TITLE PAGE

Incorporating sustainability into assessment of oral health interventions

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ABSTRACT

Prior to 1966, consumers purchased food items with very little (if any) nutritional labels. Now, nutritional labelling is an integral part of informed consumer choice. This paper advocates for a similar approach for health care related products, using the toothbrush as an example, with the need to quantify and publish data on their clinical efficacy and environmental impact. In this paper, we consider different manufacturing models and measure the environmental impact (carbon footprint) and also the human health impact (disability-adjusted life years or DALYs) for the most commonly used oral health product: the toothbrush.

INTRODUCTION

In this edition of the BDJ we report the attributional life cycle analysis (LCA), performed by our team, on the environmental impact of the toothbrush. We concluded that a plastic manual replaceable head toothbrush and bamboo manual toothbrush performed better than the traditional plastic manual and electric toothbrushes in every environmental impact outcome measure used in this study. In this article we consider the next step, how can this information be used by clinicians and policy makers to make healthcare decisions? If we use toothbrushes as an example, which is the 'best' toothbrush to use? We propose that using the LCA to determine the negative impact on health will provide this information. We suggest the DALY measure (Disability Adjusted Life Year) as an outcome measure for this negative impact on health.

Environment and health

Improving the carbon footprint is a commonly used commitment to meet environmental goals.[1] Unfortunately, it is a misrepresentation of our total impact on the environment, which also includes other environmental measures, such as loss of biodiversity, ecotoxicity, and air pollution. These broader environmental impacts have been linked with deterioration of human health.[2,3] Air pollution continues to worsen, with its detrimental impact on personal health becoming increasingly clear. The LCA methodology generates this additional information; therefore the logical next step is to use this to include the impacts of environmental damage on human health. A way of measuring this impact is by calculating the Human Health burden associated with their production, use and End of Life (EoL) disposal. Debaveye et al. demonstrated how this principle may be used in calculating the Human Health burden of psychiatric treatment.[4]

Disability adjusted life years

The Human Health burden may be expressed in Disability Adjusted Life Years (DALYs). DALYs are the number of years of life lost in a human population due to both morbidity (illness and disability) and mortality (early death).[5] DALYs can be calculated using LCA modelling, using the environmental impact associated with a product's manufacture, use and disposal. Using the data for the four toothbrushes in our original study[6], we calculated the DALYs lost from the act of one individual brushing their teeth over 5 years (the functional unit of that LCA). DALYs were calculated using ReCiPe 2016 Endpoint.[7] All DALYs attributable to the functional unit were summated. As the numbers were low (5 years of toothbrush use equates to just 20 toothbrushes or replaceable heads), the results have been expressed in hours, as seen in Table 1. The results show that an electric toothbrush has the most significant impact on DALYs - a total of 10 DALY hours - which is over 4 times worse than the plastic manual toothbrush. At closer inspection, the majority of the total personal health harm (measured in DALYs) comes from the water consumption used in electricity production.

What is the potential impact of the DALY assessment?

The Cochrane review of electric vs manual toothbrushes highlighted that there is no evidence that any type of toothbrush is superior for caries prevention, although electric toothbrushes showed a 21% better plaque reduction when used for over 3 months.[8] If direct oral health management is largely a constant, the broader environmental impacts associated with each type of brush are the variable. The question that the reader, and in turn society, need to

consider, is whether the marginal reported superiority of the electrical toothbrush is worth the DALY harm caused as part of the production, use and disposal process.

MODELLING AN "IDEAL" TOOTHBRUSH

Taking into consideration the two sides of the scales (DALYs vs environmental degradation) the research team at Trinity College Dublin and UCL decided to model the best possible manual toothbrush. This research decision was also influenced by the recent Greener NHS call for innovative solutions to reduce carbon emissions in health care.[9] The manual toothbrush was chosen, as it was clearly shown in our original study that an electric toothbrush was a long way from being environmentally friendly.

Our analysis started with the standard plastic manual toothbrush from the original LCA, which is manufactured in Switzerland. The functional unit was defined as the manufacture of 28 million manual toothbrushes over a 12 month period. The system boundary is shown in Figure 1. The same LCA methodology as the original toothbrush study was used,[6] following EU Product Environmental Footprint (PEF) guidelines.[10]

To simplify the results, and in keeping with our thoughts above, we focused on two elements: the climate change impact (measured in kg CO2 equivalents, also known as carbon footprint) and the DALY impact (measured in years). The results showed that production of manual plastic toothbrushes in 1 year produced over 2.5million kg CO2E and over 43,000 DALYs. In addition, the analysis showed that the polypropylene plastic toothbrush handle had the greatest contribution to the overall carbon footprint (62%).

We then modelled potential changes to this current practice of toothbrush manufacture, in order to improve both the carbon footprint and DALY impact. The functional unit and location (a factory in Switzerland) were kept consistent in all the models. We investigated the impacts of using different materials for the handle, such as bio-plastic, bamboo, aluminium, and recycled plastic. We also considered the packaging material; using a simple cardboard

box or recycled plastic packaging. The specific manufacturing and disposal scenarios for each model are described in Table 2.

The results for each model are shown in Figure 2. All scenarios considered showed an improvement on the overall carbon footprint compared to the current manufacture of plastic manual toothbrushes, however, the DALY results were variable. Using bioplastic instead of polypropylene for the toothbrush handle yielded unfavourable results, as this only improved the carbon footprint by 6%, but increased the DALY by 4%. Although using a bamboo handle (compared with polypropylene plastic) improved the carbon footprint by 68%, the DALY actually increased by 26%. The most optimum balance between carbon footprint and DALYs were from the model that utilised a plastic recycling scheme (90% and 72% improvements respectively). The details for this model are shown in Figure 3.

In this most balanced model (a plastic recycling scheme), the biggest impact was from the nylon bristles (responsible for 90% of the carbon footprint). In all the models, the DALYs mostly came from water use needed for electricity production (responsible for 50-90% of the total DALY result, depending on the model). This is mostly related to water used to make electricity and power the production phase. We have drawn our water consumption values from the database Ecoinvent v3.6. These were based on estimates of Swiss and Chinese electricity generation, and assume that the generation of electricity generally consumes significant amounts of water (power plants use a steam turbine to generate electricity, which also requires water for cooling). Alternative electricity production, such as solar photovoltaic and wind power electricity production do not consume such large quantities of water.[11]

DISCUSSION

Personal and environmental health impact and toothbrush selection

This research has shown that a toothbrush which comes from recycled plastic is the most environmentally friendly option, and produces the lowest DALY loss. This seems to provide a reasonably good fit to our society's current appetite for single use plastic reduction and a potential market for manufacturers to explore.

Based on our analysis, manufacturers could innovate by focusing on plastic toothbrush recycling schemes. In the winning scenario, the manufacturer would offer a facility to collect used toothbrushes and packaging from consumers, possibly at the point of purchasing e.g. collection bins at retailers. The nylon bristles and any degraded plastic (estimated 10%) would be removed and disposed of. Nylon is not currently recycled but there are no reasonable recyclable alternatives on the market at this time. The remaining plastic could be cleaned, shredded and autoclaved (sterilised). A proportion of degraded, recycled plastic would need to be replaced with NEW polypropylene (we estimated 10% in this study), and this mix could then be used to make new toothbrush handles and packaging. Consumer support is essential in creating a successful return scheme; similarities exist with battery and plastic marker pen collection schemes. This system would also require a ground shift in responsibility for recycling. Currently, there are private companies that offer recycling schemes to consumers, but recycling depot boxes cost upwards of £100. Innovative consideration of costs could lead to flexible costing models, including subscription schemes for consumers and retailers alike. This is an opportunity in-waiting.

Mapping personal and environmental health impact of an oral health intervention

Health interventions often include a number of unquantifiable variables which add a layer of complexity in terms of environmental appraisals. The toothbrush example is a rare one, in that is a fairly straightforward item to model. A purely carbon analysis would have produced entirely different, and incomplete, results. The human impact that this analysis contributed has clearly demonstrated that policy decisions should be made on a balanced consideration of all impacts, and not just carbon.

The authors believe that the evidence should now be used to explore the public's perception, in discussion with manufacturers. This is a necessary next step in order to test the commercial viability of the proposed solution. Armed with a holistic analysis of environmental and human impacts, together with a substantial market/consumer engagement assessment, it can then be presented to policy makers as an evidence-based intervention that can contribute towards more sustainable consumption patterns. This study has shown the importance of not just focussing on environmental harm such as carbon emissions, but also considering other personal health related harm such as DALYs.

Incorporating personal and environmental health impact metrics into guidance

When a local planning authority considers granting a permission for a project which may have significant impact on the environment, they can request an environmental impact assessment as part of the decision making process.

Oral health guidance such as the Scottish Dental Clinical Effectiveness Programme (SDCEP) and the Public Health England (PHE) provide an evidence-based structure to support the implementation of optimal oral health interventions.[12] Increasingly, these recommendations are accompanied by evidence of clinical effectiveness (e.g. reduction in decayed surfaces), or

cost effectiveness. The Cochrane oral health group publishes complimentary reviews of evidence to help support the delivery of effective health care at an individual or population level.[8]

With growing evidence of the potential harm of health care systems and processes, this is a time to debate the need for an environmental impact assessment to accompany evidence based guidelines. If an organisation like the Cochrane Oral Health group recommend a particular intervention (e.g. use of fluoride toothpaste), then we recommend the organisation collate the evidence of an environmental impact assessment and associated human health harm, or if, at the time of writing there is no such information available, recommend one.

This would ensure that, as well as their guidelines being evidence based, they also make financial and environment sense (the so called triple bottom line).

This is particularly relevant in the example used here (toothbrushes) where the evidence does not strongly suggest any intervention is necessarily ‘better’ than any other. The environmental impact analysis might provide sufficient information to recommend one intervention.

CONCLUSION

Prior to 1966, consumers purchased food items with very little (if any) nutritional labels.[13] Now, it forms a major part of health-informed consumer choice. This paper advocates for a similar approach for oral health products, with the need to measure and publish the data on their clinical efficacy and environmental impact using appropriate standardised methodology for common oral health products (e.g toothbrushes) and even professionally-administered oral health interventions (e.g. fluoride varnish application). Discussion should take place as to whether this data should be included in the packaging of manufactured products, or as part of an overall assessment by evidence based guideline groups for oral health interventions.

DECLARATION OF INTERESTS

This study was funded by the Eastman Dental Institute (University College London). The authors declare no conflict of interest.

REFERENCES

1. Sustainable Development Unit. Carbon footprint update for NHS in England 2015 [Internet]. Cambridge: SDU; 2016 [cited 2020 May 26]. 8 p. Available from: https://www.sduhealth.org.uk/policy-strategy/reporting/nhs-carbon-footprint.aspx
2. Wei Y, Wang Y, Di Q, et al. Short term exposure to fine particulate matter and hospital admission risks and costs in the Medicare population: time stratified, case crossover study. BMJ 2019; 367:I6258.
3. Peake BM, Braund R, Tong AYC, Tremblay LA. The life-cycle of pharmaceuticals in the environment. Woodhead Publishing, Elsevier Ltd 2016.

4. Debayeye S, De Soete W, De Meester S, et al. Human health benefits and burdens of a pharmaceutical treatment: discussion of a conceptual integrated approach. Environ Res 2016; 144: 19-31.

5. World Health Organisation. Health statistics and information systems: Disability-adjusted life year (DALY) [Internet]. New York: WHO; 2020. [cited 2020 May 26]. Available from: https://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/

6. Lyne A, Ashley PF, Saget S, et al. Combining evidence based healthcare with environmental sustainability: using the toothbrush as a model. BDJ, accepted 2020.

7. The Netherlands National Institute for Public Helath and the Environment. LCIA: the ReCiPe model [Internet]. 2018 [cited 2020 May 26]. Available from: https://www.rivm.nl/en/life-cycle-assessment-lca/recipe

8. Yaacob M, Worthington HV, Deacon SA et al. Powered versus manual toothbrushing for oral health. *Cochrane Database Syst Rev* 2014;6:No.:CD002281.

9. NHS England. A net zero NHS [Internet]. NHSE 2020 [Cited 2020 May 26]. Available from: https://www.england.nhs.uk/greenernhs/a-net-zero-nhs/

10. European Commission Joint Research Centre. Product environmental footprint category rules guidance v6.3 [Internet]. Brussels: European Commission; 2018 [cited 2020 May 26]. Available from: https://eplca.jrc.ec.europa.eu/permalink/PEFCR_guidance_v6.3-2.pdf

11. Meldrum J, Nettles-Anderson S, Heath G et al. Life cycle water use for electricity generation: a review and harmonization of literature estimates Environ. Res. Lett 2013;8:01503.

12. Department of Health. Delivering better oral health: an evidence-based toolkit for prevention [Internet]. London: Public Health England; 2017 [cited 2020 May 26]. Report no.: 2016224 Available from: https://www.gov.uk/government/publications/delivering-better-oral-health-an-evidence-based-toolkit-for-prevention

13. Wartella EA, Lichtenstein AH, Boon CS. Front-of-package nutrition rating systems and symbols: Phase 1 Report [Internet]. Washington DC: National Academies Press 2020 [cited 2020 May 26] Available at: https://www.ncbi.nlm.nih.gov/books/NBK209859/

FIGURE LEGENDS

Figure 1. System boundaries for current manufacturing practice of producing 28million plastic manual toothbrushes in a single year.

Figure 2. Toothbrush modelling results for climate change impact and DALYs.

Figure 3. The LCA system boundary model for toothbrush manufacturing that uses a recycling scheme to reuse plastic from previous toothbrushes.

TABLE LEGENDS

Table 1. DALYs lost due to one individual using a toothbrush over 5 years (displayed in DALY hours lost). Figures are rounded to 4 decimal places.

Table 2. Changes to toothbrush manufacture and disposal in each model.