



Climate change and respiratory health: a European Respiratory Society position statement

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Climate change is a major threat to lung patients, causing more frequent and extreme weather events, prolonged aeroallergen seasons, and poorer air quality. ERS calls on the health community and policymakers to act now and prepare for a complex future. <https://bit.ly/3pO27Ne>

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Introduction

The World Health Organization (WHO) has warned that climate change is the biggest global threat to humanity in the 21st century [1, 2]. By 2050, climate change is expected to cause at least 250 000 deaths every year globally due to climate-related heat stress, malnutrition, malaria and diarrhoea [3]. An additional health burden will arise from more indirect climate-related paths, including migration, conflicts, poverty, and disruption of healthcare and ecosystems. Climate change is not just a threat to future generations, but it is already an unfolding major planetary and health crisis. At accelerating speed in the past few years, the catastrophic impacts of global warming are evident with the increase in the frequency and severity of extreme weather events (*i.e.* heat waves, wind and dust storms, heavy rainfall and flooding, droughts, and wildfires), resulting in devastating consequences for human health worldwide [4, 5]. For example, Europe lived the hottest summer ever recorded in 2022, with record-breaking temperatures in many places in western and northern Europe (*e.g.* the UK with a record temperature of 40.3°C in Coningsby) [6]. At the same time, a severe drought had affected most of the Northern Hemisphere since the beginning of the year [7]. In both cases, recent attribution studies found that anthropogenic climate change played a crucial role in the severity of these events [8, 9]. The combination of long-lasting hot and dry conditions led to an exceptional wildfire season in Europe in terms of an increased number of fires, burnt areas and fire-related emissions. Extraordinary events like these lead to immediate loss of life and disturbances in healthcare services, adversely affect the health of patients with climate-sensitive diseases (cardiovascular, respiratory, metabolic, kidney and infectious diseases), and result in worse mental health, malnutrition and social crises (*e.g.* migration, conflicts) [10]. While for some individual hazards and specific locations and populations, climate change might result in a risk reduction (*e.g.* less humidity leading to lower exposure to mould) [11], there is overwhelming consensus on the deleterious effects on human health that climate change has today, which will be amplified in the future in absence of further efforts in terms of adaptation or mitigation strategies [12]. The enormous scale and unpredictable nature of

the impacts of irreversible climate change have raised a sense of urgency for action among citizens, experts, and national and international organisations, both to attenuate the progressive warming, mitigate climate change impacts, and increase the resilience of health systems and populations. More importantly, public health experts highlight that tackling climate change could provide enormous opportunities for future generations. In particular, the 2022 Lancet Countdown Report states that this can be the biggest public health policy opportunity of the century, if health, well-being and equity are at the heart of the climate mitigation and adaptation plans [5].

The climate crisis is challenging the fundamental mission of health professionals, which is to improve health, prevent harm and advance equity. The importance of climate change to health has prompted several medical societies to develop specific policies, reports, position statements and letters addressing it, and calling for policies to back necessary action. The European Respiratory Society (ERS) published its first position statement on “Climate change and respiratory disease” in 2009, identifying key areas of concern for respiratory patients and healthcare workers, making recommendations for research to address knowledge gaps, and calling for action to mitigate the climate change crisis [13]. Since then, research on the impacts of climate change, on respiratory health specifically, and health in general, has progressed and provided further scientifically grounded evidence on mechanisms, vulnerabilities and actions to protect populations from climate-related hazards. This evidence should be used to develop public health policies, increase awareness of climate change impacts on health, and drive the motivation for action among citizens, healthcare professionals, researchers and political entities.

In this consensus statement developed by the ERS, we aim to provide an overview of the state-of-the-art knowledge on the impact of climate change on respiratory health, and guidance to clinicians and other healthcare professionals and institutions, patients and patient organisations on how global warming can be addressed in clinical practice. In particular, we focus on how climate change mitigation and adaptation strategies synergise with other policies for respiratory health (*i.e.* clean air policies, sustainable urban development), how climate change impacts daily activities in clinical practice and patient behaviour, and how clinicians and patients can act as advocates for climate-friendly policies from the clinical practice. This statement is intended to be a reference resource on the impact of climate change on respiratory health and a call for action against this threat from both a clinical and public health perspective, and from members of today’s society. The statement also expresses the position of the ERS and European Lung Foundation in support of all policies that mitigate climate change impacts, which are imperative to improve the health of patients with lung disease in Europe and prevent new climate-related lung diseases [14].

Climate change as a health determinant

The continuous increase in anthropogenic emissions of carbon dioxide and other greenhouse gases since the industrial period is dramatically changing the climate at all scales. According to the recent sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC), the most important panel of experts in the field, it is unequivocal that human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years, resulting in a world 1.1°C warmer in 2020 than in the preindustrial period [12]. The IPCC states in its last report, with a variable degree of confidence depending on the region and the hazard, that this temperature rise has had impacts on physical systems (*e.g.* sea level rise), and resulted in an increase in climate variability with a higher frequency, intensity and severity of extreme weather events (*e.g.* heatwaves, droughts). Additionally, these weather changes would have led to a worsening of air quality (*e.g.* more frequent and severe wildfires, pollen, dust storms and an increase in ground-level ozone levels), changes in transmissibility of vector-borne diseases and alteration of crop production. Climate scenarios for the next century predict that the warming will progress at a much faster speed if no reductions in greenhouse gas emissions occur. Similar patterns are expected in Europe, with a steep increase in frequency and severity in extreme weather events and climate variability in all regions. Temperature will rise in all European regions at a rate exceeding the global temperature changes, with the Mediterranean region being the one probably most affected [12].

The impacts of climate change on human health are pervasive, profound and substantial. Climate change is affecting the health of every single population in the world, and it is expected that these impacts will amplify in the near future [10, 12]. Health impacts are variable in magnitude and severity, depending on the location, mostly driven by preparedness, level of vulnerability and adaptation capacity. On top of the progressive warming and changing patterns in other climate-related hazards, existing societal challenges (such as social inequality, progressive urbanisation and ageing populations) will amplify the health burden attributed to climate change [15, 16]. For example, vulnerable and already marginalised populations, including impoverished and undernourished communities, are and will continue to be disproportionately impacted by climate change. Other vulnerable groups include chronic disease patients, older populations,

children, pregnant women and people in occupations that involve working primarily outdoors (construction workers, cleaning, security personnel, *etc.*) [5].

Climate change affects human health in a variety of ways, including direct impacts derived from extreme weather events, such as heatwaves or floods, and indirect impacts through changes in aeroallergen exposure patterns, air quality and transmissibility of vector-borne diseases. Climate change could also affect health *via* socioeconomic disruption by altering crop production, disturbing water, energy and food supplies, and leading to conflicts and migration. In this statement, we will focus on the specific mechanisms by which climate change affects respiratory patients.

Climate change and respiratory health

Respiratory patients are likely among those that are most impacted by climate change [17]. Individuals with an already impaired respiratory function (*e.g.* asthma or COPD patients) are particularly sensitive to changes in weather or extreme weather events, which can directly lead to a worsening of their health and an increased risk of dying [17–20]. Climate change may furthermore amplify the current risks for respiratory health, including exposure to environmental factors such as air pollution, pollen and other aeroallergens, and can affect many respiratory outcomes [21, 22]. These include a decline in lung function, increases in allergic responses and/or new cases of chronic (asthma, COPD, lung cancer) and infectious (pneumonia, influenza, tuberculosis, COVID-19) respiratory diseases, as well as exacerbations of existing respiratory diseases (coughing, wheeze, shortness of breath, difficulties breathing, use of medication, emergency room visits, hospitalisations, death) [23–26]. Several reviews, including an earlier ERS statement [13], have provided extensive summaries of the different mechanisms by which climate change affects respiratory health, as well as outlined adaptation strategies [21, 27, 28]. While some of these reviews have focused on specific pathways, including respiratory infectious diseases [29], extreme weather events and air pollution [26], this statement provides an overview of all major pathways linking climate change with respiratory health illustrated by recent examples of studies.

Extreme heat and respiratory diseases

Increasing summer temperatures have been associated with increased risks of respiratory disease hospitalisations and mortality [30]. Exposure to high temperatures or extreme heat can trigger respiratory symptoms that may require the use of medication, general practitioner or emergency room visits and hospital admission, and may even result in death [31–33]. For example, a recent study in England found that the risk of hospitalisations due to COPD increases by 1.5% per 1°C increase in temperature, with more than 1800 events per year attributed to temperatures above 23°C [34]. High indoor temperatures may result in poor respiratory function in COPD patients [35]. Exposure to high temperatures can also decrease pulmonary function in asthmatic populations or increase asthma exacerbations in children [33, 36]. Abrupt changes in temperature and humidity have also been associated with increases in airway resistance, bronchoconstriction and increased risks of emergency room visits and hospitalisations [19]. Patients treated with certain drugs, for example diuretics in those with comorbid high blood pressure, or anti-histamines for allergies, may also be at a higher risk of impaired thermoregulation, leading to a higher risk of heat-related illnesses [37].

Changing weather patterns and respiratory infectious diseases

Climate change is making the weather more variable, by altering the seasonality of weather conditions and/or causing sudden changes in temperature and precipitation. These changing patterns alter the survival, reproduction and distribution of some climate-sensitive pathogens causing respiratory infections [29, 38]. For example, recent studies have suggested that several weather variables (*e.g.* temperature, wind, precipitation) may be associated with changes in the incidence of pulmonary tuberculosis [39, 40]. Additionally, it is unclear whether winter respiratory infections will decrease with increasing global temperatures. Recent studies have shown that fluctuating temperatures may affect the incidence of and mortality from respiratory infections [41]. Other studies have found that warm winters are usually followed by more severe influenza epidemics [42]. Finally, extreme precipitation events and other hydrological disasters have been associated with an increased risk of respiratory infections [43].

Climate, extreme weather and aeroallergens

During the past decades, shifts have been observed in pollen and other aeroallergen onset, duration, and intensity, in Europe and elsewhere [44]. Current evidence suggests that climate change might have been partly responsible for these changing temporal and spatial patterns in the pollen season and in pollen composition, which are expected to alter further in the coming decades, as well as the introduction of new aeroallergens to new areas, along with warming climate and related changes in biodiversity [45, 46]. These

changes will be challenges for both patients (longer/altere pollen seasons, new allergens) and caregivers (new patient groups, diagnostics for new allergens, *etc.*).

Additionally, climate change will likely increase the frequency of thunderstorms, which have been associated with increasing allergic asthma outbreaks mediated through allergen exposure, notably pollens and wet-air fungal spora [47, 48]. Finally, changes in weather linked to climate change can drive changes in the composition, production and spread of other aeroallergens [27]. For example, extreme weather events, such as heavy rainfall and floods, can exacerbate indoor mould and dampness exposure, leading to worsened respiratory health [49, 50].

Climate change and air pollution

Air pollution is the most important environmental risk factor. It was estimated that in 2019, particulate matter with aerodynamic diameter $<2.5\ \mu\text{m}$ ($\text{PM}_{2.5}$) was responsible for 6.7 million deaths globally [51], and 373 000 in Europe [52]. Climate change and air pollution are intrinsically connected. Greenhouse gases and air pollution share the same major sources: fossil fuel and biomass combustion (wood and coal burning for energy production and residential heating and cooking, *etc.*), animal production emitting methane (greenhouse gas), as well as ammonia, which forms particulate matter and may be harmful to respiratory patients. Additionally, weather can aggravate already poor air quality by altering its dispersion capacity, composition and toxicity. For example, higher temperatures and extended sunlight exposure promote more ground-level ozone pollution, a powerful lung irritant that can trigger asthma attacks, hospitalisations and mortality due to respiratory diseases [53, 54]. Heat and drought can lead to wildfires and dust storms, causing massive air pollution exposure. These affect local communities with devastating consequences for their health, and also produce harmful particles that can travel thousands of kilometres, affecting populations far away from the source, for days or weeks [55–57]. Another area of concern for patients with lung diseases, especially those with allergies, is the interaction between air pollution and pollen/aeroallergen exposure. Poorer air quality, and increasingly frequent and severe wildfires and dust storms, can impair lung function and growth, in particular in children [58], increasing the risk of hospitalisations and death [55, 57].

Impacts in vulnerable populations: reproductive and children's health as examples

Among the different vulnerable groups [5], children are more affected by climate change than adults. Their lungs and immune systems are still under development, they breathe faster than adults, breathing in (polluted air, hot air, or air with aeroallergens) about 2–3 times as much as adults, and they spend more time outside and are more physically active than adults [59]. Also, children typically cannot influence their living conditions or exposures to any large extent and must rely on caregivers and society to take responsibility for a healthy environment [59]. Global warming with extended pollen seasons may have severe consequences for children and adolescents with allergic asthma, which is the dominating phenotype in this age category, and sensitisation rates and respiratory allergy to airborne allergens, including grass pollen, tree pollen or dust mites, are also reported to have increased globally in recent years [60]. Importantly, climate change impacts on children's health may be taking place immediately from conception. Exposure to hot temperatures during pregnancy can increase the risk of preterm birth, low birth weight and even stillbirths, and pregnant women with asthma are among those with the highest risk [61]. Critical periods also include the first years of life, with detectable respiratory effects of, for example, air pollution, on the developing lung [62]. It has become apparent that chronic lung diseases in adults, such as COPD, may have childhood origins and that underlying pathophysiology can be explained by a series of events due to gene–environment interactions across the lifespan. Also, for classic diseases that have been linked to tobacco smoking, like chronic bronchitis, there are clear associations with air pollution exposure early in life [63, 64]. Therefore, prevention of chronic respiratory disease should start as early as possible.

Tackling climate change: an opportunity for public health

Experts are claiming that only a response with health at the core of climate action would lead to substantially larger and more immediate benefits, and pave the way for a low-carbon, more resilient and sustainable future. A critical element attached to this narrative is the concept of “co-benefits”. It refers to how climate change mitigation activities can help advance other policy goals and improve health at the same time. Thus, these mitigation strategies would not only avoid the health harms from climate change but also translate into immediate health co-benefits. This is particularly attractive for policy-makers and a key selling point for further investment in mitigation policies, as the turnover is expected to be substantially larger [65, 66]. Examples of these initiatives range from strategies for a more sustainable urban development or, more importantly, the transition to clean energy sources and more stringent air quality legislation.

Climate change and air pollution: call for unified policy

Recent reports from the WHO highlight that many measures to reduce emissions of greenhouse gases would translate into better air quality and substantial reductions in health risks [67, 68]. Thus, air pollution regulation that tackles direct sources of climate change, namely fossil fuel emissions, should be at the heart of any climate change mitigation strategy. The European Commission adopted in 2019 the European Green Deal, committing to be the first climate-neutral continent in the world, by achieving a “Zero Pollution Ambition” or net zero greenhouse gas emissions by 2050. At the core of this ambitious plan is clean air, and within the European Green Deal, the Commission in 2021 began to revise its air quality standards, as they fail to sufficiently protect the health of European citizens. The Commission has stated that is committed to aligning air quality standards more closely with the WHO Air Quality Guidelines, which guide air pollution limit values based on the comprehensive synthesis of the evidence on the impact of air pollution on health. The WHO 2021 Air Quality Guidelines made a historically bold statement, by setting strikingly low recommendations for annual average concentrations of PM_{2.5} (5 µg·m⁻³) and for NO₂ (10 µg·m⁻³), five and four times lower, respectively, than the current European Union (EU) limit values. Therefore, aligning new EU air quality standards with WHO guidelines is a historic opportunity to deliver a policy working towards reduction in greenhouse gas emissions, through an equitable transition away from burning fossil fuels, and towards reducing overall consumption in society as a key preventive health strategy. This would avoid substantial health harms related to slowing down global warming, but more importantly, it will translate into immediate gains for health in terms of reductions in health impacts due to poor air quality [69]. Furthermore, compliance with the United Nations Environment Programme’s black carbon good practice statements is needed to achieve reductions in black carbon emissions from transportation, industrial sources, residential heating and agricultural burning.

The role of respiratory physicians in the climate crisis

In the past years, we have witnessed how healthcare professionals in collaboration with patients have united to advocate on behalf of their patients and communities for climate action. Under the unanimous motto “climate crisis is a health crisis”, health experts have warned that health is already being harmed by changes in climate and the destruction of the natural world, and “only fundamental and equitable changes in our society will reverse current trajectories” – as stated in a recent joint statement of the editors of more than 200 health journals [70].

The past two COP26 and COP27 conferences are a demonstration of the growing interest and the high level of engagement of the health community in the climate fight. Before COP26 in Glasgow, there was a general lack of focus and interest in the link between climate change and health. For the first time in Glasgow, the health agenda was a central part of the COP meeting. The COP26 Health Programme, led by the UK government, WHO, Health Care Without Harm and the United Nations Framework Convention on Climate Change Climate Champions was presented as a flagship initiative highlighting the health argument for climate action. In what was called COP1 for health and climate change, COP26 delivered key commitments by over 50 countries, including the implementation of strategies to build climate-resilient and low-carbon systems, but also heightened the crucial role of healthcare professionals and patients in this health crisis as activists. The same increasing interest and engagement was found in the COP27 conference in 2022 in Egypt and brought forward crucial steps in terms of adaptation efforts, equity and climate justice with the creation of a fund for loss and damage and boosting of adaptation funding for low-income countries [71].

Within their role as health providers, health professionals have been traditionally considered one of the main actors involved in the application of adaptation strategies (*e.g.* providing advice to patients to protect themselves during heatwaves). According to the IPCC, these include all processes or interventions that would help populations to adjust to actual or expected climate and its effects. Clinicians can help to identify the most vulnerable groups (including respiratory patients) and help public health officials design and articulate targeted interventions. However, recently there have been calls from health professionals, public health institutions, medical education systems, healthcare authorities and scientific societies to become more active partners in climate change mitigation efforts that would help reduce the rate of warming. In particular, there is a growing interest today in redesigning healthcare services by focusing on planetary health because of its strong link with the community. Planetary health refers to the interlinkages between human-induced deleterious changes in the environment, including climate change, and its impact on human health, and aims to develop strategies that will help create an equitable, sustainable and healthy world [72]. Specifically, there are several ways that respiratory physicians, in their clinical practice, can contribute to reducing greenhouse gas emissions and, overall, protect the planet. These range from strategies for greening healthcare systems and promoting green prescriptions (*e.g.* inhalers) [73], active transport and more sustainable food choices [74], and advocating for larger engagement of the

communities and individuals with climate-friendly activities, such as connecting with nature [75]. Additionally, efforts towards smoking eradication are also a good example of synergies between public health policies and climate mitigation, given the deep environmental footprint of the tobacco industry nowadays [76]. All these activities have substantial and immediate benefits for health, for example by reducing the risk of cardio-respiratory diseases and other comorbidities.

Paving the way for the next generations: lessons learnt from the COVID-19 pandemic

Although the WHO declared the end of the COVID-19 pandemic in May 2023, we are still facing the consequences of the COVID-19 pandemic today: a public health crisis that has caused unprecedented damage to our society and economy, and has forced a re-examination of our existing public health strategies to face future global crises, such as climate change [77]. Both climate change and the COVID-19 pandemic are transboundary and life-altering threats for which ambitious strategies at the local, regional and global scale are required to efficiently reduce their health burden [78]. The COVID-19 pandemic has triggered new awareness about the delicate links between fossil fuel-based economy, our lifestyle, climate change, agriculture and the way we produce food, deterioration of natural biodiversity, the emergence of new infections, and planetary and human health, with the respiratory disease patient at its epicentre [79, 80]. It demonstrates that all societies, even the most advanced, can be severely impacted by such global crises with unexpected disruptions and wide-ranging effects at all levels, especially when public health systems are not well prepared. The crucial role of interdisciplinary research is another lesson brought about by the pandemic. Open collaboration and communication between experts, including clinicians, epidemiologists, public health officials, researchers and experts in natural sciences, as well as patients, to efficiently guide policy have been pivotal in this battle and a similar approach is proposed as the way to go in our fight against climate change. An example is the Next Generation EU programme that provided EUR 750 billion in grants and loans to help member states recover from the COVID-19 crisis and build more resilient and sustainable development and future, many of which are directly addressing green deal targets and climate change [81].

Need for further research

Although current evidence convincingly shows that climate change will present a major burden to respiratory disease patients, gaps in knowledge remain. More research is still needed to fully map the burden of climate change on respiratory diseases under different global warming scenarios, as well as to understand underlying biological mechanisms and identify pathways of adaptation that may be translated into public health policies [82]. For example, several environmental exposures related to climate change and of relevance for respiratory and allergic diseases are associated with altered DNA methylation levels [60]. Thus, there is a promising potential in the use of epigenetic signatures and omics profiles to detect and monitor the biological effects of climate change and to explore disease mechanisms. Furthermore, evidence on the interaction between climate change and other environmental hazards (*i.e.* air pollution, aeroallergens), and susceptibility need to be advanced. Most importantly, we need research on solutions – which actions work and what needs to be done to implement such actions in society. Addressing these gaps will require interdisciplinary collaboration between clinicians, epidemiologists, climate change experts, meteorologists, air pollution exposure and allergen experts, statisticians/data scientists, omics experts, urban planners, and social and political scientists, and will require new data resources and a mix of old and novel approaches. Novel thinking, such as the increased role of clinicians and health experts in the shaping of our cities and infrastructure, for example, could be an example of a way forward. There is a role here for Europe's new Health Emergency Response Authority to support such research, and forecast and assess future climate-related health threats.

Conclusion

Climate change represents a major threat to respiratory patients, through many different direct and indirect pathways, including the increase in temperature and related increase in ozone exposure, prolonged aeroallergen seasons and introduction of aeroallergens to new areas, and increased frequency of extreme weather events such as heatwaves, droughts, wildfires, wind and dust storms, heavy rainfall and flooding. Indirect effects include stress on society due to migration, conflicts, and economic burdens with adverse consequences for healthcare systems, ecosystems, and education. The ERS recognises the scale of the climate change impact on the planet and human health, which is now irreversible, and calls for urgent action and full support of climate change and air pollution reduction policies. Concerning the ongoing Ambient Air Quality Directive revision, the ERS endorses full alignment of new air pollution limit values with the latest WHO Air Quality Guidelines, which would help significantly in mitigating climate change by phasing out greenhouse gas emissions as soon as possible. Zero emission policies should be at the heart of climate change mitigation strategies, as these would bring major co-benefits *via* reductions in air pollution levels, leading to immediate improvements in lung health and prevention of new respiratory

diseases. Finally, the ERS calls on physicians and other health professionals around the world to serve as “role models” and unite in this huge endeavour to advocate for the protection of our planet and for the health of people that live and depend on it. We have reached a point of no return. As the recent extreme weather events have shown, we need to prepare our community for a much more complex future adapting to the ever-increasing impact of climate-related respiratory disease.

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Who we are: The European Respiratory Society (ERS) is an international medical organisation that brings together physicians, nurses, other healthcare professionals, epidemiologists, patient representatives, scientists and other experts working in respiratory medicine. We are one of the leading medical organisations in the respiratory field, with a growing membership from over 160 countries. Our mission is to promote lung health and alleviate suffering from respiratory diseases and drive standards for respiratory medicine globally. Science, education and advocacy are at the core of everything we do. The ERS itself has the responsibility to adopt internal strategies to severely reduce its carbon footprint before 2030 and become a carbon-neutral organisation before 2050 and is currently developing its internal sustainability policy.

Conflict of interest: A.M. Vicedo-Cabrera, F. Forastiere, U. Gehring, A. Yorgancioglu, C.S. Ulrik and B. Hoffmann have no conflict of interest to declare. E. Melén has received consulting fees from ALK, AstraZeneca, Novartis and Sanofi outside the submitted work, and is a member of the ERS Environmental Health Committee. K. Katsouyanni declares projects funded from the Health Effects Institute, US, and from the European Commission under the Horizon 2020 Programme, which have sponsored travel for meetings or conferences, and she is a member of the ERS Environment and Health Committee and Committee on the Health Effects from Air Pollution (CIMEAP), UK Health Security Agency. K. Hansen has received support for attending meetings and/or travel from the ERS, European Lung Foundation, and eurILDreg and RARE-ILD project and he declares leadership or fiduciary role in eurILDreg and RARE-ILD project. P. Powell is an employee of the European Lung Foundation. B. Ward is an employee of the European Respiratory Society. Z.J. Andersen is Chair of the ERS Environment and Health Committee, and recipient of a grant from the Health Effects Institute, US, which has sponsored travel to a meeting.

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