

## **The war in Ukraine is an environmental catastrophe**

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*Article submitted 9 November 2022. Final version accepted 10 November 2022.*

There is an aspect of the war in Ukraine that is little known – a form of "collateral damage" that will be with us for many years to come – the devastating impact on the environment. It is certainly less dramatic than the death and destruction we are witnessing, but it has important consequences that need to be recognised and addressed, and all efforts should be made to prevent them. For example, since the beginning of the war there has been a significant increase in greenhouse gases produced (military armies release as much carbon dioxide as do whole nations), while the clashes that have occurred near the Chernobyl and Zaporizhian nuclear power plants (the largest in Europe) are raising serious concerns about the possibility of radioactive leaks.<sup>1-4</sup> Our apprehension also relates to the contamination of groundwater and the resulting damage to plants and animals grazing in those areas. Water availability and quality are affected by the destruction of infrastructure and release of toxic products that can reach rivers, lakes and the sea.<sup>5</sup> Bombing and the digging of tunnels and trenches also negatively impact on soil degradation and formation processes by changing its constituent components. Ukraine, which is the breadbasket of Europe, risks having its productive capabilities degraded, with deep economic and social repercussions.<sup>6-10</sup> In addition, The current severe deforestation brought on by bombings and fires will have detrimental effects on the ecosystem's capacity to maintain equilibrium and protect itself against climate change and air pollution.<sup>11,12</sup> A recent survey estimated that one-third of Ukraine's agroecosystem was already unaffordable, with difficulties in the supply of corn, wheat, sunflower oil and fertilizer (and the situation has further deteriorated). According to the World Bank, one-third of the world's most fertile land (the Chernozem soil) is in Ukraine, 68 percent of which is successfully plowable. This is why, in the opinion of many international experts, the current conflict may trigger the largest global food crisis since World War II.<sup>13</sup>

Another major environmental and health factor of concern is air pollution. The use of conventional weapons and the fires caused by the fighting is leading to high levels of air pollutants in the form of particulate matter (PM), toxic gases and heavy metals. Explosions and the collapse of buildings, along with the digging of tunnels and trenches, generates a huge uptick in PMs. The health impact of air pollution, especially in the case of acute exposure, is well known. In a war zone, air pollution is likely to result in more deaths than bombs.<sup>3</sup> Short-term exposure to air pollution has been associated with an increased risk of hospitalisation and death. In a recent study on hospital admissions in Poland (which is comparable to Ukraine due to geographical proximity), the relative risks of cardiovascular and respiratory hospitalisations due to a 10  $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{10}$  (PM

of 10  $\mu\text{m}$  in diameter) are respectively 1.0077 (95% confidence interval [CI] 1.0062–1.0092) and 1.0218 (95% CI 1.0182–1.0253).<sup>14</sup> For a 10  $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$  (PM of 2.5  $\mu\text{m}$  in diameter), the risks of cardiovascular and respiratory hospitalisations are respectively 1.0088 (95% CI 1.0072–1.0103) and 1.0289 (95% CI 1.0244–1.033).<sup>14</sup> Although these are worrying estimates at the population level, they are likely to be underestimated. Underestimation is often a result of misclassification of the degree of exposure and the effects. The Copernicus programme has estimated that for natural wildfires, the level of  $\text{PM}_{2.5}$  can reach 500  $\mu\text{g}/\text{m}^3$ .<sup>15</sup> Similar elevated levels are also observed during military action. These are extreme concentrations (the WHO air quality 24-hour mean standard is 15  $\mu\text{g}/\text{m}^3$ ) and due to the exposure-response relationship, the relative risk of hospitalisation and other health outcome increases with growing concentrations. This does not take into account the fact that during the war in Ukraine the population is being exposed to other sources of air pollution, and thus, to multipollution.<sup>16</sup>

The impact of air pollution on health is also underestimated because, particularly in the case of  $\text{PM}_{2.5}$ , exposure to air pollution is associated with relapses of diseases other than cardiopulmonary, including disorders of the digestive, musculoskeletal, and genitourinary systems and cancer. For a more appropriate estimate of the overall risk, all sources of air pollution and all the linked diseases need to be considered. The psychosocial modifiers of the response to stress must also be taken into consideration. Indeed, a link between stress and immune dysfunction was observed among Gulf War veterans.<sup>17</sup> People suffering from post-traumatic stress experience chronic systemic inflammation and do not respond well to environmental catastrophes such as exposure to air pollutants. The risk estimates highlighted above and the exposure-response relationships should motivate politicians to adopt public health protection measures to counteract air pollution in Ukraine.

The environmental damage caused by the war in Ukraine will persist for many years. Even if the war were to magically end today, it will take decades to recover from the negative impact on climate change, soil degradation and biodiversity loss (Ukraine accounts for 35% of the biodiversity of the entire European continent), and significant effort will be required to restore the ecosystem put under such severe strain.<sup>4</sup> In addition, explosions and the heavy traffic of military vehicles result in the secondary emission of highly toxic substances into the air (including organic pollutants, polycyclic aromatic hydrocarbons, dioxin, carbon monoxide, polychlorinated biphenyls), some of which are persistent organic pollutants. Finally, it is expected that the long-term effects of air

pollution will lead to increased incidence of inflammatory chronic diseases.<sup>1,4</sup> The attacks against fuel and gasoline storage depots in Ukraine will have caused high peaks in air pollution. And, although the European Commission's plan, "REPowerEU," envisages a concerted action by EU countries to obtain affordable, safe and sustainable energy to expedite the green transition, the United Nations have pointed out how the energy crisis triggered by the war has resulted in a strong drive to use fossil fuels.<sup>18,19</sup> The direct and indirect health impacts of war are enormous, particularly in at-risk populations such as pregnant women, children, the elderly, the sick, and people from lower social classes, migrants and refugees who are most exposed to environmental hazards. All of these groups must be protected. In general, violent conflicts have multiple, long- and short-term impacts on physical, economic and social capital, and development, and thus on human health.<sup>20,21</sup>

In conclusion, the environmental devastation caused by the war in Ukraine will have dramatic effects on pollution levels in air, water and on land – and on the entire ecosystem and biodiversity – far beyond our current ability to anticipate or prevent. The resulting risks to human health will need to be addressed with careful European and international policies to secure the future of Ukraine and the surrounding countries.

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