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COVID-19: Implications for plastic reduction, with a focus on Personal Protective Equipment (PPE)

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ABSTRACT

With over 190 million cases reported and nearly 4.1 million deaths worldwide, COVID19 has been the center of global attention. This pandemic has changed many aspects of daily life and has, perhaps, indelibly changed the way we live and it is quite likely that there will be no full return to normality. Owing to its impacts across all societal aspects – from micro- and macroeconomics, information management and research, education, to governance, mental health and even territorial integrity and cohesion – the global ecosystem upon which modern society has evolved will have to be redesigned. Many have, indeed, pointed out that the economy will have to be restructured and growth will have to be defined as prosperity – not continuous growth. Perhaps nowhere is this more evident than in the environment

Dear Editor,

With over 190 million cases reported and nearly 4.1 million deaths worldwide (WHO 2021), COVID-19 has been the center of global attention. This pandemic has changed many aspects of daily life and has, perhaps, indelibly changed the way we live and it is quite likely that there will be no full return to normality. Owing to its impacts across all societal aspects – from micro- and macroeconomics (Atkeson, 2020; McKibbin and Fernando, 2020), information management and research (Dwivedi et al., 2020), education (Azevedo et al., 2020), to governance (Janssen and van der Voort, 2020), mental health (Kumar and Nayyar, 2021) and even territorial integrity and cohesion (OECD 2020) – the global ecosystem upon which modern society has evolved will have to be redesigned. Many have, indeed, pointed out that the economy will have to be re-structured and growth will have to be defined as prosperity – not continuous growth (da Costa et al., 2020). Perhaps nowhere is this more evident than in the environment.

From isolated municipal regulations, in the early 2000's, to the United Nations "war on plastics", the issue of plastic pollution, particularly in the ocean, gained momentum due to intensive public awareness and engagement, propelling its rise in governments' agendas (da Costa, 2021). The COVID-19 pandemic, however, disrupted this impetus, largely owing to the need and subsequent overflow of personal protective equipment (PPE) and the concomitantly generated medical waste (You et al., 2020). Moreover, confinements observed globally – voluntary or mandatory – led to a marked increase in online shopping. As a result, so has packaging plastic waste increased, especially for healthcare products and in the e-commerce sectors. Though no extensive and global data on this aspect exist, estimates describe an increased

revenue of up to 16% by the e-commerce sector above business-as-usual levels between March and September 2020 (EEA 2021). This had subsequent effects on parcel packaging and delivery services, which witnessed an all-time high in 2020, with the Deutsche Post DHL Group reporting an overall increase of nearly 15% compared with the previous year, corresponding to a total of approximately 1,8.10⁹ parcels in Germany alone (DHL 2019). In the food sector, the generation of plastic waste is perhaps more challenging to estimate: from March to August 2020, the turnover of the sector, which had observed a steady growth of 25% since 2015, was reduced by 45% compared with business-as-usual levels (EEA 2021). And, while consumption of on-the-go food and drinks likely decreased owing to the general implementation of telework and school closures observed, many restaurants shifted to take-away meals or even developing home delivery business models, which may have resulted in an increased use of single-use packaging. Presently, there are no reliable data detailing the general trends on the use of single-use plastic packaging by the food services industry during the COVID-19 pandemic, making impossible to accurately evaluate the *de facto* environmental impacts that may have been propelled by this sector.

Initial reports also point towards significant alterations in waste generation dynamics, with associated higher risks to sanitation workers and increased uncertainties for policymakers (H.B. Sharma et al., 2020). Whether infected or not, different types of hazardous medical waste, including gloves, masks, disinfectant containers and other PPE, are continuously generated and may potentially contaminate the general municipal solid waste, including in the form of microplastics, particularly microfibers released from disposable facemasks (Fadare and Okoffo, 2020; Saliu et al., 2021), inherently carrying a risk of transmission

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(da Costa et al., 2020). Again, exact values are not known, and conflicting estimates have been put forth. For example, Benson et al. (Benson et al., 2021) have suggested an average use of 3.38 billion masks worldwide on a daily basis, though, surprisingly, nearly 2 billion were suggested to be used and discarded in Asia alone. Moreover, some simplifications on their estimations render the reported values highly doubtful, such as assuming little variation on the overall acceptance rate by different populations (70–80%), a usage averaging one mask per day and that all of these were single-use masks. Other estimates point to nearly 130 billion face masks and 65 billion gloves now used globally every month (Vasil, 2020). Perhaps a better proxy is to consider the increases reported on facemask production, and China alone increased its facemask production from January to February to 110 million units, representing an increase of 450% (Bown, 2020). Drawing from these production values and estimates put forth by the World Wide Fund for Nature (WWF), da Costa and colleagues estimated the need for 7.4 and 3.7 billion units of masks and gloves, respectively, needed on a monthly basis for the European population alone (da Costa et al., 2020). As such, either as a direct or indirect result of the Global pandemic, some researchers have guesstimated an overall increase varying between 250 and 300% in single-use plastics when compared to pre-pandemic times (Knowles, 2020).

Fighting the pandemic has taken precedence over nearly all other policies and initiatives, and measures for combating plastic pollution are no different. In many cases, policies or regulatory instruments have been halted (da Costa, 2021), stemming from a renewed hierarchization of priorities. Environmentally, however, this hierarchal shift paradigm will likely significantly impact and compromise the integrity of ecosystems. As reported, plastic producers have seized this opportunity to extol the benefits of single-use plastics (Hale and Song, 2020), gravely jeopardizing any remaining chance of firmly addressing the issue of plastic pollution, which remains one of the greatest challenges of our age.

The road ahead

The COVID-19 pandemic has taught us that we should prepare now for potential disruptive events in an uncertain future, which should encompass addressing the environmental and climate impacts of the responses to this pandemic, such as the impacts generated from PPE and packaging. Scientists and policy-makers should be at the forefront of this preparedness, and, whilst precaution should guide both research and policy-making, alarmist approaches should be fiercely discouraged. For example, Enyoh and colleagues (Enyoh et al., 2020) have put forth the suggestion that SARS-CoV-2 could “be accommodated in formed viral biofilms on microplastics surfaces and can thus be deposited over longer distances”, without any evidence supporting this claim. Not only did the authors ignore the processes that lead to the presence of microplastics in environmental matrices, they also supported this hypothesis by stating that some bacteria (*Vibrio* spp.) have been described to form biofilms on the surface of microplastics (Keszy et al., 2021). Yet, only some virus have been shown to be able to form biofilms (Thoulouze and Alcover, 2011), and there is no evidence that respiratory viruses can form such a structure, although some have been demonstrated to contribute to the formation of bacterial biofilms (e.g., (Hendricks et al., 2016)). Such unsupported claims have also been made by other authors, as well (Prata et al., 2020). The exposure to the elements, that could actively contribute towards the inactivation or elimination of any putative presence of SARS-CoV-2 is also ignored, although these factors are considered by other researchers (Moresco et al., 2021). Yet, again, it is assumed that some bacteria “could” produce exopolymeric substances, that “could” be amenable to the adhesion of – importantly – a sufficient viral load of this virus, in order to counteract the effects of salinity. Potential resistance to UV radiation and temperature by SARS-CoV-2 in environmental microplastics is also suggested, by equivocally equating enteroviruses to respiratory viruses. All of this underlies that, again, while precaution is needed, hypotheses on, namely, the risks of trans-

mission and contagion, particularly within a context of integration and discussion of other policies, such as those aimed at combatting plastic pollution, should be based on experimental data and observations, not speculations. And, whilst generalist calls for “more research” are certainly welcomed, whether centered in calls for “rethinking” waste management (e.g., (Kalina and Tilley, 2020)), the search for alternatives to plastics (e.g., (Sarkodie and Owusu, 2021)), or just, simply put, “more research on plastics” (Patrício Silva et al., 2020), it is necessary not only to identify the key knowledge gaps, but also to put forth specific strategies and actions that may successfully accomplish these goals. Broadly, this should be reached through a four-pronged strategy, as summarized in Fig. 1, and it is quite probable that, barring the execution of all, the overarching goals could not be achieved.

From a research perspective, biodegradable, bio-based or bioplastics have been described as the most innovative solution to plastic pollution; yet, these materials, whose description is often used interchangeably but that refer to different materials and/or characteristics (da Costa et al., 2020), are still lacking in thorough determinations of their suitability, at a large scale, in areas such as food packaging, and certainly as ingredients in PPE, as well as in subsequent environmental impacts. The production costs of true biodegradable bioplastics, such as polyhydroxyalkanoates (Pratt et al., 2019), remain, however, prohibitively high, and, therefore, new production routes – as biotechnological-based strategies – should be further looked into. Obtaining new materials will not be sufficient, as, frequently, new packaging also involves reimagined product designs, which, ideally, are considered throughout all of the product’s life cycle, including at their recycling stage. Presently, recycling remains the destination of only a fragment of all generated plastic waste (EPC 2020), though a conscious product design – contrary to those observed in, for example, numerous coffee pods – may actively contribute in significantly increasing this fraction. Specifically regarding PPE, initial research was centered on their protective role, but, following that assessment, it is mandatory to determine their potential environmental impact. In an attempt to minimize said impacts, multiple calls for their reuse, through sterilization, for example, have been made (e.g., (Vanapalli et al., 2021)), noting the efficacy of methods such as steam-, radio-wave- and microwave-based sterilization procedures, as well as chemical disinfection. In locations where this is not possible, incineration and deep burial have been suggested (H.B. Sharma et al., 2020). However, less conventional potential solutions were recently proposed, as repurposing used PPE, namely, facemasks, for pavements base/subbase (Saberian et al., 2021). Yet, feasibility studies still need to be conducted, but this offers a creative solution to an emerging and, quite likely, enduring issue.

Commercial and environmental monitoring will also be key. Only by knowing exactly the volumes of plastic generated and their networked distribution will it be possible to devise models that accurately depict the prevalence of these materials, both at their source and destinations. These will also facilitate research and guide future policy options (EEA 2021).

From a legislative and regulatory approach, many suggestions have already been made (da Costa et al., 2020; da Costa, 2021). Nevertheless, perhaps the most promising approaches may be those not voluntary in nature, but rather those based on a “stick and carrot”, rewarding those – consumers, producers and suppliers – contributing towards a zero-waste strategy, while highly punitive actions, that strongly discourage reoffences, should be developed and implemented. This should include establishing reduction targets, while simultaneously supporting alternatives to retailers and should be accompanied by ring-fenced revenues originating from fines and levies for activities – from research, to policy, industrial or even citizen levels – developed towards the mitigation of plastic waste and associated impacts. Strengthening the infrastructures for the collection, separation and processing of plastic waste, including in rural areas, should also be prioritized. Policy-wise, all of the suggested strategies will be of little value, however, if not adequately monitored and the existing policies enforced; therefore, such a regulatory body,

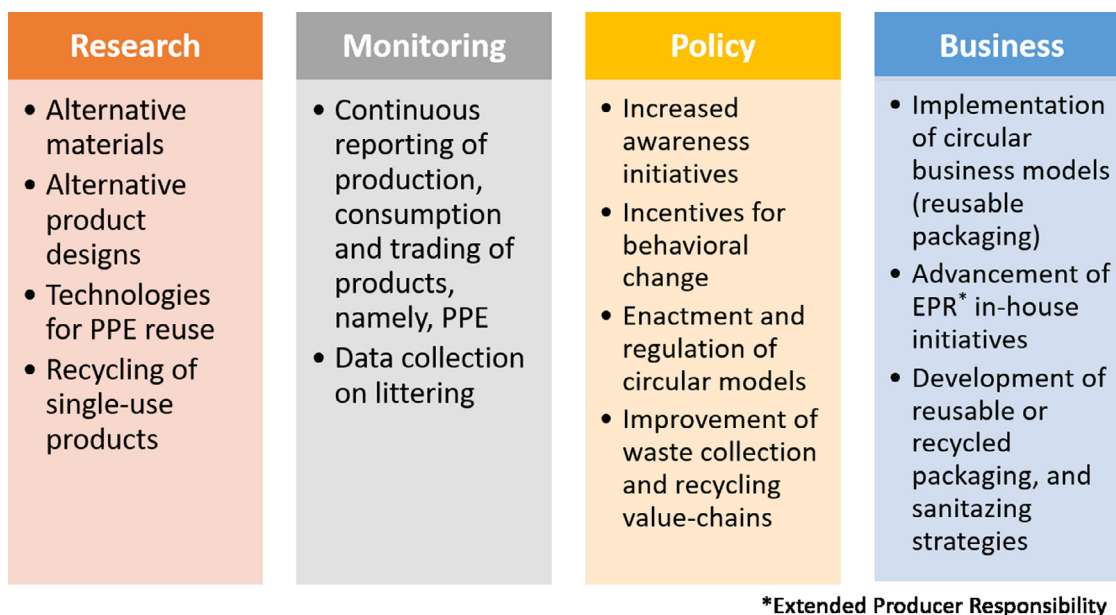


Fig. 1. Suggested approaches for addressing environmental and climate impacts on the extended use of PPE, and on the general use of plastics. Strategies should include all of the identified key areas.

that may act at national or supra-national levels, independently, should be envisioned.

At a business level, circular economy models are considered the main pillars towards plastic waste reduction, grounded on enhanced or improved recycling but, perhaps more importantly, in reusable packaging. This is a critical part of the solution to eliminate plastic pollution and may be achieved at multiple levels, ranging from “refill at home” (users refill reusable containers at home), “refill on the go” (users refill reusable containers away from home, such as stores), “return from home” (packaging is picked up from home), “return on the go” (users return packaging at a drop-off point) or “business to business”, such as supply chain packaging-as-a-service (ELM 2019). The benefits of such an approach are not restricted to reduced generation of plastic waste: based on a study conducted by Circular Economy Portugal, the Rethink Plastic Alliance estimated that, based on a 20% target of reusable packaging, by as early as 2027, 1.3 million tons CO₂-equivalent, 3.5 billion cubic meters of water and 10 million tons of raw materials could be saved, in addition to the inherent economic advantages, which would benefit both producers and consumers (RethinkPlastic 2021).

Lastly, EPR’s, or extended producer’s responsibilities, are policies under which those responsible for generating waste (producers) are given a significant responsibility, either at the financial or physical levels, or both, over the treatment or disposal of post-consumer products. Though the pandemic seems to have resulted in a shift of the focus of legislators away from previous efforts to advance these policies, supporters of EPR schemes assume that the pandemic could have had a positive effect, by raising public awareness for the importance of waste and recycling management (Boucher, 2020). And, in fact, the European Union has stated that, in spite of the global pandemic, there are currently no plans for the EU to delay the implementation of the upcoming single-use plastic legislation (da Costa, 2021). Though companies tend to view this as a trade-off under which profits may suffer, thorough implementations could result in significant savings, by, for example, re-incorporating collected materials back into production supply chains, resulting in the development of resource resiliency and, in light of the growing environmental awareness of consumers, customer loyalty.

Hence, though COVID-19 has made bare our general dependency on plastics, and, more precisely, on single-use plastics, including PPE, there is no reason that focused strategies, at multiple levels, will not successfully combat this dependency and, subsequently, minimize the

risks these materials pose to the environment, biota, and, ultimately, human health. But decisive actions will be needed and these should not be delayed any longer.

Declaration of Competing Interest

The authors declare 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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