Health Innovation
Kent Surrey Sussex

ApostHealth®

Sustainability review

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Introduction

The purpose of this report is to conduct a high-level assessment of the environmental impact and carbon savings associated with Apos®; an FDA-cleared medical device clinically proven to reduce the symptoms of knee osteoarthritis. In the UK, one in five people over 45 years suffer from knee osteoarthritis.[1] This costs the NHS an estimated £10.2 billion per year, which is expected to increase.[2]

Source: Apos Health

To address this significant health challenge, the Apos® medical device was developed. Apos® is a specially designed sport shoe with calibrated pods, offering a non-invasive, personalised treatment that alleviates pain by retraining gait and redistributing weight away from painful areas. The National Institute for Health and Care Excellence (NICE) has recently recognised Apos®, highlighting its safety, clinical effectiveness and cost-saving potential.[3] The intervention is particularly beneficial for patients with severe knee osteoarthritis as it can help avoid or delay the need for knee replacement surgery, and is recognised as an alternative for those eligible for surgery in the NHS England patient decision support tool for knee osteoarthritis.[4] Reflecting the clinical and real-world evidence for the device, in 2023 Apos® was selected for support by NHSE on the Med Tech Funding Mandate (MTFM) with support commencing in April 2024.[5] The MTFM aims to ensure patients and the NHS benefit from clinically effective and cost saving medical technologies faster and more equitably, with support from England's 15 Health Innovation Networks.

Given that climate change poses a major threat to public health, identifying pathways to achieve net zero emissions is imperative. Sustainable innovation is a crucial driver of this transformation and therefore it is essential that businesses ensure their products or services contribute to the NHS's net zero targets. This review outlines how, when adopted at scale, Apos® has the potential to significantly decrease the environmental impact associated with surgical procedures.

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[1] Felson, D. T., Naimark, A., Anderson, J., Kazis, L., Castelli, W., & Meenan, R. F. (1987). *The prevalence of knee osteoarthritis in the elderly.* The Framingham Osteoarthritis Study. Arthritis & Rheumatism, 30(8), 914–91.
[2] Woolf, A. D., & Pfleger, B. (2003). *Burden of major musculoskeletal conditions*. Bulletin of the World Health Organisation, 81(9), 646–656.
[3] NICE. (2023). AposHealth for knee osteoarthritis Medical technologies guidance.
[4] Decision tool found here: Making a decision about knew osteoarthritis (NHSE).
[5] Details in the Med Tech Funding Mandate here: NHS Accelerated Access Collaborative » Medical technology (MedTech) funding mandate and support (england.nhs.uk)

Methodology

This report aims to explore the environmental benefits of Apos® by examining both its carbon footprint and the potential carbon savings from reduced surgical interventions, thereby providing a holistic view of its net environmental impact.

While a full life cycle assessment (LCA) includes detailed data on raw materials, production processes and end-of-life disposal, such data was unavailable for Apos®. Therefore, this review does not constitute a LCA. Instead, we have utilised a combination of industry-standard estimates, data from similar products, relevant databases and published literature to approximate the environmental footprint of Apos®. This report aims to assess three objectives:

1. **To estimate the carbon footprint of Apos®** — This analysis aims to quantify the environmental footprint associated with the production, international and local shipping and patient appointments following use of Apos.®
2. **To measure the carbon savings from surgery** — This analysis aims to evaluate the carbon savings from the reduced need for surgical interventions. Due to the therapeutic efficacy of Apos®, we anticipate a significant decrease in the number of surgeries and thus a decrease in carbon emissions, which will be quantified.
3. **To measure the net carbon savings from Apos®** — The objective of this analysis is to evaluate the net carbon savings from the assessments conducted, providing a clear understanding of the sustainability of the Apos® device.

By assessing the environmental benefits of Apos®, this report also aims to evaluate its role in supporting sustainable healthcare practices and contributing to the NHS's net zero emissions targets. This approach, while not exhaustive, offers a meaningful evaluation of the device's impact based on the best available data.

This report was completed by Amelia James, Sustainability Lead for Health Innovation Kent, Surrey and Sussex and Oxford and Thames Valley, Julian O'Kelly, Innovation Manager for Health Innovation Kent, Surrey and Sussex and reviewed by Peter Waddingham, Net Zero Lead for the Health Innovation Network.

It is important to note that whilst we report on UK data, the MedTech Funding Mandate's support for Apos® is only for England through NHS England.

Sustainability evaluation

The evaluation is structured into two distinct assessments. The first assessment aims to estimate the carbon footprint of the Apos® device, while the second assessment evaluates the carbon savings associated with the reduction in surgical procedures.

1) An estimation of the carbon footprint of Apos®

This analysis aims to quantify the environmental footprint associated with the production, international and local shipping and patient appointments following use of Apos®.

Production of sports shoe and plastic pods: Apos® is described as a sports shoe, made with a soft inside liner and breathable, lightweight mesh. An evaluation undertaken by the Massachusetts Institute of Technology found that a single sports shoe can contain

65 discrete parts that require 360 processing steps for assembly.[6] While brand dictates product design and material specifications, the manufacturing of footwear is typically contracted to manufacturers in emerging economies. Using the life cycle assessment methodology in accordance with the ISO 14040/14044 standards, research at Massachusetts Institute of Technology found that the carbon footprint of a pair of sports shoes made of synthetic materials equates to 14.27kg of CO_2e.[7]

The plastic pod on the base of the sports shoe weighs 60g. There are two pods per shoe, thus four pods per pair. The carbon footprint of plastic varies depending on the type of plastic and the production process. The carbon footprint of plastic production ranges from 1.7kg to 3.5kg of CO_2e per kg.[8] Given the additional impact of coal-based energy in Vietnam, the carbon footprint will likely be on the higher end of this range. Thus, it is predicted that the carbon footprint of 240g of plastic made in Vietnam would be close to 0.84kg of CO_2e.[9] Thus, for the purpose of this report, we will use **15.11kg of CO_2e** as an estimation of the footprint associated with production.

International and local shipping: Shipping operations contribute to the carbon footprint of a product. Apos® is manufactured in Vietnam and shipped to the UK. Therefore, we can presume products will need to travel c.6000 miles and their weight is c.2lbs based on the weight of an average pair of sports shoes with packaging. Therefore, based on the National Council for Air and Steam Improvement Industry Report, international shipping from Vietnam to the UK by ship produces the equivalent of 1.33kg of CO_2e.[10] The Apos® device is then posted to patients in the UK. We can presume postage distance on average is c.100 miles and their weight is 2lbs, producing the equivalent of 0.38kg of CO_2e.[11] Thus, the total shipping **footprint is 1.71kg of CO2e**.

Patient travel: Significant carbon emissions arise from patient travel, contributing to 14% of the NHS's carbon footprint.[12] The current recommended Apos® pathway involves patients travelling to a hospital or community healthcare provider for two appointments following use. The distance a patient may travel can vary significantly, dependent on the type of condition, availability of healthcare facilities, geography, rural or city based, country

[6] Cheah, Lynette, Natalia Duque Ciceri, Elsa Olivetti, Seiko Matsumura, Dai Forterre, Richard Roth, and Randolph Kirchain. "*Manufacturing-Focused Emissions Reductions in Footwear Production*." Journal of Cleaner Production 44 (April 2013): 18–29.
[7] Cheah, Lynette, Natalia Duque Ciceri, Elsa Olivetti, Seiko Matsumura, Dai Forterre, Richard Roth, and Randolph Kirchain. "*Manufacturing-Focused Emissions Reductions in Footwear Production*." Journal of Cleaner Production 44 (April 2013): 18–29.
[8] Plastics Europe (2020). Plastics – the Facts 2020.
[9] Crippa, M., et al. (2019). A comprehensive global inventory of methane emissions from the oil and gas sector. Environmental Research Letters.
[10] National Council for Air and Stream Improvement: NCASI. (2017). 2014 *Life Cycle Assessment of U.S. Average Corrugated Product.*
EPA: Environmental Protection Agency. (2018B). Emission Factors for Greenhouse Gas Inventories.
[11] National Council for Air and Stream Improvement: NCASI. (2017). 2014 *Life Cycle Assessment of U.S. Average Corrugated Product.*
EPA: Environmental Protection Agency. (2018B). Emission Factors for Greenhouse Gas Inventories.
[12] Delivering a Net Zero NHS: *B1728-delivering-a-net-zero-nhs-july-2022.pdf (england.nhs.uk)*

size, density and a range of other factors.[13] In the UK, the Health Foundation and the Nuffield Trust published a report that calculated the average distance from home to hospital for an admission was 8.7km based on five million admissions[14]. Thus, for two appointments, 34.8km would be travelled.[15]

A patient may travel using a variety of modes including car, van, motorcycle, taxi, bus, rail, ferry, walking or cycling. The UK department for Transport publishes statistics on the different modes of transport used for certain activities.[16] The category titled *Personal Business* includes medical consultations or treatment. These are captured below with the corresponding grams of carbon per km according to the 2023 Department of Transport conversion factors.[17] Without knowledge of the specific mode of transport, we would expect an average of 159g of CO_2e to be produced per km taken from the table below.[18] Thus, the total travel footprint per patient is **5.53kg of CO_2e**.[19]

Travel Mode	Percentage of patients who travel	Grams of CO_2e per km
Car[20]	80.8%	178
Bus	9.5%	102
Rail	3.6%	35
Walk	3%	0
Taxi	2.7%	149
Motorcycle	0.4%	101
Bicycle	0.2%[21]	0

Therefore, the estimated carbon footprint of manufacturing, shipping and patient travel for one Apos® medical device is **22.35 kg of CO_2e**.

It is important to note that clinicians have the capability to conduct follow-up assessments digitally by utilising information from the device's app and via telephone consultations. This digital approach presents opportunities to significantly reduce the carbon footprint associated with patient travel. Additionally, there are likely further carbon savings from a reduction in appointments related to pain management, as the device effectively alleviates

[13] Care Pathways: Guidance on Appraising Sustainability, Patient Travel Module: *Normal template (shcoalition.org)*
[14] Focus on: Distance from home to emergency care: *1540325897_qualitywatch-distance-emergency-care.pdf (nuffieldtrust.org.uk)*
[15] Calculation: 8.7km x 4 = 34.8km.
[16] Focus on: Distance from home to emergency care: *1540325897_qualitywatch-distance-emergency-care.pdf (nuffieldtrust.org.uk).*
[17] 2023 Conversion factors: ghg-conversion-factors-2023-condensed-set-update.xlsx (live.com)
[18] Calculation: 80 x 178 = 14382, 9. 5 x 102 = 969, 3.6 x 35 = 126, 2.7 x 149 = 402.3, 0.4 x 101 = 40.4, = 15,919.7 / 100 = 159kg of CO_2e per km.
[19] Calculation: 34.8km travelled x 159kg of CO_2e = 5.53kg of CO_2e.
[20] The findings of the UK Department for Transport propose that 2.3% will be travelling by ferry or plane. We do not believe this will be likely in the UK, and therefore have allocated that percentage to car travel as is the most common form of travel.
[21] The percentages in the *Guidance on Appraising Sustainability Report* add up to 100.2 due to rounding up. We have kept the same figures in this report for continuity, thus the total equals 100.2.

symptoms. It is also necessary to consider the potential additional travel required for healthcare professionals to receive training in the use of the Apos® device. Accurately predicting the carbon cost of this training requires detailed information, including the location of training sessions, the number of professionals trained and the number of patients each clinician will subsequently educate. However, we anticipate that the carbon footprint associated with training would be minimal and predominantly a one-time cost per clinician.

2) Carbon savings from surgery

This analysis aims to evaluate the carbon savings from reduced surgeries.

Research to date: According to the primary study underpinning the NICE guidance, 74% of 365 patients avoided surgery over a three-year period.[22] More recently a retrospective audit on 571 patients has evidenced most patients (89%) did not proceed to secondary care consultation during their time in treatment for up to 6 years[23]. These studies indicate 6% of patients using the Apos® device still required a total knee replacement in year 1 and a further 5 % at 6 years. These findings highlight that while the Apos® device can be effective for many patients in managing knee osteoarthritis symptoms and potentially delaying surgery, it does not completely eliminate the need for total knee replacement in all cases. While the long-term implications and the potential need for surgery at a later date remain uncertain, current evidence indicates that Apos® has been effective in helping patients avoid surgical interventions thus far.

The carbon impact of surgery: To contextualise the carbon impact of surgery, a baseline scenario has been established, representing the standard treatment pathway involving a total knee replacement. The Life Cycle Assessment of a total knee replacement procedure is estimated to produce 190.5 kg of CO_2e.[24] Last year in the UK, a total of 132,000 total knee replacements were performed, across private and public healthcare.[25]

3) To measure the net carbon savings from Apos®

This analysis aims to evaluate the net carbon savings from the assessments above.

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[22]: Greene, A., & Miles, C. (2023). Long-term outcomes on the rates of total knee replacement amongst patients with end-stage knee osteoarthritis who meet surgical criteria and received a non-invasive biomechanical intervention. *Musculoskeletal Care*, *21*(3), 936-938.

[23] Benn, R., Rawson, L., & Phillips, A. (2023). Utilising a non-surgical intervention in the knee osteoarthritis care pathway: a 6-year retrospective audit on NHS patients. *Therapeutic Advances in Musculoskeletal Disease*, *15*, 1759720X231187190

[24] Delaie, Camille, et al. "Ecological Burden of Modern Surgery: An Analysis of Total Knee Replacement's Life Cycle." *Arthroplasty Today* 23 (2023): 101187: This consisted of 53.7 kg CO_2 (28%) for the manufacture of the prosthesis, 50.9 kg CO_2 (27%) for travel, 57.1 kg CO_2 (30%) for surgery, and 28.8 kg CO_2 (15%) for waste management.

This table below presents scenarios of the carbon costs and savings associated with the adoption of the Apos® device, with varying adoption rates. It compares the carbon cost of adopting the device to the potential carbon savings from avoiding total knee replacement surgeries over one and six years.

At each adoption rate (ranging from 5% to 50%), there is an initial carbon cost for manufacturing, distributing and using the Apos® device. However, the carbon savings from avoiding surgery outweigh the carbon cost significantly, and as adoption increases, so do the savings. The substantial savings from Apos® adoption highlight its potential as a sustainable treatment option within the NHS, reducing the environmental impact of healthcare while offering patients an effective alternative to surgery. Wide-scale adoption could contribute meaningfully to the NHS's carbon reduction goals, impacting positively on forecast increases in demand for total knee replacement surgery in the future.

Figure 1: The carbon costs and savings associated with the Apos® device.

Adoption Rate	Apos Units / Surgeries saved	Carbon Cost of Apos Adoption *(Tonnes of CO_2e)*	Carbon Saving from Surgery *(Tonnes of CO_2e)*	Carbon Saving in Yr 1 *(Tonnes of CO_2e)*	Carbon Saving in Y6 *(Tonnes of CO_2e)*
5%	6,600	148	1,257	1,182	**971**
10%	13,200	295	2,515	2,364	**1,943**
15%	19,800	443	3,772	3,546	**2,914**
20%	26,400	590	5,029	4,727	**3,886**
25%	33,000	738	6,287	5,909	**4,857**
30%	39,600	885	7,544	7,091	**5,829**
35%	46,200	1,033	8,801	8,273	**6,800**
40%	52,800	1,180	10,058	9,455	**7,772**
45%	59,400	1,328	11,316	10,637	**8,743**
50%	66,000	1,475	12,573	11,819	**9,715**

In the Appendix, **Figure 2 provides the full calculations of the carbon costs and savings.*

Conclusion

This analysis highlights that while there is an upfront carbon cost for the Apos® device, the overall environmental benefit from reducing the number of surgeries grows over time, offering substantial carbon savings, even after 6 years. Thus, Apos® presents a significant opportunity for carbon savings within the NHS. Given the high carbon footprint associated with surgical procedures, Apos® offers a low-carbon alternative for managing knee osteoarthritis. By reducing the need for replacement surgeries, Apos® can substantially alleviate the current burden on the healthcare system.

Furthermore, Apos® can contribute to addressing the pressing issue of long elective care waiting lists, which have not fully recovered since the COVID-19 pandemic. By providing an effective, non-invasive treatment option, Apos® not only mitigates the environmental impact of surgical interventions but also enhances healthcare efficiency. This dual benefit underscores the potential of Apos® to support both sustainability goals and improved patient care outcomes in the UK.

Appendix

Figure 2: The full calculations on carbon costs and savings of using the Apos® device.

Adoption Rate *(%)*	Apos Units / Surgeries Saved	Carbon Cost for Apos Adoption *(Tonnes of CO_2e)*	Carbon Savings from Surgery *(Tonnes of CO_2e)*	Carbon Saving Overall (Apos – Surgery) *(Tonnes of CO_2e)**	Plus 6% TKR in Yr 1[22] *(Tonnes of CO_2e)*	Total surgeries saved Yr 1	Actual Carbon Saving in Yr 1 *(Tonnes of CO_2e)*	Actual Carbon saving after returns to TKR in Y1 *(Tonnes of CO_2e)*	Plus 5% TKR Yr 6[23]	Total Surgeries Saved Yr 6	Actual Carbon saving from surgery *(Tonnes of CO_2e) **	**Actual Carbon saving Using Apos After Y6 *(Tonnes of CO_2e)* ***
5%	6600	148	1257	1110	396	6204	1181.86	1034	330	5874	1119.00	**971**
10%	13200	295	2515	2220	792	12408	2363.72	2069	660	11748	2237.99	**1943**
15%	19800	443	3772	3329	1188	18612	3545.59	3103	990	17622	3356.99	**2914**
20%	26400	590	5029	4439	1584	24816	4727.45	4137	1320	23496	4475.99	**3886**
25%	33000	738	6287	5549	1980	31020	5909.31	5172	1650	29370	5594.99	**4857**
30%	39600	885	7544	6659	2376	37224	7091.17	6206	1980	35244	6713.98	**5829**
35%	46200	1033	8801	7769	2772	43428	8273.03	7240	2310	41118	7832.98	**6800**
40%	52800	1180	10058	8878	3168	49632	9454.90	8275	2640	46992	8951.98	**7772**
45%	59400	1328	11316	9988	3564	55836	10636.76	9309	2970	52866	10070.97	**8743**
50%	66000	1475	12573	11098	3960	62040	11818.62	10344	3300	58740	11189.97	**9715**

**Converted to absolute number to show avoided emissions/carbon saving*