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Letter to the Editor

## The urgency of a Circular healthcare economy amidst geopolitical turbulence; strategies in the fight against raw materials and energy scarcity

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Dear Editor,

Raw materials and energy are crucial to society. The rapid increase in global consumption is leading to imminent shortages of critical raw materials (CRMs) and energy and wars seem to be triggered by this resource scarcity. Since 1800, the world population has surged from 1 billion to a projected 8.73–10.82 billion by 2050 (Sands, R. D., & Sut-tles). This exponential growth is mirrored by the rising consumption of fossil fuels, minerals and energy. As a result, global waste generation is expected to grow by approximately 70 % by 2050 (Plan, 2020; Kaza et al., 2018).

Meanwhile, the prices of virgin raw materials have risen sharply since the early 2000s (Haar, 2024), reflecting both increasing demand and limited supply. The growing need for critical raw materials and energy is likely to reach unsustainable levels, posing risks to global stability and contributing significantly to greenhouse gas emissions.

The COVID-19 pandemic illustrated the vulnerabilities of our current system, with life-threatening shortages of face masks and personal protective equipment (PPE) in hospitals worldwide (De Man et al., 2020). This crisis highlighted the urgent need for more resilient, circular supply chains that reduce dependence on virgin resources and improve preparedness for future disruptions.

The European Commission has established a list of CRMs essential to the EU economy. These materials are characterized by their high economic importance and the significant risks if supply gets disrupted (European Commission, 2024). Growing geopolitical instability—manifested through trade barriers, territorial claims, and even military invasions targeting countries rich in valuable resources—has exposed the vulnerability of global supply chains. These CRMs are essential for microchip production, the energy transition, robotics, and the defense industry (Timon Bohn et al., 2023).

Healthcare, one of the largest waste-producing sectors globally, is facing a dramatic rise in waste generation (Thakur V & Ramesh, 2025). Much of this waste is incinerated, despite that they contain valuable materials, even when contaminated, with clear potential for urban mining – mining valuable materials from discarded products, buildings,

or waste streams, rather than extracting virgin resources from the earth through traditional geological mining (Van Straten, Bruins, Horeman, 2025) – and circular reuse, as we previously demonstrated (Van Straten, Horeman et al., 2021). These studies show the feasibility of reusing and recycling polypropylene based waste streams such as blue wrap, gowns, face masks as well as stainless steel waste such as discarded instruments.

In the growing geopolitical unrest, policymakers, healthcare institutions, and industry leaders therefore, must take immediate action to develop and implement circular strategies that will secure resource availability, minimize environmental impact, and support a more sustainable and resilient future, by using methods such as:

**1. Policymaking and International Collaboration:** Policymakers must prioritize the development of infrastructure that supports recycling and reprocessing, while streamlining permitting procedures to accelerate the implementation of circular initiatives with supporting legislation and increasing the number of permits to recycle. Promoting reuse, remanufacturing, and recycling of waste streams to reduce environmental impact and strategic dependency on other countries.

**2. Building energy grid independent local power stations:** Governmental support and attention is needed for developing energy grid-independent local power stations that harvest renewable energy from sources like wind turbines, solar panels, or kinetic energy systems. These modular stations store energy in integrated battery packs, enabling stable, off-grid power to use in the transition toward a circular economy.

**3. Designing Circular Products and Processes:** Circular design principles must be integrated at the early stages of product development. By considering material selection, using recycled materials, increase product lifetime, design for modularity, repairability and recyclability, designers and engineers can contribute to more durable, repairable, and recyclable medical technologies.

**4. Implementing Circular Strategies in Healthcare:** Hospitals as well as companies play a crucial role in the transition toward a circular healthcare economy. Emphasizing strategies such as reduce, reuse, refurbishment, recycling in procurement, healthcare institutions can

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significantly lower operational costs, reduce environmental impact, and enhance sustainability performance.

**5. Acknowledging Urban Mining as a Resource Strategy:** The recovery of valuable materials from waste—especially medical and hospital waste—offers a promising opportunity to reduce raw material dependency. Urban hospital mining, the mining of valuable materials from hospital waste, should be encouraged to strengthen supply chains by unlocking secondary resources that are currently underutilized.

**6. Building Interdisciplinary Green Teams:** (Voudrias, 2018) The creation of dedicated “Green Teams” within healthcare organizations enables cross-functional collaboration. These teams can drive circular innovations, ensure the integration of sustainability targets, and foster a culture of continuous improvement in collaboration with the medical industry.

These methods require coordinated action at multiple levels within society. Policymakers could take the lead in proposing legal and infrastructural foundations with streamlined permitting procedures for recycling facilities, incentivizing the recovery of valuable materials through urban mining, and integrating circular economy principles into national healthcare strategies. Hospitals and healthcare systems can implement circular strategies by setting up green teams that drive awareness, track waste reduction, and pilot re-use initiatives. In the Netherlands, hospitals such as Leiden University Medical Center (Van Nieuwenhuizen, et al., 2024), Erasmus MC, Amsterdam UMC and OLVG are examples that focus on such methods.

The medical industry has a crucial role in designing and manufacturing circular products, such as instruments or devices made from recycled materials, while also ensuring they can be disassembled and recycled again at end-of-life such as conducted in the GreenCycl FieldLab where disposed bluewrap is reprocessed into raw material and new products (Van Straten...Horeman et al., 2021), valuable components and rare Earths are recovered from complex surgical instruments such as staplers, cardiac catheters and vessel sealers with the aim to reuse or remanufacture. Meanwhile, local authorities and hospital consortia can pioneer energy grid-independent power stations, reducing reliance on fossil fuels and securing resilience against energy disruptions.

With growing global tensions, trade restrictions, territorial claims, military and tariff threats, the access to raw materials and energy through local, circular strategies is no longer a choice—it is a necessity. Urban mining hospital waste, hazardous and non-hazardous, combined with advanced waste separation at the source, thermally disinfected at 90 degrees Celsius after collection, and reprocessed for reuse and recycling not only reduces environmental footprint (Van Straten et al., 2021b), the negative risks of disposed medical hazardous waste (Janik-Karpinska, 2023) but can also become economically superior to virgin mining. The world relies on only a few mining locations and just a few countries who dominate the world production. Given the scarcity of

resources, the need for geopolitical resilience, and the urgency of reducing both waste streams and CO<sub>2</sub> emissions, a transitioning toward a circular economy is imperative and needed. Therefore, policymakers, hospitals, universities, and the medical industry need to be urged to take action and build a circular (healthcare) system where all waste becomes the foundation for new resources.

## Declaration of competing interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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