estimated to increase by about 9% following similar decreases in temperature (Wargocki and Wyon, 2017[40]). Additionally, decreasing humidity levels when temperatures are high has been found to mediate the impact on cognitive impairment (Tian, Fang and Liu, 2020[41]).

Indoor air quality refers to "the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants" (EPA, 2021[37]). It is the combination of: 1) indoor pollution from indoor sources (e.g. chemical and biological contaminations from furnishing, building materials and appliances); 2) indoor pollution that originated from ambient pollutants; and 3) their interactions with a variety of processes, such as ventilation, temperature, building characteristics and occupant activity and density. The indoor air in schools world wide has been found to be unsatisfactory and linked to asthma and other health issues. For example, in 2014, around 65% of classrooms in the WHO European region were estimated to have PM2.5 concentrations higher than the daily maximum recommended by the WHO guidelines at the time (25 $\mu g/m^3$) (Annesi-Maesano et al., 2014[42]).

A primary mediating factor in the relationship between ambient temperature and pollution levels and their indoor counterparts is ventilation: the flow of air into and out of a space. Adequate ventilation improves IAQ by diffusing the concentrations of indoor pollutants and introducing fresh air. Higher ventilation rates are associated with increased student attendance and improved cognitive performance on school tests based on cross-section and intervention studies. Empirical estimates from the United States suggest that the average school construction project aimed at improving IAQ through ventilation leads to 7% and 11% standard deviations improvements in math and reading scores, respectively (Stafford, 2015[43]). Outside of school environments, a one-unit standard deviation increase in indoor CO_2 levels (~300 ppm) is associated with a 1.8 percentage-point increase in the probability of advanced chess players making a meaningful error during competitive tournaments (Künn, Palacios and Pestel, 2019[38]), indicating impaired decision making of adults during highly cognitive activities. Additionally, increasing ventilation by 10 L/s improves the performance of office work by 6% as long as new air filters are installed (Wargocki, Wyon and Fanger, 2004[44]).

However, the effects on health and IAQ and performance are also partially dependent on the mode of ventilation and other factors, such as occupancy rate and occupant activity (Toftum et al., 2015[45]). Mechanical ventilation refers to either systems that extract indoor pollutants (i.e. mechanical exhaust ventilation) or systems that both remove indoor pollutants and concurrently supply fresh indoor air (i.e. mechanical supply and exhaust ventilation or balanced ventilation) (Toyinbo et al., 2016[46]). Natural ventilation, typically achieved by opening windows and doors of classrooms, refers to "the introduction of outdoor air into a building driven by natural produced pressure differentials" (Owen, 2009[47]). While outdoor air supply to buildings is an essential component of ventilation, it must be balanced with the evidence that allowing outdoor air into buildings can add to the burden of indoor air pollution (Leung, 2015[48]). Estimates suggest that in the United States, the net annual costs per person of improving ventilation to adequate levels would be less than 0.1% of current public spending on elementary and secondary education (Fisk, 2017[49]).

4.2.5. Education systems can adapt to changing environmental conditions

The potential of online learning to reduce the harmful effects of wildfires and particulate matter

Destructive wildfires have become increasingly common, with countries in the Mediterranean and others such as Australia, Chile and the United States experiencing record-breaking wildfire disasters in recent years (OECD, 2021[50]). In the United States alone, 7.4 million children annually are exposed to unhealthy levels of PM2.5 due to fires (Rappold et al., 2017[51]).[3] In addition, wildfires affect the respiratory health of surrounding populations, partly due to the large amounts of PM they release. The projected increase in wildfire risk and severity is so significant that increase in burning could offset the decrease in PM emissions achieved by a country such as the United States by 2050 (Ford et al., 2018[52]; McClure and Jaffe, 2018[53]).

Early evidence suggests that PM2.5 from wildfires could have as much as ten times larger negative impacts on the respiratory health of children and adults than PM2.5 from alternatives sources, as well as larger effects on high-stakes exams (Aguilera et al., 2021[54]; 2021[55]; Graff Zivin et al., 2020[34]).[4] Given that children spend much of their early lives in the classroom, schools and educational systems must implement mitigation and adaptation measures to protect the health and learning of students and vulnerable adults.

For one, building schools away from wildfire- and pollution-prone areas may be an important method of reducing exposure. Additionally, improving air filtration systems, adopting the use of portable air cleaners and providing surgical masks and N95 respirators in schools can protect against inhaling fire-related particles, although more evidence is needed to understand the full effects of face coverings for young children. Furthermore, allowing for flexibility concerning when and how classes occur can ensure that children are protected during long wildfire seasons without losing instructional time due to school closures.

For example, switching to online provision of course material and digital learning as an alternative to classroom-based learning during significantly polluted weeks or months also could help reduce ambient exposures (Box 4.1).

Box 4.1. Impacts of the shift to online learning during the COVID-19 crisis and lessons learned

The pandemic has improved understanding of the technological, pedagogical and other factors that can contribute to making online learning successful, such as improving teacher preparedness to use digital tools (Dhawan, 2020[56]; OECD, 2021[57]) and the effects of school closures on learning outcomes of different groups. Ensuring that interventions aimed at limiting the effects of school closures due to environmental conditions on learning require an awareness of the conditions that are needed to make them a success but also disparities that may arise. For example, the lower technological infrastructure in the homes of disadvantaged children and the need to provide additional guidance and support to vulnerable students (Bacher-Hicks, Goodman and Mulhern, 2021[58]; OECD, 2021[57]) may negatively impact equity in learning outcomes.

Analyses of national or subnational assessments and studies that are either census-based (i.e. cover all pupils in the target grade(s) or age group(s) in a jurisdiction or school system) or assess a representative sample of the target grade(s) or age group(s) that were standardised in order to allow comparisons of learning outcomes of cohorts of students assessed in 2021-22 and those of cohorts assessed before the pandemic.

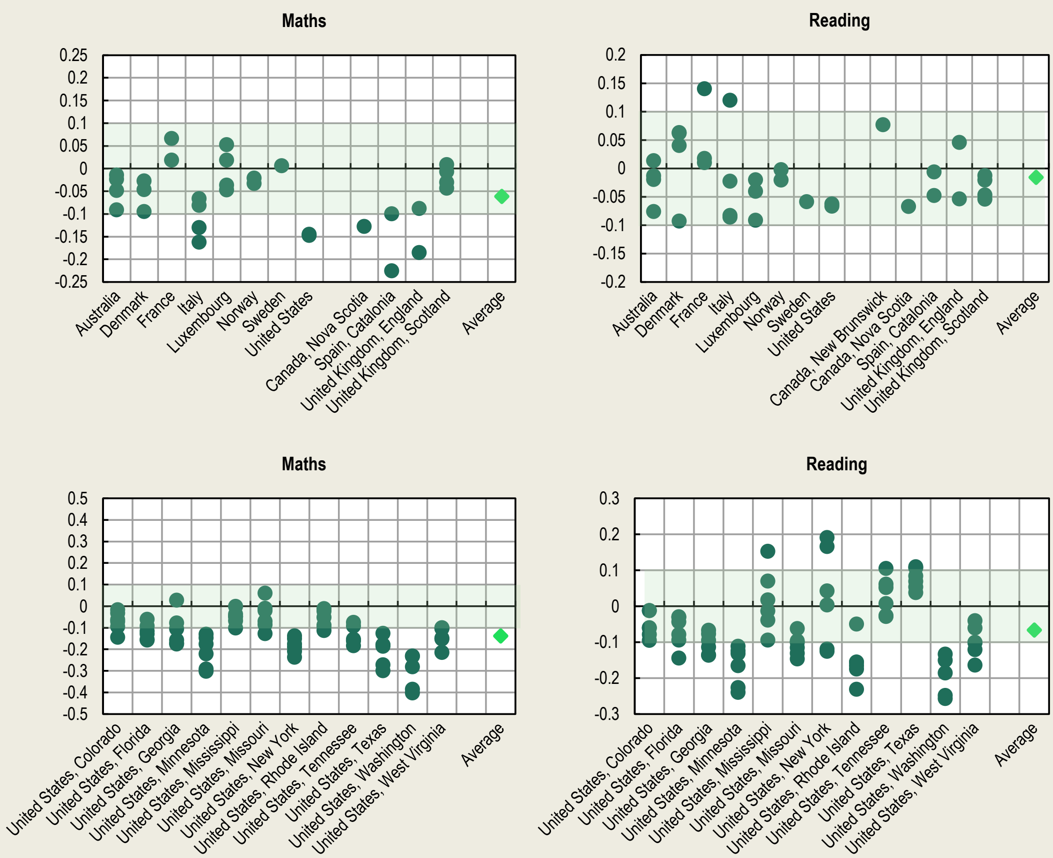
Results presented in Figure 4.6 reveal that declines in performance are observed more frequently than increases between the immediate pre-pandemic and 2022, both in reading and in mathematics, in primary and secondary education. Among the group of States of the United States, observations of declines are far more frequent than those of increases in both domains. No clear evidence emerges of differential impacts of pandemic-related disruptions by grade level.

The scale of changes in performance, whether negative or positive, is generally less than 10% of a standard deviation, except in the United States, where falls in performance are generally above 10% of a standard deviation and in India. Declines in performance are generally larger in mathematics than in reading and the scale of falls in performance is generally greater in mathematics too.

In jurisdictions in which there were large initial falls in performance in 2020-21 compared to the immediate pre-pandemic period, there were often large increases in performance in the following school year. This is particularly true of States of the United States where, performance generally increased between 2020-21 and 2021-22, often significantly, in both English and mathematics. The small number of jurisdictions for which these data are available and the lack of diversity in terms of geographic region and income level mean that they cannot be considered representative of any broader groupings.

Figure 4.6. Evolution of learning outcomes between pre-COVID and 2021-22 assessments

Effect sizes by country or jurisdiction, all grades assessed



Note: A positive effect size means that performance has increased between the latest pre-pandemic assessment and 2021, while a negative effect size denotes a fall in performance. The different points represent the results of the effects for each grade that has been assessed within a jurisdiction in both primary and secondary education. The average is the average of the average effect size for all grades within a jurisdiction. The shaded area represents effects sizes (changes in outcomes) that are small or negligible, whether on the positive or negative side.
Source: Thorn and Vincent-Lancrin (forthcoming[59]), "Learning continues: effects of the pandemic on schooling and achievement".

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Finally, data collection and dissemination of air quality conditions during wildfire episodes using low-cost sensors should be made widely accessible to teachers, administrators, students and parents, and particularly pregnant mothers, to help guide decision making and induce avoidance behaviours, such as staying indoors, whenever possible.

Adaptive technologies can reduce the cognitive burden of high pollution levels and extreme temperatures

Children and adolescents spend a significant portion of their lives in classrooms. Thus, ensuring that schools and education systems are adequately prepared and supplied with the technology to deal with the burden of air pollution and high temperatures may be one way policy makers can mitigate against the early environmental impact on cognition. Air conditioning and air filters are two main technologies that may confer significant health and cognitive benefits.

Air filters trap small particulates that may easily pass indoors. In the United States, replacing filters with high-efficiency air filters (minimum efficiency reporting value > 12) in schools is estimated to reduce the asthma burden due to PM2.5 by 13% per year (Martenies and Batterman, 2018[60]). These health effects are likely to confer additional cognitive benefits. In fact, early estimates suggest that the installation of air filters in schools can raise math scores by 20% of a standard deviation over four months at an annual cost of only USD 1 000 per class (Gilraine, 2020[61]). However, filters must be frequently replaced in heat, ventilation and air conditioning systems to avoid accumulated particles diffusing from filters attached to air conditioning units.

Additionally, air conditioning can offset a majority of the cognitive losses due to heat. In the United States, home and school air conditioning offset 41% and 57%, respectively, of the learning losses encountered on hot school days, with similar effects found in China (Park et al., 2020[27]; Zhang, Chen and Zhang, 2021[62]). For example, construction projects installing air conditioning units in schools that did not previously have them were found to increase reading scores by 15% standard deviations in Connecticut (Neilson and Zimmerman, 2014[63]). Although such school renovations present high upfront costs, they may be more cost-effective in improving test scores than class-size reductions and are highly scalable compared to other educational interventions as they require straightforward technical solutions. Although using technologies such as air filters and air conditioning can significantly reduce the negative effects of pollution and high temperatures on cognition, they use energy and, by doing so, potentially contribute to global warming. When new school buildings are planned, locations should be identified so as to minimise exposure to pollutants, and design solutions should be implemented to reduce exposure to high temperatures.

In addition to air filters and air conditioning, retrofitting school bus engines of an entire district, which may decrease PM emissions by as much as 60-90%, is associated with improvements in reading of 9% standard deviations (Austin, Heutel and Kreisman, 2019[64]). Additionally, night-time cooling through ventilation, which refers to opening windows or using low-energy cooling devices during the night, has been found to be a cost-effective way of improving the productivity of office workers. Cool roofs, which can be achieved by retrofitting rooftops with cooling materials or white paint, have also been shown to improve thermal comfort and reduce energy load by lowering air conditioning use in European office and school buildings. Passive measures such as installing low-energy windows and removing classroom and office furniture or devices that trap heat, such as printers, can additionally lower energy generation.

Importantly, any policy design that aims to improve children's and adults' health and performance outcomes should consider personal exposure to environmental conditions rather than aggregate indoor or outdoor levels. In European cities, for example, more than 90% of the variation in air pollution exposure of individuals is determined by individual characteristics, such as employment status and occupation, rather than pollution differences between cities (Schweizer et al., 2006[65]). Additionally, a study from Portugal found that rather than classrooms, cafeteria rooms had the highest levels of ultrafine particles while being outdoors during the school day sometimes contributed up to 70% of the total daily dose of pollution (Slezakova, de Oliveira Fernandes and Pereira, 2019[66]). Thus, improving learning outcomes depends on consideration of the outdoor-indoor environmental relationship, the activities of the targeted population, and the micro-environments within which they occur.

Reorganising high-stakes exams can help reduce inequalities arising from worsening environmental conditions

High-stakes exams at the end of secondary school are used worldwide as a signal of student cognitive ability, and in some countries, as the primary admissions criteria for admission into higher education. However, random disturbances on the day or week of high-stakes exams, including higher levels of transitory air pollution and temperatures, can affect students' performance on such exams, with long-term economically significant consequences. As socio-economically disadvantaged students are more likely to attend schools with lower adaptive technologies and live in areas with worse environmental conditions, high-stakes exams can exacerbate existing inequalities by lowering tertiary educational attainment and the quality of that education.

Schools and education systems could take several measures to attenuate the impact of adverse environmental conditions on the high-stakes performance of disadvantaged students to ensure that all students have an equal chance to perform to their potential. For one, limiting the pollution around testing sites and requiring that all testing sites have adequate indoor protections, such as air conditioning and air filters, can reduce unequal exposure during test taking. Furthermore, in addition to evidence that students perform better early in the day, scheduling high-stakes exams early in the morning when temperatures are lower could help avoid the impacts of heat and cognitive fatigue, although the positive effects of lower temperatures early in the day should be weighted against the negative effects on the cognitive capacity of teenagers early in the morning due to sleep disturbances (Van Someren, 2000[67]). Additionally, because rescheduling and retaking exams can be costly in terms of time and money, reducing barriers to retaking exams can ensure that disadvantaged students have the same opportunities to retake and prepare for exams as their advantaged counterparts.

Finally, as the academic year typically finishes when historically the agricultural harvest was organised, at the start of summer (May to July in the northern hemisphere and December to February in the southern hemisphere), high-stakes exams are typically taken in the early summer months, when temperatures tend to reach high levels. Adjusting the general schedule of the academic year and the timing of high-stakes exams according to local climate may help reduce students' exposure to adverse environmental conditions. Allowing further flexibility of such policies to take into account when temperatures and pollution levels are high can reduce the overall health and cognitive burden on students. As the COVID-19 pandemic saw dozens of highly selective tertiary institutions waving standardised testing requirements, shifting reliance from high-stakes exams to other signals of student quality may become increasingly necessary.

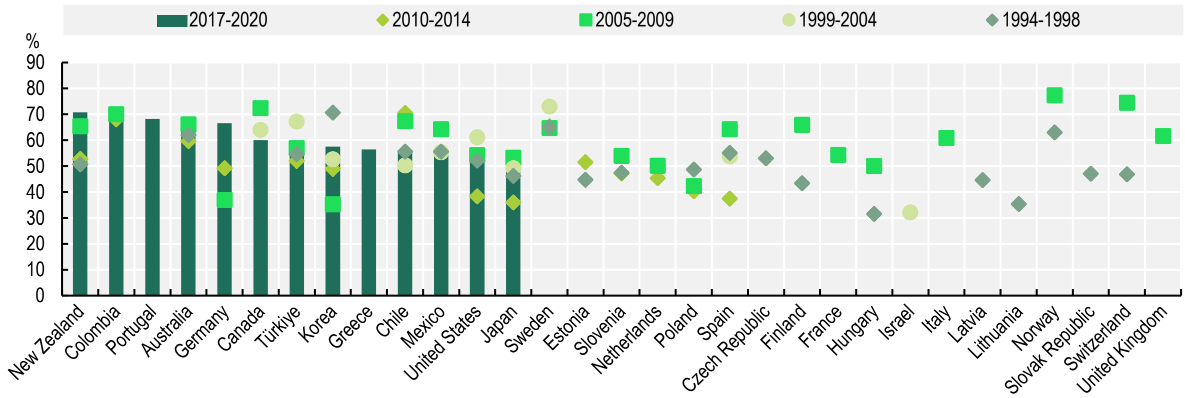
4.3. Environmental and macroeconomic conditions shape human attitudes and dispositions

4.3.1. Experiencing environmental disasters due to human activity increases the extent to which individuals report being willing to prioritise environmental protection

Although there is mounting evidence on the severity of the climate crisis and growing awareness of climate change among the general population (Lorenzoni and Pidgeon, 2006[68]; Poortinga et al., 2011[69]), there has not been a significant increase in the willingness to prioritise the environment over the economy (Figure 4.7). The fact that within each country, individuals' reported intention to prioritise environmental protection varies over time suggests that people's perception of their priorities depends on the environmental, social and economic context they face. In particular, the fact that in many of the countries with available data, individuals' willingness to prioritise the environment over the economy was lowest between 2010 and 2014, the period just after the financial crisis, suggests that both environmental conditions and economic conditions may shape individuals' attitudes towards environmental protection.

Figure 4.7. Trends in stated prioritisation of the environment over the economy, selected countries, 1994-2020

Percentage of individuals aged 16 or older who reported that the environment has priority over the economy



Note: The figure shows the percentage of individuals aged 16 years or older who prioritise the environment over economic growth and job creation by country and wave. The missing value indicates either the country did not participate in the survey or the question was not asked. Countries are ranked in descending order of the mean value for the latest available wave.
Source: Calculations based on World Values Survey (2014[70]), *World Values Survey: All Rounds - Country-Pooled Datafile Version* (database), www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (used waves 3-7).

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The occurrence of natural disasters can affect how people perceive the environmental and economic trade-off. For example, if individuals experience a natural disaster that is potentially due to climate change or environmental degradation, their perception of the environmental and economic benefits associated with enacting climate change mitigation policies can increase, thereby pushing them to prioritise the environment over short-term economic benefits. In fact, research indicates that natural disasters raise the endorsement of pro-environmental attitudes: when individuals experience bad environmental conditions, they are more willing to take environmental action, irrespective of their attitudes towards environmental protection (see also Chapter 2 on this topic). For example, individuals who have been negatively affected by air pollution are more likely to take environmentally-friendly action and believe that additional measures are needed by the government to tackle climate change. Equally, those who have experienced flooding express more concern about climate change and are more willing to take climate-mitigating action.

Risk perceptions increase as a result of experiential factors, such as natural disasters. When one personally experiences a natural disaster, the psychological distance of climate change decreases: climate change stops being something that will affect people and places far away and becomes more personal and tangible. Risk perception and concern for climate change have been found to increase right after a recent natural disaster; however, the increased risk perception caused by extreme weather appears to fade with time.

Table 4.2 reveals the association between the likelihood that individuals will be willing to prioritise the environment over the economy and their experience in the preceding 12 months of natural disasters related to climate change, such as droughts, extreme temperatures, floods, landslides, storms and wildfires. The following measures of natural disaster intensity were constructed: the number of disasters; the number of affected persons per 1 000 people in a country; the number of deaths per 1 000 people in a country; the number of injured people per 1 000 people in a country. The last three measures are population-standardised (i.e. per 1 000) to take into account the differences in population size, providing the likelihood of exposure to and damages from natural disasters.

Table 4.2. Effect of natural disasters on the likelihood that individuals will prioritise the environment over the economy

Regression coefficients of natural disaster measures

	(1)	(2)	(3)	(4)
Number of disasters	0.0020 (0.0015)			
Number of affected persons per 1 000		0.0015** (0.00078)		
Number of deaths per 1 000			0.79** (0.39)	
Number of injured persons per 1 000				15.3*** (2.39)
Individual controls	Yes	Yes	Yes	Yes
Fixed effects	Country, year	Country, year	Country, year	Country, year
Observations	79 145	79 145	79 145	79 145

Note: The table summarises the estimated effects of natural disasters on the probability of prioritising the environment over economic growth and job creation. All regressions control for individual characteristics (age, gender, educational attainment, employment status and income deciles) and include fixed effects in the country and year in which the survey took place. Natural disaster measures were constructed based on all the disasters recorded in the International Disaster Database (EM-DAT) that occurred within 12 months before the survey month. Each column differs in the natural disaster measures used, as indicated in the table. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01. The full regression table is available in Asai, Borgonovi and Wildi (2022[2]).
Source: Calculations based on World Values Survey (2014[70]), *World Values Survey: All Rounds – Country-Pooled Datafile Version* (database), www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (used waves 3-7) and EM-DAT (2021[10]), *International Disasters Database*, www.emdat.be.

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All coefficients are positive, suggesting that an increased prevalence of higher natural disasters is associated with a higher share of individuals reporting that they prioritise the environment over the economy. However, the estimated effect of the number of natural disasters is not significant. This may be because the occurrence of natural disasters alone may not alter the perceived cost and damage of environmental destruction. However, results indicate that when the number of affected persons per 1 000 in the year before the survey took place increased by 1 (that is, when the probability of being affected by natural disasters increased from 0.001 (=1/1000) to 0.002 (=2/1000)), the probability that respondents reported being willing to prioritise the environment over the economy increased by 0.15 percentage point. Since one standard deviation (s.d.) for the number of affected persons per 1 000 is 3.6 in the sample, a 1-s.d. effect will be 0.83 percentage point. The results, therefore, suggest that individuals are more willing to prioritise the environment over the economy when they perceive a higher risk of being affected by climate-change-related natural disasters.

The effect of experiencing a natural disaster and the subsequent change in the likelihood of being willing to prioritise the environment over the economy could be temporary. In other words, the impact of natural disaster shocks could be transitory and have little long-term effects on environmental attitudes and beliefs. Yet, effects could be permanent or long-term if individuals regularly experience natural disasters and their risk perceptions are permanently updated or if affected individuals experience scarring effects and long-term economic costs due to the disasters. To examine these questions, Asai, Borgonovi and Wildi (2022[2]) considered relations including measures of exposure to natural disasters in the year prior to the survey being conducted as well as exposure in the two years prior to the survey. Results indicated that experiencing natural disasters may have a relatively persistent effect on the likelihood that individuals will be willing to prioritise the environment over the economy. However, the effect is not permanent, as it is inconsistent with the fact that despite a long-term increase in the occurrence of natural disasters, there does not appear to be a corresponding long-term increase in the likelihood that individuals reporting being willing to prioritise the environment over the economy (as shown in Figure 4.7).

4.3.2. When unemployment increases, individuals are less likely to prioritise the environment over the economy

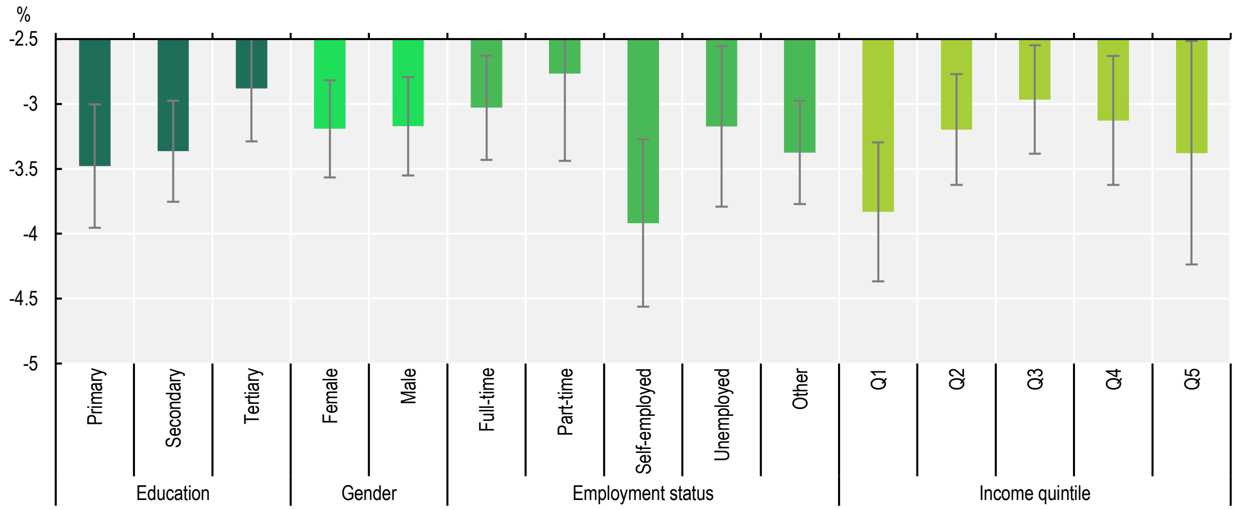
Supporting a just transition that guarantees the employment opportunities of all is not just important for equity considerations but may be a precondition of policies to promote the green transition in the first place. Prior evidence, in fact, suggests that during periods of economic contraction and rising unemployment, public support for the environment decreases. During economic recessions and/or increases in unemployment, individuals may expect policy makers to focus on economic recovery rather than on the environment, since immediate economic costs may be more salient than future benefits arising from environmental protection. On average, when the unemployment rate increases by 1%, the probability that individuals will prioritise the environment falls by around 1.7 percentage points (Asai, Borgonovi and Wildi, 2022[2]). The relatively high responsiveness of individuals' willingness to prioritise the environment over the economy as a function of the contemporaneous unemployment rate suggests that public support for green growth policies is likely to be very sensitive to the economic conditions individuals experience.

Individuals with higher educational qualifications and incomes are more likely to prioritise the environment over the economy. For example, less than half (46%) of those with only primary education prioritise the environment, whereas 59% of tertiary graduates do (see also Chapter 2). The difference is similar in magnitude to the difference observed between the first (lowest) and the fifth (highest) income quintiles.[5] The effect of unemployment on the probability that individuals will prioritise the environment over the economy could be higher among social groups that are more vulnerable to economic shocks and fluctuations. Conversely, those with higher education and stable, full-time jobs may be less sensitive to economic situations because they may be less likely to lose their jobs and be personally affected by negative economic conditions.

Figure 4.8 indicates that the effects of unemployment are negative and statistically significantly different from the null hypothesis of no effects among all socio-economic groups. The effect of unemployment over the likelihood that individuals will prioritise the environment over the economy is similar among men and women and individuals who completed different levels of education. Self-employed individuals appear more sensitive to the unemployment rate than others. Finally, Figure 4.8 reveals an inverse U-shape: individuals in the lowest and highest income groups appear to be the most sensitive to the unemployment rate.

Figure 4.8. Heterogeneity of the effect of unemployment on environment prioritisation, by socio-demographic group, 1995-2020

Impact of a 1% increase in the unemployment rate



Note: Each bar represents the impact of the unemployment rate on environmental prioritisation by socio-demographic group (educational, attainment, gender, employment status and income quantile). The coefficients were obtained by interacting unemployment rate with dummy variables associated with each socio-demographic group from separate regressions. Grey spikes in the figure indicate the 95% confidence interval.
Source: Calculations based on World Values Survey (2014[70]), *World Values Survey: All Rounds - Country-Pooled Datafile Version* (database), www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (used waves 3-7).

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4.4. Physical skills needed to adapt to a changing climate

As climate change continues to result in more frequent and extreme weather events, individuals will need to acquire new skills and knowledge to adapt. Physical education programmes in areas prone to flooding, for example, will need to prioritise teaching individuals how to swim to prevent drowning in the aftermath of destructive events. Furthermore, as extreme heat becomes more prevalent, it is important for individuals to be able to undertake medium-length trips without walking, which can be dangerous due to prolonged exposure to intense heat. This is particularly important for socio-economically challenged individuals who may not have access to a car. Therefore, cycling education programmes might be incorporated into physical education curricula, along with road safety for cyclists. By learning these skills, individuals can reduce the use of cars, which emit CO_2, and avoid the dangers of walking in extreme heat. Additionally, planting vegetation in urban settings will be necessary to provide shade, absorb CO_2 emissions and reduce the urban heat island effect. Science courses can also integrate modules on water requirements for different plants and their resistance to extreme weather conditions. Understanding the effects of extreme heat and humidity on human physiology, especially among different genders and age groups, can also help individuals and organisations avoid risk behaviour and undertake protective practices to reduce the negative impacts of climate change on human health and productivity.

4.4.1. Many people do not know how to ride a bicycle

To develop effective policies for climate change adaptation, it is essential to comprehend human mobility patterns and identify the skill sets required for populations to respond effectively to natural disasters and changing environmental conditions. Research suggests that accessibility to urban centres, where economic opportunities are concentrated, varies significantly worldwide (Wu et al., 2021[71]) and is a crucial limitation to the opportunities for personal realisation and economic empowerment, particularly for individuals living in low-income settings (Weiss et al., 2018[72]).

However, physical infrastructure (or lack thereof) is only one of the factors shaping the use of different modes of transportation by different groups of individuals, the degree of accessibility and the types of connections existing between the places in which different individuals reside, work, shop, socialise and learn – see also Box 4.2 on improving the quality of active travel in cities. The affordability of, access to, and skills can limit the ability of different socio-economic and demographic groups to use a range of modes of transportation. For example, cost can limit the accessibility to cars among low-income groups and, in many countries, gender norms, cultural barriers and fear of sexual harassment and assault can deter women from using certain modes of transport or travel at certain times (Goel et al., 2022[73]).

The use of bicycles is being promoted in cities around the world as a way to reduce GHG emissions and reduce traffic. Cycling allows individuals to engage in medium-length travel in a way that is fast, limiting prolonged exposure to intense heat and extreme weather conditions. At the same time, many individuals world wide do not have the skills necessary to use bicycles. Cycling can also reduce the risk of non-communicable diseases like obesity and diabetes.

Between 25 March and 8 April 2022, Ipsos conducted the online Cycling Across the World survey in 28 countries world wide. In total, 20 057 adults participated. In most countries, participation involved people aged 16-74, except for Norway (where 16-99 year-olds participated) and the United States, Canada, Malaysia, South Africa and Türkiye (where 18-74 year-olds participated). Samples in Argentina, Australia, Belgium, Canada, France, Germany, Great Britain, Hungary, Italy, Japan, Korea, the Netherlands, Norway, Poland, Spain, Sweden and the United States represented these countries' general adult populations under the age of 75. Samples in Brazil, Chile, People's Republic of China, Colombia, India, Malaysia, Mexico, Peru, Saudi Arabia, South Africa and Türkiye were more urban, more educated, and/or more affluent than the general population in the respective countries.

Box 4.2. Improving the quality of active travel in cities

Walking, cycling and other active mobility solutions can benefit cities and urban environments and add resiliency to urban transportation systems. In addition to the potential positive health benefits of active travel, these modes and the facilitation of their use can be valuable levers for improving cities' livability and environmental quality.

Encouraging people to walk and cycle, and ensuring they can do so safely and enjoyably, goes beyond the simple provision of infrastructure and must include components beyond the transport system. There is ample evidence of people walking and cycling despite poor or non-existent infrastructure and underused infrastructure in other contexts. Understanding how, when, where and why people actively travel is complex. To answer these questions, it is necessary to:

1. consider the underlying policy and legal frameworks currently in place that disadvantage other forms of mobility in many cities
2. reduce the inherent systemic violence that reinforces car-centric mobility systems
3. understand the local population's wants and needs.

More specifically, it is necessary to change the context of city transport environments, the attitudes of policy makers and planners, and the general perceptions associated with different modes. Changes in context can induce changes in attitudes and behaviour by changing the provision of conditions that reward and encourage some mobility behaviours and penalise and discourage others. At the same time, attitudinal shifts are a catalyst for new or increased changes to an existing transport system.

The encouragement of more active mobility in cities should follow sound safety principles like those which form the basis of the "Safe System" approach. The Safe System builds on the fundamental proposition that there is no acceptable level of fatalities or serious injuries due to road crashes. This approach means that rather than making road users responsible for their safety in a sometimes inherently unsafe traffic system, all actors – especially those designing and maintaining the road environment and establishing rules for its use – bear a fundamental responsibility to ensure safety (ITF, 2022[74]).

All road users, including children, teenagers, young adults and elderly adults, each having varying capacities and skills, must understand how city road space functions for all types of users and not just drivers. As such, a fundamental change is needed in how transport networks are designed so that they can account for a greater variety of uses without prioritising large and fast vehicles above all else.

More specifically for children, following the lead of countries like Denmark and the Netherlands, it is essential to look ahead and focus on future generations and teach school children how to navigate urban streetscapes independently. In the Netherlands, it is a common rite of passage to go through bicycle training. It allows children to learn traffic rules and desired behaviours while still young and is an important milestone in their development. Expanding these training efforts to other transport modes at different stages can be conducive to sustained changes in the societal perceptions of what is feasible and acceptable as a mode of transport.

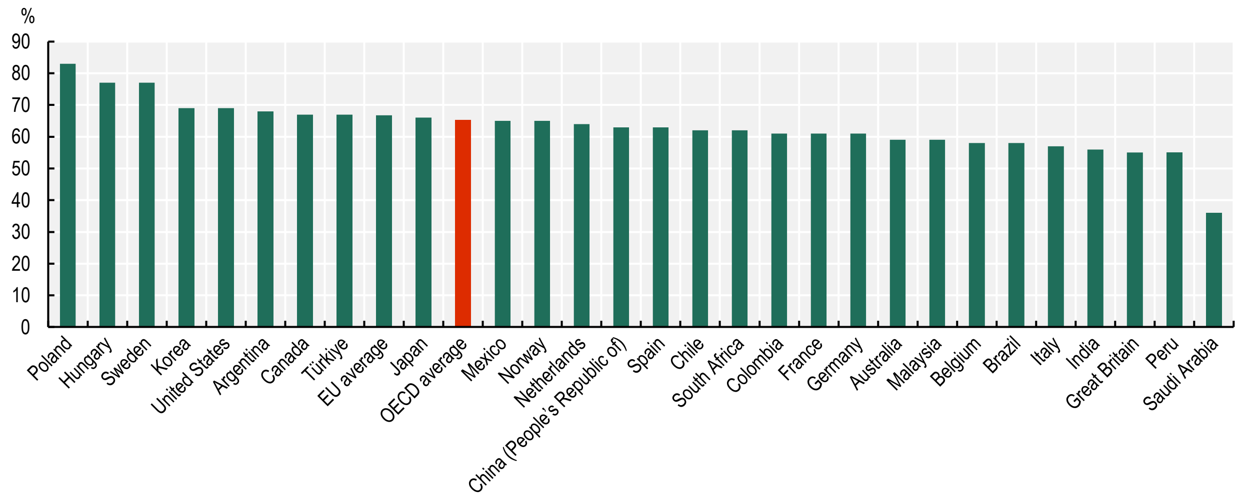
Finally, building capacity and training planners and decision makers is also key. These stakeholders make decisions that define the context of how cities' transport systems are designed and function. There needs to be a shift from a mobility paradigm centred on motorised hypermobility and vehicular throughput to one prioritising accessibility and safety.

Source: ITF (2023[75]), "Towards the light: Effective light mobility policies in cities", www.itf-oecd.org/sites/default/files/docs/towards-the-light-effective-light-mobility-policies-cities.pdf; ITF, (forthcoming[76]), "Beyond infrastructure: Improving the quality of walking and cycling in cities".

Results indicate that, except for Saudi Arabia, most adults in participating countries reported being able to ride a bicycle, but significant minorities in virtually all countries did not (Figure 4.9). For example, 83% of respondents reported being able to ride a bicycle in Poland, and in Hungary and Sweden, 77% of respondents did. By contrast, only 36% of respondents in Saudi Arabia reported being able to ride a bicycle. Furthermore, in Australia, Brazil, Belgium, Great Britain, India, Italy, Malaysia and Peru, less than 60% of the adult population reported being able to ride a bicycle. Moreover, Figure 4.10 suggests that across the 28 countries considered, the ability to ride a bicycle was higher among males and individuals with higher educational qualifications.

Figure 4.9. Cycling skills in selected countries around the world, 2022

Percentage of the population who report being able to ride a bicycle



Note: The figure shows the percentage of a country's population who report being able to ride a bicycle. Respondents are aged 16-99 in Norway, 18-74 in Canada, Malaysia, South Africa, Republic of Türkiye, and the United States, and 16-74 in the remaining countries.
Countries are sorted in descending order of the percentage of the population who reported being able to ride a bicycle.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

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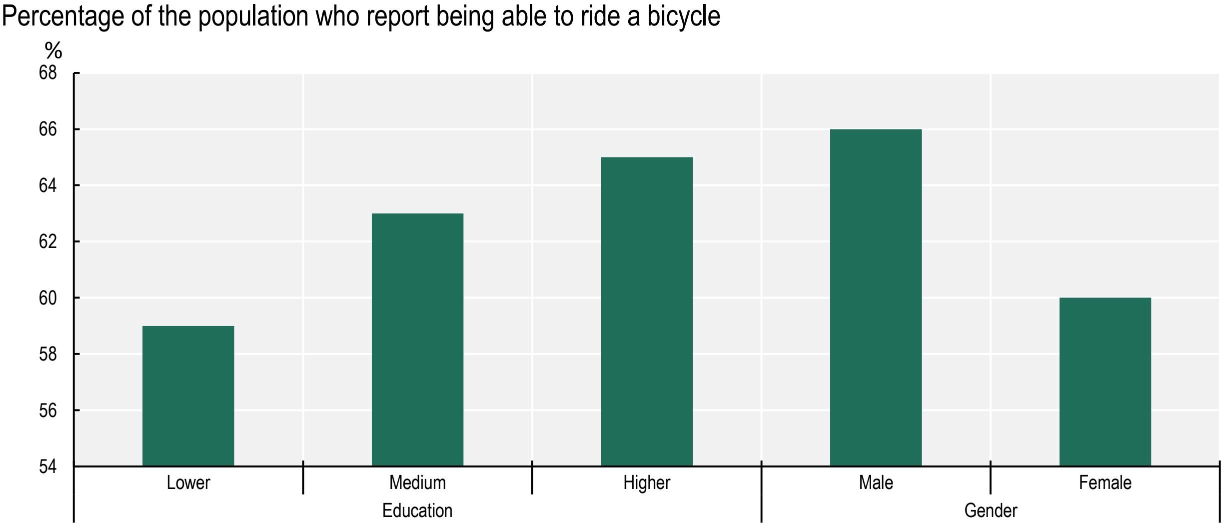
Figure 4.10. Cycling skills in selected countries around the world, by education and gender, 2022

Percentage of the population who report being able to ride a bicycle



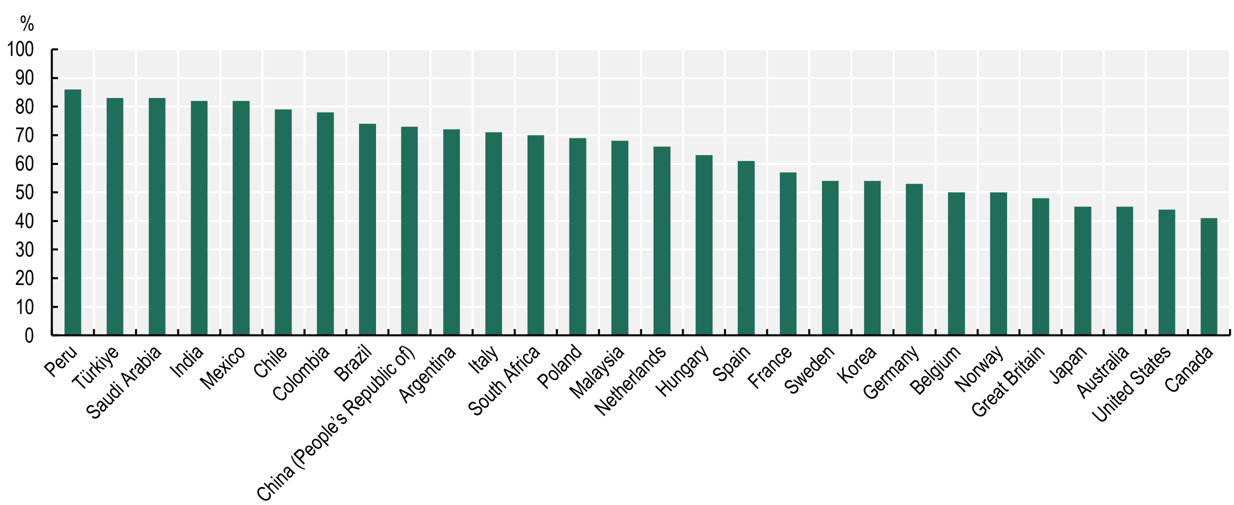
Note: The figure shows the percentage of the population who reported being able to ride a bicycle by education and gender. Respondents were aged 16-99 in Norway, 18-74 in the United States, Canada, Malaysia, South Africa, and Republic of Türkiye and 16-74 in the remaining countries. Country specific educational categories used to define educational attainment are available via the Statlink.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

StatLink https://stat.link/j4p5me

In most countries, over one in two individuals interviewed in 2022 indicated that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects. However, Figure 4.11 indicates that supporters of bicycle prioritisation projects were a minority in Great Britain, where 48% of respondents said that new road and traffic infrastructure projects should prioritise bicycles over automobiles, Japan and Australia (where 45% of respondents did), the United States (44%) and Canada (41%). By contrast, in Peru, as many as 86% of respondents noted that new road and traffic infrastructure projects should prioritise bicycles over automobiles. Within countries, individuals' willingness to prioritise bicycles over automobiles in new road and traffic infrastructure projects did not differ by level of educational attainment. However, it was higher among young people than among older age groups and was higher among individuals living in large cities than in rural areas (Figure 4.12). These differences most likely reflect differences in health – with younger individuals being more willing to use active modes of transportation than the elderly – as well as differences in existing infrastructures and the length of the average travel – with communities living in rural areas being less likely to be able to use bicycles for a large share of their travel needs.

Figure 4.11. Willingness to prioritise bicycles over automobiles in new road and traffic infrastructure projects in selected countries around the world, 2022

Percentage of the population reporting that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects

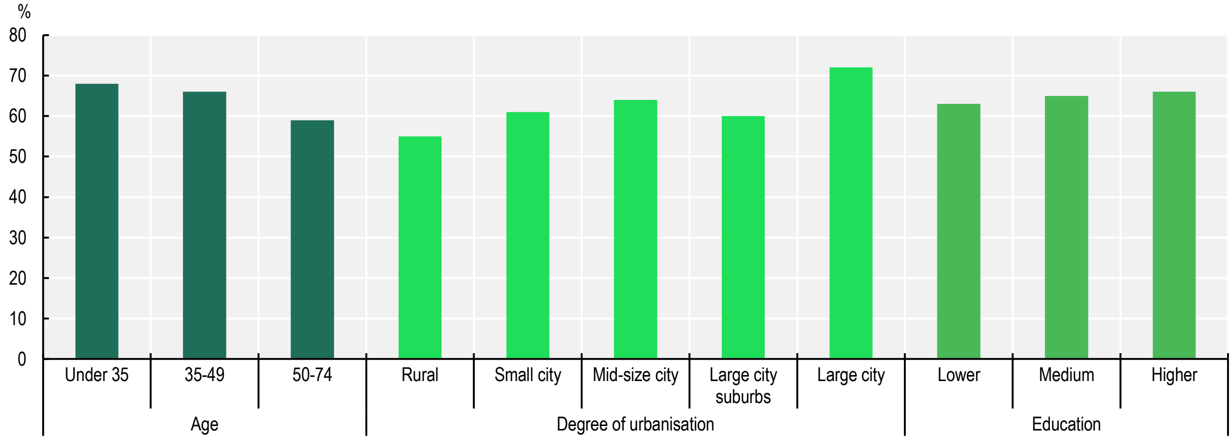


Note: The figure shows the percentage of the population who report that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects. Respondents are aged 16-99 in Norway, 18-74 in Canada, Malaysia, South Africa, Republic of Türkiye and the United States, and 16-74 in the remaining countries. Countries are sorted in descending order of the percentage of the population prioritising bicycles over automobiles.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

StatLink https://stat.link/plitfe

Figure 4.12. Willingness to prioritise bicycles over automobiles in new road and traffic infrastructure projects, by age, degree of urbanisation and education in selected countries around the world, 2022

Percentage of the population reporting that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects, by age, degree of urbanisation and education.



Note: The figure shows the percentage of the population who report that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects, by age, degree of urbanisation and education. Respondents are aged 16-99 in Norway, 18-74 in Canada, Malaysia, South Africa, Republic of Türkiye and the United States, and 16-74 in the remaining countries. Country specific educational categories used to define educational attainment are available via the Statlink.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

StatLink https://stat.link/ar78o2

4.4.2. Many people do not know how to swim without assistance

Disparities in life skills, such as the ability to swim, can disproportionally reduce the welfare of certain groups in society. This is in part because some groups may be especially likely to face situations in which these skills are valuable and in part because some groups lack skills that would provide alternative opportunities for personal realisation and economic empowerment. For example, socio-economically disadvantaged groups may be especially vulnerable to extreme weather events because they tend to live in areas susceptible to floods or extreme heat (Sam et al., 2017[78]). They may also have less access to mitigation technologies and may therefore be more likely to try to cool off in water during extreme temperatures. There is also evidence that the vulnerability to extreme weather events is gendered (Salvati et al., 2018[79]). Similarly, in many situations, women's opportunities related to the use of physical skills, how they move and what such movement would entail in terms of clothing are determined by a range of explicit and implicit cultural and legal restrictions, as well as lack of skills and capabilities to use their bodies.

Many life skills, such as swimming, are acquired during childhood when children in most countries have the right and duty to devote their time to learning. When certain skills are not taught (and learnt) in formal educational settings, opportunities for skills development depend on the resources and willingness to impart instruction at the household and community levels. While it is reasonable to expect that, as adults, individuals may vary in their preferences for engaging in activities that require swimming, the acquisition of swimming skills among children is mostly a function of the provision of instruction at school or organised by families and the extent to which such instruction is prioritised. Therefore, large and pervasive differences in levels of swimming ability between socio-demographic groups can be taken to reflect disparities in opportunity rather than underlying differences in preferences between members of such groups.

Swimming is essential to reduce the risk of drowning when individuals are in or near water. In many developing countries, labour market opportunities are often geographically concentrated near lakes, rivers and other water sources. Being able to swim may be a precondition if individuals are to benefit from such opportunities. Furthermore, the sea, rivers and other waterways constitute important trade routes, so individuals who know how to swim are more likely to be able to safely travel and engage in trade and commerce between different villages or areas. In many countries, waterways also interrupt roads seasonally or permanently, and boats or other vessels are the only way to travel across. The ability to swim is also necessary to work in professions such as marine biology and naval engineering, as technicians in offshore wind farms, and in conservation projects to remove plastics from the ocean. Many of the occupations involved in the development of sustainable exploitation of renewables for energy production and conservation of natural habitats require being able to swim.

Over the past years, weather and climate extremes, such as flooding, have increased (IPCC, 2021[80]). Recent global shocks, such as the COVID-19 pandemic and the Russian Federation's war of aggression against Ukraine, with its effect on energy costs, have highlighted the fragility of education systems, not only in maintaining academic skills (Hanushek and Woessmann, 2020[81]), but also in teaching essential life skills such as swimming, which may be associated with decreasing drowning deaths in high-income countries.

The ability to swim without assistance is a key component of swimming skills, alongside water competencies about how to be safe in water, such as risk awareness or knowledge of hazards (Stallman et al., 2017[82]). The ability to swim without assistance is unevenly distributed among countries with different economic development levels (Figure 4.13). Among OECD countries, for example, in Finland, Germany, the Netherlands, Norway and Sweden, over nine in ten adults report being able to swim without assistance. By contrast, less than one in two individuals report the same in Mexico. Among OECD countries, differences in swimming ability amount to up to almost 50 percentage points between Sweden, with the highest share of swimmers, and Mexico, with the lowest share of swimmers. Differences are even more pronounced when considering the full set of 138 countries with available data. In Sweden, 95% of adults report being able to swim without assistance, whereas in Rwanda, Pakistan and Ethiopia, 15%, 17%, and 19%, respectively, do. The between-country variation in swimming ability maps closely between-country differences in levels of economic development.

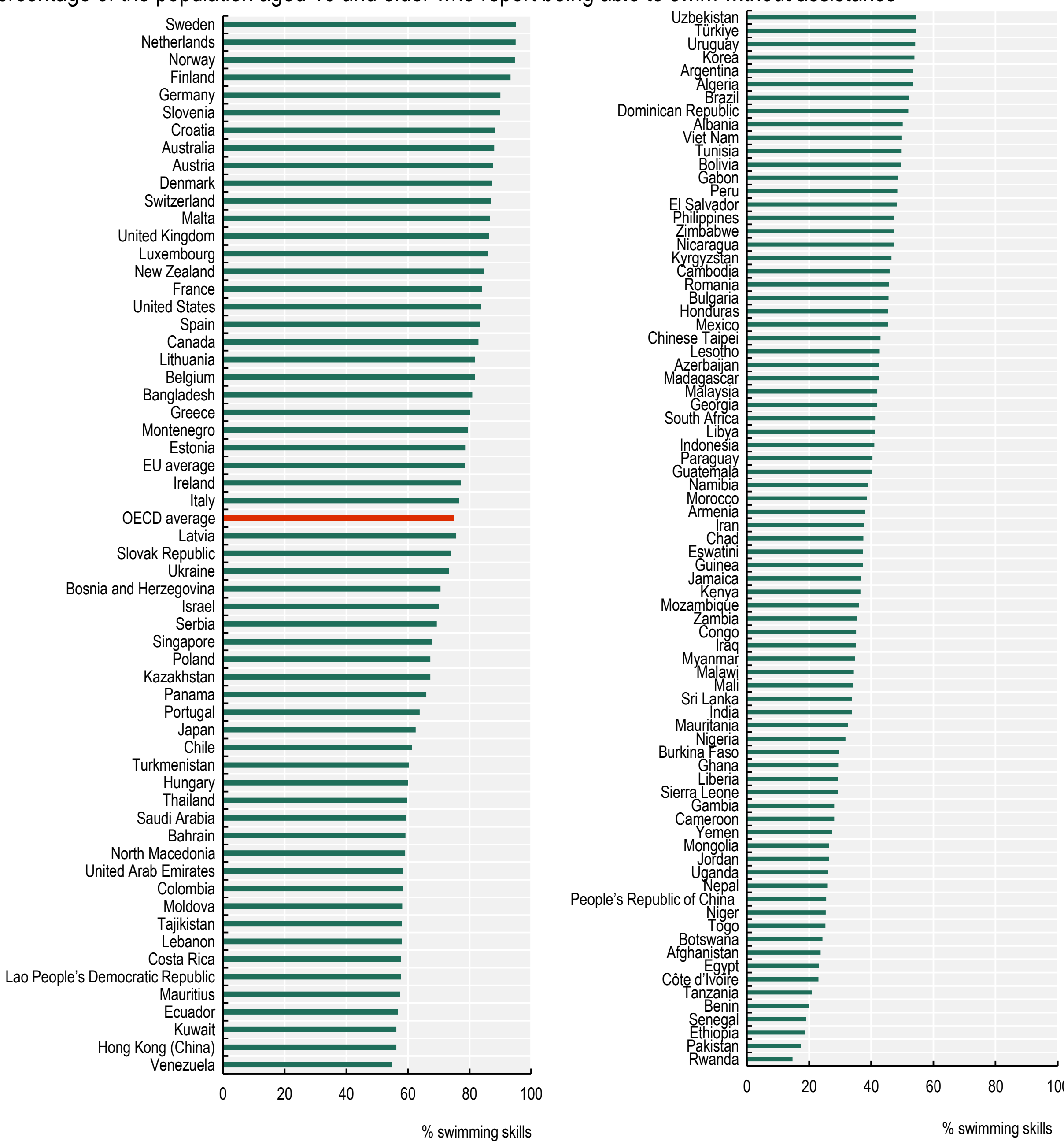
Embedding swimming classes in schools is one way in which countries ensure that young children have swimming skills. Doing so can also reduce inequalities in who knows how to swim and who does not. In some countries, swimming lessons are mandatory in the elementary school curriculum, such as in Austria, France, Germany, and Sweden.

On the contrary, the Netherlands has removed mandatory swimming lessons from its curriculum. The country introduced compulsory swimming lessons in the late 1960s, early 1970s, but this changed in 1985 (Floor, 2016[83]; Isgeschiedenis, 2022[84]). Over the years, the number of schools in the Netherlands that offered swimming as part of the curriculum dropped considerably, from about 90% of schools in the early 1990s to less than 50% in the early 2010s. A reason for the decision of schools not to voluntarily continue to offer swimming classes was that many children reported already being able to swim. Some municipalities consequently felt swimming classes did not provide sufficient added value to justify the investment in school swimming programmes, particularly at a time of tight budgets for local authorities (van der Werff and Breedveld, 2013[85]). In order to reduce adverse effects arising from discontinuing compulsory swimming programmes in schools, a series of safety net schemes were introduced at the local level to support young people with disadvantaged backgrounds (Borgonovi, Seitz and Vogel, 2022[3]).

Another essential element of swimming competence is knowledge of water safety (Stallman et al., 2017[82]; WHO, 2022[86]). Providing people with the ability to swim and water safety knowledge gives them the agency to engage in water-related activities and reflect on their behaviour and actions. For children, however, restricting access to water and supervision by parents or caretakers is essential to drowning prevention.

Figure 4.13. Swimming ability around the world, 2019

Percentage of the population aged 15 and older who report being able to swim without assistance



Note: Countries are sorted in descending order of individuals who are 15 or older who reported being able to swim without assistance.
Source: Adapted from World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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Disparities in swimming ability

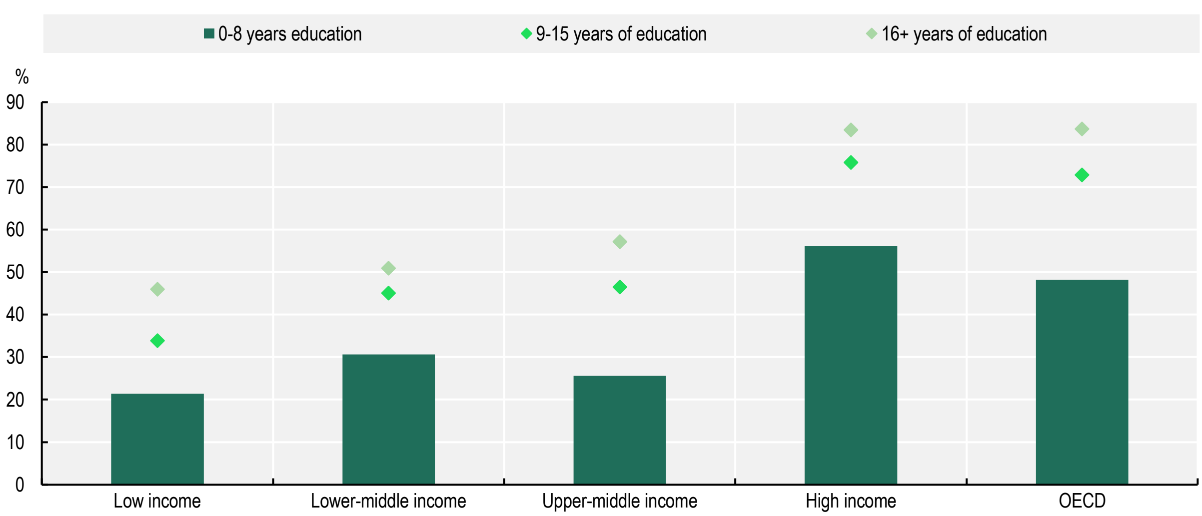
Individuals who attended school longer are more likely to report being able to swim

The ability to swim without assistance and the risk of drowning differ by level of educational attainment. Figure 4.14 shows that irrespective of the level of economic development, individuals who attended school longer are more likely to report being able to swim without assistance than individuals who attended school for fewer years. In low-income countries, for example, among people with a maximum of eight years of education, on average, 21% report being able to swim. However, this share is 34% among those who attended between 9 and 15 years of education, while among those with more than 16 years of education, 46% report being able to swim without assistance. In contrast, in high-income countries, among people with a maximum of 8 years of education, on average, 59% report being able to swim, while this share is 76% and 84% among those who attend between 9 and 15 years of education and those with more than 16 years of education, respectively.

The positive individual-level association between years of education completed and swimming ability illustrated in Figure 4.14 is also mirrored by a country-level correlation between the share of individuals in a country who completed, at most, primary school and the percentage of individuals who report being able to swim without assistance. Figure 4.15 shows a strong negative association between the percentage of individuals in a country who obtained, at most, primary education and the percentage of people who can swim without assistance. In other words, the higher the share of people with only basic educational qualifications, the lower the average swimming ability in a given country.

Figure 4.14. Swimming ability, by education and country income group, 2019

Percentage of the population aged 25 and older who report being able to swim without assistance, by country income group and by years of education



Note: The figure shows the swimming ability by country income group and by educational level of the population aged 25 and older.
Source: Adapted from World Bank (2022[88]), *World Bank Current Classification by Income* (database), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups; World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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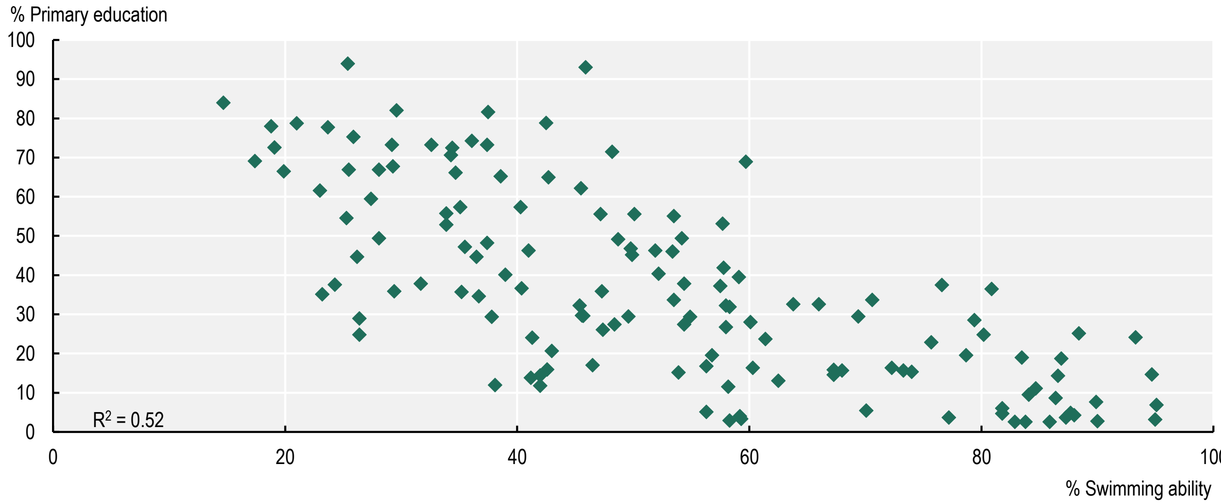
Figure 4.15. Country-level association between educational level and swimming ability, 2019

Correlation between the percentage of the adult population who obtained at most primary school and the percentage of the population who reports being able to swim without assistance



Note: The figure shows the correlation between the share of completed primary educated (y-axis) and the percentage of people who are able to swim without assistance (x-axis). While Belarus and the Russian Federation are not among the data points shown in this figure, their data are included in the R^2 calculation.
Source: Adapted from World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/; World Bank (2022[88]), *World Bank Current Classification by Income* (database), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

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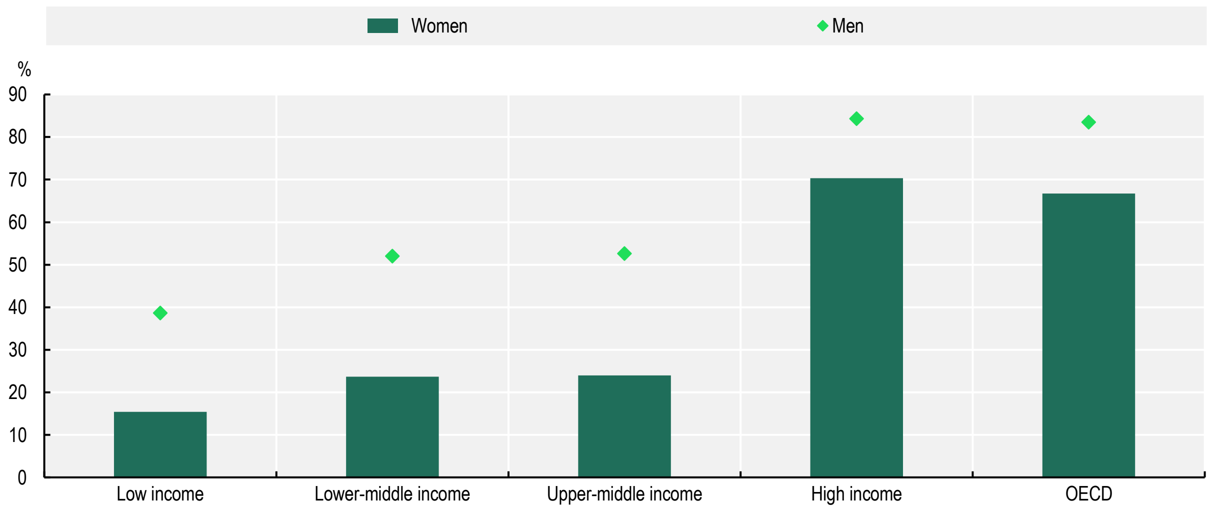
Men are more likely than women to report being able to swim

Men are more likely to report being able to swim than women in countries of different levels of economic development (Figure 4.16). For example, in low-income countries, 15% of women report being able to swim without assistance. This figure is 24% in lower-middle- and upper-middle-income countries, 70% in high-income countries, and 67% in OECD countries. Among men, 39% report being able to swim without assistance in low-income countries, 52% and 53% in lower-middle- and upper-middle-income countries, and 85% in high-income and OECD countries.

Several explicit and implicit barriers could explain why women are less likely to report being able to swim than men (Borgonovi, Seitz and Vogel, 2022[3]). These include, among others, cultural and religious norms, lower levels of engagement in physical activity in general, fear of judgement and struggles with one's body image. Because lack of engagement is potentially due to a variety of factors, the relative importance of which could vary depending on the context, tackling the gender gap in swimming requires action at multiple levels and needs to be adapted to local contexts and circumstances. For example, it is important to normalise the use of a diverse range of swimwear so that girls and women feel comfortable going in water regardless of their body shapes and willingness to show their bodies in social situations. It is equally important to educate girls and women about swimming while menstruating, so that they feel comfortable going in water at any stage of their cycles. Around the world, there have been numerous initiatives, some at the national and others at a local level, to draw attention to the fact that many women do not learn how to swim or do not feel comfortable in water, and so lose confidence in their swimming ability or lose proficiency over time.

Figure 4.16. Swimming ability, by gender and country income group, 2019

Percentage of male and female respondents aged 15 and older who reported being able to swim without assistance



Note: The figure shows the percentage of women (bars) and men (markers) within one country income group who reported being able to swim without assistance.

Source: Adapted from World Bank (2022[88]), *World Bank Current Classification by Income* (database), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups; World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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4.5. Conclusions

Climate change is one of the greatest threats facing humanity, with far-reaching and devastating impacts on people, the environment and the economy. Lessons from the past suggest that while technological innovations and human progress created many environmental problems that plague the planet, they also have the potential to solve these problems. The capacity to solve highly complex problems, process vast amounts of information and engage in interpersonal communication and social co-operation are some of the distinct human abilities that have led to human progress over millennia. This chapter clarifies that climate change and persistent levels of environmental pollution require education and training systems to adapt in multiple ways. Although it is important for children and young adults to learn higher-order cognitive skills, it is also essential for them to acquire life skills, such as learning how to safely engage in physical exercise and use their bodies to go about work and everyday life.

First, they need to consider the effects environmental conditions have on the capacity of individuals to develop their skills to their potential and use them effectively. This requires considering infrastructural, pedagogical and organisational investments to ensure learning environments are redesigned and aligned to facilitate learning.

Second, adapting to environmental conditions requires populations to acquire new skills, especially in those contexts that will be most severely affected by environmental changes and disasters. Greater awareness of the natural world and physical skills, such as the ability to ride bicycles or swim without assistance, will also need to be considered as skills that education and training systems should provide more systematically to promote effective adaptation to a changing natural environment and reduce inequalities in the distribution of risk associated with new environmental challenges.

Third, education and training systems should recognise the extent to which public support for public policies aimed at halting climate change and promoting environmental sustainability can fluctuate depending on the context individuals experience. In particular, whereas public support for efforts prioritising the environment over the economy is generally stronger after individuals experience natural disasters that are linked to human activity, memories of such disasters tend to fade over time and are thus not sufficient to sustain long-term investments to promote environmental sustainability. Moreover, individuals appear less willing to prioritise the environment over the economy – when these two objectives are not aligned – in periods characterised by higher unemployment.

Notwithstanding the relevance of efforts to map how well or poorly education systems worldwide are equipping individuals with key information processing skills, such as literacy and numeracy, this chapter makes clear that major inequalities persist even in physical skills needed to adapt to changing environmental conditions, such as the ability to swim without assistance or to ride a bicycle. Such inequalities make it clear that the substantive freedom many groups have to engage in activities that can enhance their subjective well-being, economic prospects, and safety is restricted and curtailed. For example, when individuals do not know how to swim, their choice set is restricted. Climate change and environmental degradation may lead to higher welfare losses due to the lack of life skills such as swimming and cycling.

The outbreak of the COVID-19 pandemic in early 2020, which was followed by containment measures in most parts of the world, provides important lessons about how schooling can be reorganised and learning supported in extreme conditions requiring the physical closure of schools and training institutions. It also drew attention to the importance of IAQ as a pre-condition of students' learning (and safety) and the inadequacy of the physical infrastructures of schools and training institutions in many countries. The pandemic led to pervasive limitations to movement and the closure of sporting facilities as well as schools and, as such, impacted not only the extent to which individuals learnt academic skills but also the extent to which they learnt valuable physical skills and how to keep safe in their surroundings. Such closures weighed most heavily on socio-economically disadvantaged children who primarily depended on schools to learn these key competencies.

References

Aguilera, R. et al. (2021), "Wildfire smoke impacts respiratory health more than fine particles from other sources: Observational evidence from Southern California", *Nature Communications*, Vol. 12/1, https://doi.org/10.1038/s41467-021-21708-0. [54]

Aguilera, R. et al. (2021), "Fine particles in wildfire smoke and pediatric respiratory health in California", *Pediatrics*, Vol. 147/4, https://doi.org/10.1542/peds.2020-027128. [55]

Annesi-Maesano, I. et al. (2014), *SINPHONIE: Schools Indoor Pollution & Health Observatory Network in Europe: Final Report*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2788/99220. [42]

Asai, K., F. Borgonovi and S. Wildi (2022), "Understanding how economic conditions and natural disasters shape environmental attitudes: A cross-country comparison to inform policy making", *OECD Social, Employment and Migration Working Papers*, No. 280, OECD Publishing, Paris, https://doi.org/10.1787/8e880ea2-en. [2]

Austin, W., G. Heutel and D. Kreisman (2019), "School bus emissions, student health and academic performance", *Economics of Education Review*, Vol. 70, pp. 109-126, https://doi.org/10.1016/j.econedurev.2019.03.002. [64]

Bacher-Hicks, A., J. Goodman and C. Mulhern (2021), "Inequality in household adaptation to schooling shocks: Covid-induced online learning engagement in real time", *Journal of Public Economics*, Vol. 193, p. 104345, https://doi.org/10.1016/j.jpubeco.2020.104345. [58]

Bharadwaj, P. et al. (2017), "Gray matters: Fetal pollution exposure and human capital formation", *Journal of the Association of Environmental and Resource Economists*, Vol. 4/2, pp. 505-542, https://doi.org/10.1086/691591. [19]

Bond, T. et al. (2013), "Bounding the role of black carbon in the climate system: A scientific assessment", *Journal of Geophysical Research: Atmospheres*, Vol. 118/11, pp. 5380-5552, https://doi.org/10.1002/jgrd.50171. [13]

Borgonovi, F., H. Seitz and I. Vogel (2022), "Swimming skills around the world: Evidence on inequalities in life skills across and within countries", *OECD Social, Employment and Migration Working Papers*, No. 281, OECD Publishing, Paris, https://doi.org/10.1787/0c2c8862-en. [3]

Chambers, J. (2020), "Global and cross-country analysis of exposure of vulnerable populations to heatwaves from 1980 to 2018", *Climatic Change*, Vol. 163/1, pp. 539-558, https://doi.org/10.1007/s10584-020-02884-2. [6]

Cho, H. (2021), "Does particulate matter affect cognitive performance? Evidence from the city of Seoul", *American Journal of Health Economics*, Vol. 8/3, https://doi.org/10.1086/717922. [30]

Cho, H. (2017), "The effects of summer heat on academic achievement: A cohort analysis", *Journal of Environmental Economics and Management*, Vol. 83, pp. 185-196, https://doi.org/10.1016/j.jeem.2017.03.005. [31]

Dhawan, S. (2020), "Online learning: A panacea in the time of COVID-19 crisis", *Journal of Educational Technology Systems*, Vol. 49/1, pp. 5-22, https://doi.org/10.1177/0047239520934018. [56]

Ebenstein, A., V. Lavy and S. Roth (2016), "The long-run economic consequences of high-stakes examinations: Evidence from transitory variation in pollution", *American Economic Journal: Applied Economics*, Vol. 8/4, pp. 36-65, https://doi.org/10.1257/APP.20150213. [32]

EM-DAT (2021), "International Disasters Database", *Centre for Research on the Epidemiology of Disasters and Université catholique de Louvain*, http://www.emdat.be. [10]

EPA (2021), *Indoor Air Quality*, United States Environmental Protection Agency, https://www.epa.gov/report-environment/indoor-air-quality#note2 (accessed on 4 December 2021). [37]

Fisk, W. (2017), "The ventilation problem in schools: Literature review", *Indoor Air*, Vol. 27/6, pp. 1039-1051, https://doi.org/10.1111/ina.12403. [49]

Floor, C. (2016), *Schoolzwemmen 2016 Betrokkenheid van scholen en gemeenten en lokale vormgeving (School Swimming 2016 School and Community Involvement and Local Design)*, https://www.kennisbanksportenbewegen.nl/?file=8081&m=1504521748&action=file.download (accessed on 17 October 2022). [83]

Ford, B. et al. (2018), "Future fire impacts on smoke concentrations, visibility, and health in the contiguous United States", *GeoHealth*, Vol. 2/8, pp. 229-247, https://doi.org/10.1029/2018gh000144. [52]

Garg, T., M. Jagnani and V. Taraz (2020), "Replication Data for Temperature and Human Capital in India", *Harvard Dataverse, V1, UNF:6:duBqn2y0jZsh8Znza2Bt0Q== [fileUNF]*, https://doi.org/10.7910/DVN/LPLVF9. [24]

Gilraine, M. (2020), *Air Filters, Pollution, and Student Achievement*, Department of Economics, New York University, https://www.edworkingpapers.com/sites/default/files/ai20-188.pdf. [61]

Global Commission on Adaptation (2019), *Adapt Now: A Global Call or Leadership on Climate Resilience*, World Resources Institute, Washington, DC, https://openknowledge.worldbank.org/handle/10986/32362. [1]

Goel, R. et al. (2022), "Gender differences in active travel in major cities across the world", *Transportation*, Vol. 50/2, pp. 733-749, https://doi.org/10.1007/s11116-021-10259-4. [73]

Gottfried, M. (2015), "Chronic absenteeism in the classroom context: Effects on achievement", *Urban Education*, Vol. 54/1, pp. 3-34, https://doi.org/10.1177/0042085915618709. [36]

Graff Zivin, J. et al. (2020), "The unintended impacts of agricultural fires: Human capital in China", *Journal of Development Economics*, Vol. 147, https://doi.org/10.1016/j.jdeveco.2020.102560. [33]

Graff Zivin, J. et al. (2020), "Temperature and high-stakes cognitive performance: Evidence from the national college entrance examination in China", *Journal of Environmental Economics and Management*, Vol. 104, https://doi.org/10.1016/j.jeem.2020.102365. [34]

Gutiérrez, J. et al. (2021), *In Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I, Cambridge University Press, Cambridge, https://www.ipcc.ch/report/ar6/wg1/. [8]

Hanushek, E. and L. Woessmann (2020), "The economic impacts of learning losses", *OECD Education Working Papers*, No. 225, OECD Publishing, Paris, https://doi.org/10.1787/21908d74-en. [81]

Horvath, D. and F. Borgonovi (2022), "Global warming, pollution and cognitive developments: The effects of high pollution and temperature levels on cognitive ability throughout the life course", *OECD Social, Employment and Migration Working Papers*, No. 269, OECD Publishing, Paris, https://doi.org/10.1787/319b9a1f-en. [4]

IEA/OECD (2022), "Climate-related hazards: Extreme temperature", *Environment Statistics (database)*, https://oe.cd/dx/4TF (accessed on 18 November 2022). [12]

IPCC (2021), "Summary for policymakers", in *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I, Cambridge University Press, Cambridge, https://doi.org/10.1017/9781009157896.001. [80]

Ipsos (2022), *Cycling across the world*, https://www.ipsos.com/en/global-advisor-cycling-across-the-world-2022. [77]

Isgeschiedenis (2022), *Invoering van het schoolzwemmen (Introduction of school swimming)*, https://isgeschiedenis.nl/nieuws/invoering-van-het-schoolzwemmen (accessed on 16 October 2022). [84]

ITF (2023), "Towards the light: Effective light mobility policies in cities", *International Transport Forum Policy Papers, OECD Publishing, Paris.*, https://www.itf-oecd.org/sites/default/files/docs/towards-the-light-effective-light-mobility-policies-cities.pdf. [75]

ITF (2022), *The Safe System Approach in Action*, ITF Research Reports, OECD Publishing, Paris, https://doi.org/10.1787/ad5d82f0-en. [74]

ITF (forthcoming), *Improving the quality of walking and cycling in cities: Summary and Conclusions*. [76]

Künn, S., J. Palacios and N. Pestel (2019), *The Impact of Indoor Climate on Human Cognition: Evidence from Chess Tournaments*, https://conference.iza.org/conference_files/environ_2019/palacios_j24419.pdf. [38]

Leung, D. (2015), "Outdoor-indoor air pollution in urban environment: Challenges and opportunity", *Frontiers in Environmental Science*, Vol. 2 - 2014, p. 69, https://doi.org/10.3389/FENVS.2014.00069. [48]

Li, D., J. Yuan and R. Kopp (2020), "Escalating global exposure to compound heat-humidity extremes with warming", *Environmental Research Letters*, Vol. 15/6, p. 064003, https://doi.org/10.1088/1748-9326/ab7d04. [7]

Lorenzoni, I. and N. Pidgeon (2006), "Public views on climate change: European and USA perspectives", *Climatic Change*, Vol. 77/1-2, pp. 73-95, https://doi.org/10.1007/s10584-006-9072-z. [68]

Maes, M. et al. (2022), "Monitoring exposure to climate-related hazards: Indicator methodology and key results", *OECD Environment Working Papers*, No. 201, OECD Publishing, Paris, https://doi.org/10.1787/da074cb6-en. [11]

Marcotte, D. (2017), "Something in the air? Air quality and children's educational outcomes", *Economics of Education Review*, Vol. 56, pp. 141-151, https://doi.org/10.1016/j.econedurev.2016.12.003. [25]

Martenies, S. and S. Batterman (2018), "Effectiveness of using enhanced filters in schools and homes to reduce indoor exposures to PM2.5 from outdoor sources and subsequent health benefits for children with asthma", *Environmental Science & Technology*, Vol. 52/18, pp. 10767-10776, https://doi.org/10.1021/acs.est.8b02053. [60]

Matthews, B. and V. Paunu (2019), *Review of Reporting Systems for National Black Carbon Emissions Inventories*, EU Action on Black Carbon in the Arctic-Technical Report 2, https://www.amap.no/documents/doc/review-of-reporting-systems-for-national-black-carbon-emissions-inventories/1780 (accessed on 3 December 2021). [14]

McClure, C. and D. Jaffe (2018), "US particulate matter air quality improves except in wildfire-prone areas", *Proceedings of the National Academy of Sciences*, Vol. 115/31, pp. 7901-7906, https://doi.org/10.1073/pnas.1804353115. [53]

Molina, T. (2021), "Pollution, ability, and gender-specific investment responses to shocks", *Journal of the European Economic Association*, Vol. 19/1, pp. 580-619, https://doi.org/10.1093/jeea/jvaa005. [20]

Neilson, C. and S. Zimmerman (2014), "The effect of school construction on test scores, school enrollment, and home prices", *Journal of Public Economics*, Vol. 120, pp. 18-31, https://doi.org/10.1016/j.jpubeco.2014.08.002. [63]

OECD (2021), "Air quality", in *Environment at a Glance Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/80661e2d-en. [17]

OECD (2021), *Exposure to PM2.5 in countries*, https://stats.oecd.org/. [18]

OECD (2021), *Managing Climate Risks, Facing up to Losses and Damages*, OECD Publishing, Paris, https://doi.org/10.1787/55ea1cc9-en. [50]

OECD (2021), *Using Digital Technologies for Early Education during COVID-19: OECD Report for the G20 2020 Education Working Group*, OECD Publishing, Paris, https://doi.org/10.1787/fe8d68ad-en. [57]

Orru, H., K. Ebi and B. Forsberg (2017), "The interplay of climate change and air pollution on health", *Current Environmental Health Reports*, Vol. 4/4, pp. 504-513, https://doi.org/10.1007/s40572-017-0168-6. [16]

Owen, M. (ed.) (2009), *2009 ASHRAE Handbook: Fundamentals*, American Society of Heating, Refrigeration and Air-Conditioning Engineers, 2009. [47]

Park, R. (2020), "Hot temperature and high stakes performance", *Journal of Human Resources*, Vol. 57/2, pp. 400-434, https://doi.org/10.3368/jhr.57.2.0618-9535r3. [35]

Park, R., A. Behrer and J. Goodman (2020), "Learning is inhibited by heat exposure, both internationally and within the United States", *Nature Human Behaviour*, Vol. 5/1, pp. 19-27, https://doi.org/10.1038/s41562-020-00959-9. [26]

Park, R. et al. (2020), "Heat and learning", *American Economic Journal: Economic Policy*, Vol. 12/2, pp. 306-339, https://doi.org/10.1257/POL.20180612. [27]

Peet, E. (2020), “Early-life environment and human capital: Evidence from the Philippines”, *Environment and Development Economics*, Vol. 26/1, pp. 1-25, https://doi.org/10.1017/s1355770x20000224. [21]

Persico, C., D. Figlio and J. Roth (2020), “The developmental consequences of superfund sites”, *Journal of Labor Economics*, Vol. 38/4, https://doi.org/10.1086/706807. [22]

Poortinga, W. et al. (2011), “Uncertain climate: An investigation into public scepticism about anthropogenic climate change”, *Global Environmental Change*, Vol. 21/3, pp. 1015-1024, https://doi.org/10.1016/j.gloenvcha.2011.03.001. [69]

Rappold, A. et al. (2017), “Community vulnerability to health impacts of wildland fire smoke exposure”, *Environmental Science & Technology*, Vol. 51/12, pp. 6674-6682, https://doi.org/10.1021/acs.est.6b06200. [51]

Rojas-Vallejos, J. et al. (2021), “The short-term impact of urban air pollution on student achievement”, *Revista Desarrollo y Sociedad* 87, pp. 11-32, https://doi.org/10.13043/dys.87.1. [28]

Salvati, P. et al. (2018), “Gender, age and circumstances analysis of flood and landslide fatalities in Italy”, *Science of The Total Environment*, Vol. 610-611, pp. 867-879, https://doi.org/10.1016/j.scitotenv.2017.08.064. [79]

Sam, A. et al. (2017), “Vulnerabilities to flood hazards among rural households in India”, *Natural Hazards*, Vol. 88/2, pp. 1133-1153, https://doi.org/10.1007/s11069-017-2911-6. [78]

Sanders, N. (2012), “What doesn’t kill you makes you weaker: Prenatal pollution exposure and educational outcomes”, *The Journal of Human Resources*, Vol. 47/3, pp. 826-850, https://doi.org/10.1353/jhr.2012.0018. [23]

Schweizer, C. et al. (2006), “Indoor time–microenvironment–activity patterns in seven regions of Europe”, *Journal of Exposure Science & Environmental Epidemiology 2007*, Vol. 17/2, pp. 170-181, https://doi.org/10.1038/sj.jes.7500490. [65]

Slezakova, K., E. de Oliveira Fernandes and M. Pereira (2019), “Assessment of ultrafine particles in primary schools: Emphasis on different indoor microenvironments”, *Environmental Pollution*, Vol. 246, pp. 885-895, https://doi.org/10.1016/j.envpol.2018.12.073. [66]

Stafford, T. (2015), “Indoor air quality and academic performance”, *Journal of Environmental Economics and Management*, Vol. 70, pp. 34-50, https://doi.org/10.1016/j.jeem.2014.11.002. [43]

Stallman, R. et al. (2017), “From swimming skill to water competence: Towards a more inclusive drowning prevention future”, *International Journal of Aquatic Research and Education*, Vol. 10/2, https://doi.org/10.25035/ijare.10.02.03. [82]

Thorn, W. and S. Vincent-Lancrin (forthcoming), *Learning continues: effects of the pandemic on schooling and achievement*. [59]

Tian, X., Z. Fang and W. Liu (2020), “Decreased humidity improves cognitive performance at extreme high indoor temperature”, *Indoor Air*, Vol. 31/3, pp. 608-627, https://doi.org/10.1111/ina.12755. [41]

Toftum, J. et al. (2015), “Association between classroom ventilation mode and learning outcome in Danish schools”, *Building and Environment*, Vol. 92, pp. 494-503, https://doi.org/10.1016/j.buildenv.2015.05.017. [45]

Toyinbo, O. et al. (2016), “Building characteristics, indoor environmental quality, and mathematics achievement in Finnish elementary schools”, *Building and Environment*, Vol. 104, pp. 114-121, https://doi.org/10.1016/j.buildenv.2016.04.030. [46]

UNFAO (2021), “Temperature change statistics 1961-2020. Global, regional and country trends.”, *FAO Statistics*, https://www.fao.org/3/ca9943en/CA9943EN.pdf (accessed on 6 December 2021). [9]

van der Werff, H. and K. Breedveld (2013), *Zwemmen in Nederland De zwemsport in al zijn facetten nader belicht (Swimming in the Netherlands: Swimming sport in all its facets in more detail)*, https://www.kennisbanksportenbewegen.nl/?file=2668&m=1422883202&action=file.download . [85]

Van Someren, E. (2000), “Circadian Rhythms and Sleep in Human Aging”, *Chronobiology International*, Vol. 17/3, pp. 233-243, https://doi.org/10.1081/cbi-100101046. [67]

Wang, Y. et al. (2023), “Global future population exposure to heatwaves”, *Environment International*, Vol. 178, p. 108049, https://doi.org/10.1016/j.envint.2023.108049. [5]

Wargocki, P., J. Porras-Salazar and S. Contreras-Espinoza (2019), “The relationship between classroom temperature and children’s performance in school”, *Building and Environment*, Vol. 157, pp. 197-204, https://doi.org/10.1016/j.buildenv.2019.04.046. [39]

Wargocki, P. and D. Wyon (2017), “Ten questions concerning thermal and indoor air quality effects on the performance of office work and schoolwork”, *Building and Environment*, Vol. 112, pp. 359-366, https://doi.org/10.1016/j.buildenv.2016.11.020. [40]

Wargocki, Wyon and Fanger (2004), “The performance and subjective responses of call-center operators with new and used supply air filters at two outdoor air supply rates”, *Indoor Air*, Vol. 14 Suppl 8/8, pp. 7-16, https://doi.org/10.1111/J.1600-0668.2004.00304.X. [44]

Weiss, D. et al. (2018), “A global map of travel time to cities to assess inequalities in accessibility in 2015”, *Nature*, Vol. 553/7688, pp. 333-336, https://doi.org/10.1038/nature25181. [72]

WHO (2022), *Preventing Drowning: Practical Guidance for the Provision of Day-Care, Basic Swimming and Water Safety Skills, and Safe Rescue and Resuscitation Training*, World Health Organization, Geneva, https://www.who.int/publications/i/item/9789240046726. [86]

WHO (2021), *WHO Global Air Quality Guidelines: Particulate Matter (PM2.5 and PM10), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide*, World Health Organization, Geneva, https://apps.who.int/iris/handle/10665/345329. [15]

World Bank (2022), *World Bank Country and Lending Groups: World Bank Current Classification by Income (database)*, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed on 17 October 2022). [88]

World Risk Poll (2019), *The Lloyd’s Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/. [87]

World Values Survey (2014), *World Values Survey: All Rounds - Country-Pooled Datafile Version*, https://www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (accessed on 2022 May 18). [70]

Wu, H. et al. (2021), "Urban access across the globe: an international comparison of different transport modes", *npj Urban Sustainability*, Vol. 1/1, https://doi.org/10.1038/s42949-021-00020-2. [71]

Zhang, X., X. Chen and X. Zhang (2021), *Temperature and Low-stakes Cognitive Performance*, Medrxiv, https://doi.org/10.1101/2021.10.15.21265034. [62]

Zivin, J., S. Hsiang and M. Neidell (2018), "Temperature and human capital in the short and long run", *Journal of the Association of Environmental and Resource Economists*, Vol. 5/1, pp. 77-105, https://doi.org/10.1086/694177. [29]

Notes

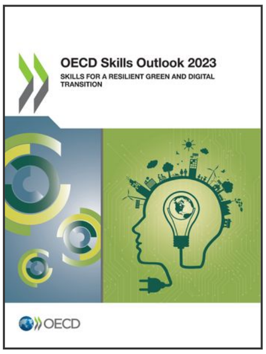
1. Relative to the base period of between 1850 and 1900.

2. In this study, poor countries are defined as countries whose per capita income was less than USD 14 000 in 1995, while rich countries are defined as countries whose per capita income was greater than USD 14 000 in 1995.

3. This statistic is based on data from 2008 to 2012. The threshold for high exposure to fire-PM2.5 was annual levels of 1.5 μg/m^3 or above.

4. In the People's Republic of China, the effects of wildfire-induced PM2.5 on reduced performance on high-stakes examinations are significantly larger than those found due to PM2.5 in other countries from other sources (Graff Zivin et al., 2020[34]). However, this difference may be attributable to other country-specific mechanisms, such as lower protective investments in classrooms.

5. In each wave, income deciles are defined in each country/region.



From:
OECD Skills Outlook 2023
Skills for a Resilient Green and Digital Transition

Access the complete publication at:
https://doi.org/10.1787/27452f29-en

Please cite this chapter as:

OECD (2023), "Preparing for a changing world: Promoting key skills to adapt to climate change through education and training", in *OECD Skills Outlook 2023: Skills for a Resilient Green and Digital Transition*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/5e221e4e-en