

## PEER REVIEW HISTORY

BMJ Open publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form (<http://bmjopen.bmj.com/site/about/resources/checklist.pdf>) and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below.

### ARTICLE DETAILS

<b>TITLE (PROVISIONAL)</b>	Which strategy for using medical and community masks? A prospective analysis of their environmental impact.
<b>AUTHORS</b>	Bouchet, Alexandre; Boucher, Julien; Schutzbach, Kevin; Senn, Nicolas; Genton, Blaise; Vernez, David

### VERSION 1 – REVIEW

<b>REVIEWER</b>	Benson, Nsikak Covenant University
<b>REVIEW RETURNED</b>	06-Apr-2021

<b>GENERAL COMMENTS</b>	<p>This manuscript bmjopen-2021-049690 titled “What is the environmental impact of different strategies for the use of medical and community masks?” has been reviewed. The manuscript is generally written in standard, grammatically correct English. The methodology is appropriate with clear explanations of the experimental procedures. The conclusions are adequately supported by data provided in the manuscript. It can be further strengthened by incorporating the following suggestions:</p> <p>Line 32 Page 3. Replace “The use of protective masks...” with “The use of personal protective equipment...”</p> <p>Lines 33 – 34 Page 3. Do the authors have the reference to substantiate this claim “...a majority of them are produced in China and imported to the European market.”? If not rephrase or expunge.</p> <p>Lines 57 – 65 Page 4. Some of the itemized “strengths and limitations” are verbose and should be concise and clearly expressed.</p> <p>Lines 73 – 74 Page 5. The sentence “Positive effects have also been observed ... on river pollution.” requires references. Authors should look at the followings and others:</p> <p>M. Travaglio, Y. Yu, R. Popovic, L. Selley, N.S. Leal, L.M. Martins. Links between air pollution and COVID-19 in England. Environ. Pollut., 268 (2021), p.115859, <a href="https://doi.org/10.1016/j.envpol.2020.115859">https://doi.org/10.1016/j.envpol.2020.115859</a></p> <p>Noor Albayati, Basma Waisi, Mustafa Al-Furaiji, Mohammed Kadhom, Hayder Alalwan, Effect of COVID-19 on air quality and pollution in different countries, Journal of Transport &amp; Health, Volume 21, 2021, 101061, <a href="https://doi.org/10.1016/j.jth.2021.101061">https://doi.org/10.1016/j.jth.2021.101061</a>.</p> <p>Lines 89 – 90 Page 5. This sentence requires references “The consumption of protective equipment and most particularly</p>
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	<p>facemasks has also experienced a sharp increase during the crisis.”          Authors should consider the under listed references for citation:</p> <p>Nsikak U. Benson, David E. Bassey, Thavamani Palanisami, COVID pollution: impact of COVID-19 pandemic on global plastic waste footprint, <i>Heliyon</i>, 7, 2, 2021, e06343, <a href="https://doi.org/10.1016/j.heliyon.2021.e06343">https://doi.org/10.1016/j.heliyon.2021.e06343</a>.</p> <p>Ana L. Patrício Silva, Joana C. Prata, Tony R. Walker, Diana Campos, Armando C. Duarte, Amadeu M.V.M. Soares, Damià Barcelò, Teresa Rocha-Santos, Rethinking and optimising plastic waste management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment, <i>Science of The Total Environment</i>, 742, 2020, 140565, <a href="https://doi.org/10.1016/j.scitotenv.2020.140565">https://doi.org/10.1016/j.scitotenv.2020.140565</a>.</p> <p>Line 96 Page 6. Replace “wide” with “extensive” or “widespread”</p> <p>Line 96 Page 6. Replace “consider” with “understand”</p> <p>Line 98 Page 6. A reference is required for this claim “...the bulk of production comes from Asia...”</p> <p>Line 170 Page 9. Check the font colour of “virus load”</p> <p>Lines 131 - 132 Page 8. What is the ratio of medical masks to community masks and used in this study?</p> <p>In my opinion, the discussion section is robust and clearly expressed. However, I would like to see the authors highlight in a paragraph the environmental implications of the use of medical and community masks in relation to the data presented in this work.</p> <p>I recommend that the manuscript should be accepted for publication subject to minor revision.</p>
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<b>REVIEWER</b>	McGain, Forbes Western Health, Anaesthesia and Intensive Care Medicine
<b>REVIEW RETURNED</b>	27-May-2021

<b>GENERAL COMMENTS</b>	<p>“What is the environmental impact of different strategies for the use of medical and community masks?”</p> <p>This is an interesting life cycle assessment of the environmental impacts of using different medical masks in Switzerland.</p> <p>Major Queries.</p> <ol style="list-style-type: none"> <li>1. What software program was used to actually undertake the LCA? Certainly Ecoinvent is a life cycle inventory (LCI), but it is not in itself possible to undertake an LCA by Ecoinvent alone. One requires SimaPro, Gabi, an open access site, or some other software program to undertake an LCA.</li> <li>2. It would be useful to have a figure/diagram that serves as a system boundary.</li> <li>3. There are no uncertainty analyses, and thus no CIs for the figures. These require the use of software programs to run Monte Carlo simulations. It would be ideal to have such CIs, but if the authors are unable to do this, it’s best to have this mentioned in the Discussion as a study limitation.</li> </ol>
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	<p>4. Although the Discussion does make mention of the differing efficacy of surgical masks versus community masks there is no note anywhere of the use of community masks in other settings, e.g. in hospitals. If improved versions of licenced community masks that are as effective as surgical masks were available this would make them attractive to healthcare workers. Please consider in light of potentially challenging infection prevention protocols also.</p> <p>5. How can these LCA results influence choice of masks now? Does a 20% reduction in efficacy in community masks versus surgical masks (from Neupane (ref. 29)), but better environmental outcomes mean that many of us will change practice?</p> <p>Minor Queries.</p> <p>1. The Introduction could be truncated, particularly the first 10 lines.</p> <p>2. Please explain plastic leakage further with an included reference. This is not part of routine LCA environmental impacts list (eutrophication, greenhouse gases, air pollution, etc.).</p> <p>3. Please make very clear initially that this LCA does not relate to N95/P2 masks.</p> <p>4. Page 8/26. 1,24.105 tons, including 0,66,105 tons. There are a few instances of the ‘,’ (français style) being used in lieu of ‘.’ (english style). I assume you mean 1.24 x 10<sup>5</sup> tonnes? I would simply write out the total amount, rather than use scientific notation.</p> <p>5. Best to introduce the UBP term = umweltbelastungspunkte earlier on.</p> <p>6. Some discussion about why there may be a difference between the Swiss and French standards for the effects?</p>
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<b>REVIEWER</b>	Paszkiewicz, Peter Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA), Central Division
<b>REVIEW RETURNED</b>	30-May-2021

<b>GENERAL COMMENTS</b>	<p>I have some questions and comments for clarification:</p> <p>64: what are regular European masks? Approved and CE-marked? How can an undefined community mask be regular?</p> <p>138: Directive 93/42/EEC has been replaced by Regulation (EU) 2017/745</p> <p>139: Why are medical masks constituted of 3 different layers? Where is this requirement from? EN 14683 does not make this design restriction;</p> <p>209-212: How does the calculation of the environmental impact assessment consider the number of masks washed in a washing machine or heated in an oven</p> <p>Fig.3: only 7 of 8 curves are presented</p> <p>290/291: one word is too much “by or for”</p> <p>I am missing a perspective for a material improvement: Isn't it worth to consider a recommendation for the development of compostable and reusable masks?</p>
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## VERSION 1 – AUTHOR RESPONSE

Reviewer: 1

7.Line 32 Page 3. Replace “The use of protective masks...” with “The use of personal protective equipment...”

Ok, corrected

8.Lines 33 – 34 Page 3. Do the authors have the reference to substantiate this claim “...a majority of them are produced in China and imported to the European market.”? If not rephrase or expunge.

A reference to the EU statistics website has been added. The arrival of the pandemic has caused a dramatic increase in the importation of masks from China. In spring 2020, 92% of face masks imported into Europe were of Chinese origin.

9.Lines 57 – 65 Page 4. Some of the itemized “strengths and limitations” are verbose and should be concise and clearly expressed.

The strength and limitation section has been modified and rephrased

10.Lines 73 – 74 Page 5. The sentence “Positive effects have also been observed ... on river pollution.” requires references. Authors should look at the followings and others:

Right, it was missing. A reference specific for river pollution has been added.

11.Lines 89 – 90 Page 5. This sentence requires references “The consumption of protective equipment and most particularly facemasks has also experienced a sharp increase during the crisis.” Authors should consider the under listed references for citation:

- Nsikak U. Benson, David E. Bassegy, Thavamani Palanisami, COVID pollution: impact of COVID-19 pandemic on global plastic waste footprint, Heliyon, 7, 2, 2021, e06343, <https://doi.org/10.1016/j.heliyon.2021.e06343>.
- Ana L. Patrício Silva, Joana C. Prata, Tony R. Walker, Diana Campos, Armando C. Duarte, Amadeu M.V.M. Soares, Damià Barcelò, Teresa Rocha-Santos, Rethinking and optimising plastic waste management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment, Science of The Total Environment, 742, 2020, 140565, <https://doi.org/10.1016/j.scitotenv.2020.140565>.

The first reference has been added, a more recent reference from Silva (2021) has been added for the second.

12.Line 96 Page 6. Replace “wide” with “extensive” or “widespread”

Done

13.Line 96 Page 6. Replace “consider” with “understand”

“consider” was replaced by “take into account”, as it reflected better our meaning than “understand”

14.Line 98 Page 6. A reference is required for this claim “...the bulk of production comes from Asia...”

The same reference as for question 8 has been added

15.Line 170 Page 9. Check the font colour of “virus load”

Thanks, it is corrected

16.Lines 131 - 132 Page 8. What is the ratio of medical masks to community masks and used in this study?

Community mask and medical masks are considered in distinct use and re-use scenarios. Scenarios are then compared per functional units (one functional unit being the quantity necessary to equip one person with a mask during a month). There is no hypothesis on the proportions of use between community and medical masks.

17.In my opinion, the discussion section is robust and clearly expressed. However, I would like to see the authors highlight in a paragraph the environmental implications of the use of medical and community masks in relation to the data presented in this work.

The discussion has been improved (see Q3). Elements have been added to emphasize the significance of the results

**Reviewer: 2**

18. What software program was used to actually undertake the LCA? Certainly Ecoinvent is a life cycle inventory (LCI), but it is not in itself possible to undertake an LCA by Ecoinvent alone. One requires SimaPro, Gabi, an open access site, or some other software program to undertake an LCA.

We used a proprietary tool developed in EA (environmental action). So we added the following sentence. “A proprietary excel tool developed by the authors was used to perform the LCA based on Ecoinvent datasets.”

19. It would be useful to have a figure/diagram that serves as a system boundary.

We added a simple diagram illustrating the life-cycle stages to show that we are taking a cradle to grave approach (figure 1). It represents the system boundary for all scenarios involved in the study.

20. There are no uncertainty analyses, and thus no CIs for the figures. These require the use of software programs to run Monte Carlo simulations. It would be ideal to have such CIs, but if the authors are unable to do this, it's best to have this mentioned in the Discussion as a study limitation.

We did an uncertainty analysis based on low and high values for the littering rate (ranging from 0.2% to 12%, with the medium value being set at 2%), but changes were not significant enough for CO<sub>2</sub> and UBP to update graphs with uncertainty ranges and were too obviously correlated to the littering rate for plastic leakage (not deemed relevant to add a graph for that)

A paragraph was added in the limitation section of the Discussion.

"We performed an uncertainty analysis based on low and high values for the littering rate (ranging from 0.2% to 12%, with the medium value being set at 2%). We have observed that the plastic leakage results would be changing proportionally to the leakage rate factor between the medium value and the low or high value, but that the climate change or UBP impact results would deviate from the medium case by around 1% or below. No other uncertainty analysis was undertaken for this study."

21. Although the Discussion does make mention of the differing efficacy of surgical masks versus community masks there is no note anywhere of the use of community masks in other settings, e.g. in hospitals. If improved versions of licenced community masks that are as effective as surgical masks were available this would make them attractive to healthcare workers. Please consider in light of potentially challenging infection prevention protocols also.

From a technical point of view, you are right. The performance of community masks varies greatly, but some certified masks have attractive aerosol permeation performance. In Switzerland, and I imagine in a good number of European countries, community masks are not allowed in hospitals and care centers. The reason for this is essentially normative, as medical masks are tested on a wide range of parameters according to EN14683 (for a medical use). So we believe that it is difficult to recommend the use of community mask for healthcare worker in the current regulatory and normative context.

22. How can these LCA results influence choice of masks now? Does a 20% reduction in efficacy in community masks versus surgical masks (from Neupane (ref. 29)), but better environmental outcomes mean that many of us will change practice?

Yes, it should in our opinion. First, the relative performance of the filtration media is only one aspect of its performance. Since neither community nor medical mask are airtight, their overall performance is strongly dependent on facial leakage and usage behaviors. Secondly, when used in a community setting, the expected protection shouldn't be more that what you expect from a community mask.

Further comments have been added in the discussion section about the significance of the results and levers to support adoption of the reuse practices we advocate in this paper.

23. The Introduction could be truncated, particularly the first 10 lines.

It has been slightly shortened.

24. Please explain plastic leakage further with an included reference. This is not part of routine LCA environmental impacts list (eutrophication, greenhouse gases, air pollution, etc.).

The following explanation has been added in the method section:

“Leakage is a result of both loss and release and can be simply described by the following equation:

(with Loss rate = mismanaged rate + littering rate )

In the case of Switzerland, the only loss occurring is related to littering since the mismanaged rate is equal to 0%. The littering rate will then be assimilated to the leakage rate as we are here assessing the release rate to all environmental compartments at once.”

25. Please make very clear initially that this LCA does not relate to N95/P2 masks.

We did indeed not refer to respirators when using the term “masks”. A sentence has been added early in the method section to make that clear: *“Filtering facepiece respirators, such as N95 (US) and FFP2 (EU), which are mainly used by healthcare professionals are not considered in this study.”*

26. Page 8/26. 1,24.105 tons, including 0,66,105 tons. There are a few instances of the ‘,’ (français style) being used in lieu of ‘.’ (english style). I assume you mean 1.24 x 105 tonnes? I would simply write out the total amount, rather than use scientific notation.

Right, the notations have been harmonized

27. Best to introduce the UBP term = umweltbelastungspunkte earlier on.

It is now referred to into the abstract, along with the GW100

28. Some discussion about why there may be a difference between the Swiss and French standards for the effects?

Right, it is due to the fact that the number of reuses recommended in the two labels are not the same. An explanation was added in the result section: *“The use of labelled community mask (PES\_1 and PES\_2) has an intermediate environmental impact, the use of AFNOR masks (French label) being more advantageous than the TESTEX mask (Swiss label). The difference between the two is mainly due to the different number of reuses recommended between the two labels.”*

Reviewer: 3

29.64: what are regular European masks? Approved and CE-marked? How can an undefined community mask be regular?

The strength and limitation section has been modified and rephrased.

30.138: Directive 93/42/EEC has been replaced by Regulation (EU) 2017/745

Right, it has been changed

31.139: Why are medical masks constituted of 3 different layers? Where is this requirement from?

EN 14683 does not make this design restriction;

EN14683 mentions that the mask must consist of a filtering layer between two non-woven materials. But it is right, it is not specified that the mask must have three layers. In practice however surgical mask have generally three layers. This is consistent with the description of Chua et al 2020. The sentence has been modified to “Medical masks are usually constituted...”

32.209-212: How does the calculation of the environmental impact assessment consider the number of masks washed in a washing machine or heated in an oven

Two short explanations have been added to explain the computation of the washing machine and oven scenarios.

“We have allocated the energy, water and soap used to wash a mask based on the ratio between the weight of the mask and the total dry load of clothes assumed when running one cycle. These consumptions features have then been scaled up to represent the functional unit chosen for the study.”

“As the oven utilization is exclusively dedicated to sterilizing masks, we had to make an assumption on the number of masks being sterilized at once. We assumed that a batch of 5 masks were sterilized for each oven utilization, hence an energy consumption of 0.069 kWh per mask sterilized.”

33.Fig.3: only 7 of 8 curves are presented

The curves PES\_1 and PES\_2 are overlapping. The following explanation has been added in the result section:

“The curves for scenarios PES\_1 and PES\_2 are overlapping since the composition of EMPA and AFNOR masks has been assumed identical. The only slight difference between these scenarios, although not significant enough to distinguish both curves on the graph, stems from the distinct origins of the masks.”

34.290/291: one word is too much “by or for”

Thanks, it has been corrected

35.I am missing a perspective for a material improvement: Isn't it worth to consider a recommendation for the development of compostable and reusable masks?

This is a good point. We added a comment about this in the discussion, thanks for the suggestion.

### VERSION 2 – REVIEW

<b>REVIEWER</b>	McGain, Forbes Western Health, Anaesthesia and Intensive Care Medicine
<b>REVIEW RETURNED</b>	06-Jul-2021

<b>GENERAL COMMENTS</b>	<p>Dear Researchers,</p> <p>Thank you for your revised manuscript. You have answered my queries.</p> <p>I have only one minor concern, that of the definition of 'leakage' (of plastic) on page 12/50 of the pdf which I don't understand:  <i>Leakage= Waste · Loss rate · Release rate</i> (with Loss rate = mismanaged rate + littering rate ).          Are the '.' a multiplication ('x')? If so, how does this equation make sense?          Is 'Waste' actually waste as a mass (e.g. in kg)?          In my simple approach say we make 1,000 kg of masks ('release rate' or 'waste' mass?) every year, and the loss rate is 1% then that makes 10kg of waste masks per annum. I can't fathom the multiplication of loss rate X release rate.</p>
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## VERSION 2 – AUTHOR RESPONSE

Reviewer: 2

The definition of leakage has been made clearer and justification for the choice of the different rates has been fleshed out in the dedicated section.

The reason why we need a release rate in addition to a loss rate depends on the residual value of items as waste. When the residual value is high enough, it has chances to be picked up from the ground and returned to the waste management system for recycling, thus driving the release rate below 100%. This is usually the case for items made from PET, such as PET bottles, which will be picked up by scavengers or committed citizens after loss (through either littering or mismanagement). However, in the case of COVID masks, the residual value is low and it is assumed that the release rate will be 100%. In this specific case, leakage rate and loss rate are the same.

## VERSION 3 – REVIEW

<b>REVIEWER</b>	McGain, Forbes Western Health, Anaesthesia and Intensive Care Medicine
<b>REVIEW RETURNED</b>	14-Aug-2021
<b>GENERAL COMMENTS</b>	Accept thank you.