GREEN TEAM COMPETITION
CENTRE FOR SUSTAINABLE HEALTHCARE

NHS Gloucestershire Managed Services

NHS Gloucestershire Hospitals NHS Foundation Trust

REDUCING CARBON (CO2E) WASTE FROM PULSE LAVAGE SYSTEMS USED IN JOINT REPLACEMENT SURGERY, ORTHOPAEDIC THEATRES

TEAM MEMBERS:

- Matthew Chan, ST8 Trauma & Orthopaedics Registrar, matthew.chan1@nhs.net
- Amanda Neale, Principal Operating Department Practitioner, amanda.neale1@nhs.net



Background:

Pule lavage is used widely in orthopaedic surgery. It plays an important role in modern cementing techniques for total joint arthroplasty by ensuring a clean cancellous bone bed to allow cement inter-digitation[1, 2, 3]. Additionally, it also plays a role in providing high volume washout of soft tissues during wound irrigation[4]. A variety of different disposable pulsatile lavage system are available commercially. These differ mostly in the source of power (battery/AC), plastic/carbon and cost.

We perform over 1000 joint replacements per year whilst nationally it is estimated that 215,000 - 440,000 total hip and knee replacements will be performed by 2035[5]. Consequently, thousands of disposable pulsatile lavage systems are used and discarded per year resulting in significant environmental and economic implications. The current system used at our trust is the Pulsvac Plus supplied by Zimmer-Biomet® (Warsaw, US). This is a single use, disposable, battery-operated system (8xAA) and is like most of the pulsatile lavage systems used across the UK. We propose the use of a novel pulsatile lavage system called the Ecopulse (De Soutter Medical Ltd.®, Aylesbury, UK).

De Soutter have provided a certificate of carbon neutrality making the Ecopulse the only commercially available carbon neutral pulsatile lavage system on the market. The main difference between these systems is that the Ecopulse is powered via the power tool handpiece already in use on joint replacement sets. This removes the battery waste and reduces the size and weight of the product, resulting in less raw materials required. This leads the potential for significant environmental and cost savings.

Specific Aims:

1) Evaluate and compare the carbon footprint of the Ecopulse compared to the Pulsvac Plus
2) Evaluate and compare the cost of Ecopulse compared to Pulsvac Plus
3) Clinical evaluation of Ecopulse by surgeons

Methods:

Project timeframe

Organisation of the project began in August 2022 and data collection started between October 2022 and December 2022.

The Centre for Sustainable Healthcare is registered as a company limited by guarantee in England & Wales No. 7450026 and as a charity No 1143189. Registered address 8 King Edward Street, Oxford OX1 4HL.

Baseline data

Our local National Joint Registry (NJR) report for 2018-2019 (last pre-COVID year) was used to provide an estimate on our annual knee and hip replacements. The NJR is used by our trust to collect data on all of the total joint replacements performed across the UK. This figure was then used to estimate the annual carbon footprint and cost of each product.

Clinical implementation and analysis

The Ecopulse was trialled using a product evaluation form provided by De Soutter. This trial period was done over a two-week period between 5/9/22 – 23/9/22. The product was used by orthopaedic surgeons and their teams across this period and then an evaluation form was completed. The evaluation form is shown in the appendix. The products were provided by De Soutter free of charge and no funding was required.

Measurement:

Patient / clinical outcomes:

Surgeon product evaluation form shown in the appendix. This was completed by surgical teams following the use of the Ecopulse.

Environmental sustainability:

The total raw materials of the product, their weights and packaging were provided by the manufacturers. We also weighed the products and packaging individually to confirm this data. Using carbon emission factors provided by UK Government GHG conversion factor report[6] the carbon footprint of each product was calculated. For transportation, carbon emissions were calculated by estimating total miles from distribution centre to our trust and then using the carbon emissions factors from the UK Government GHG conversion factor report[6]. A total carbon footprint for each product was then created by combining these figures. We then projected the total carbon footprint annually. The Ecopulse comes with a carbon neutral certificate with a formal carbon footprinting analysis carried out by Carbon Fooprint Ltd. This is a very detailed report which we could not replicate as well when assessing the other models. We felt repeating the carbon footprinting using our simplified method would verify the results and allow us to get a more accurate comparison to the other products available. Table 1 shows the factors used in the carbon footprint analysis.

Table 1: Factors used for carbon footprint calculation	***Pulse Lavage system***		
Main components of instrument	*Ecopulse®*	*Pulsvac® (Battery)*	*Pulsvac® (AC)*
Hard plastic main body	✓	✓	✓
Batteries	×	✓	×
Tubing	✓	✓	✓
Inner Packaging	✓	✓	✓
Outer packaging	✓	✓	✓
Transport			
Distance from distribution centre to Hospital	✓	✓	✓

Economic sustainability:

Costings were provided by our procurement department. Unfortunately, due to Non-Disclosure Agreement exact figures were not available. Cost savings were calculated annually by estimating the procurement of 2,500 pulsatile lavage kits per year. This saving was based on using one pulse lavage system per operation and on 95% replacement of the current Pulsvac model.

Social sustainability:

Details of this were taken from the comments provided by the evaluation forms

Results:

Patient / clinical outcomes:

The Ecopulse favoured well in the clinical trial period and was acceptable for most surgeons. Some of the advantages that were highlighted were that it was much quieter than the Pulsvac and hence made communication and training easier. One of the disadvantages is that once attached to the power tool it was heavier than the Pulsvac. In addition, with the power tool in use mechanical brushes could not be used simultaneously to clear the femoral canal of debris. Neither of these problems will negatively impact patient care but it does mean that not all surgeons will be able to use the Ecopulse and so a supply of the Pulsvac option will be required.

Environmental sustainability:

Item	KgCO2e / use	Uses per year	KgCO2e / year
Ecopulse (De Soutter, Aylesbury, UK)	1.69	1,800	3,045
Pulsvac Plus Battery (Zimmer-Biomet, Warsaw, US)	4.32		7,783
Pulsvac Plus AC (Zimmer-Biomet, Warsaw, US)	2.90		5,213

The estimated annual carbon emissions of each device are shown in the table 1. The overall footprint of the Ecopulse was significantly smaller than that of the Pulsvac, reflecting a 2.6x carbon emissions saving compared to the battery powered Pulsvac. In addition, the carbon neutral Ecopulse means it offsets their carbon emissions providing even better savings in comparison to the existing Pulsvac

We currently use the Pulsvac **Plus Battery** for 100% cases. Assuming, 95% of cases are eligible to switch to the Ecopulse we project a saving of **4,501.1 kgCO2e.** This is equivalent to driving 12,9634 miles driven in an average car. In addition, switching from the battery to the AC powered option for the remaining 5% of cases will save a further **128.5 kgCO2e** giving a total saving estimate of **4,629.6 kgCO2e** (13,334 miles driven).

The main environmental benefits arise due to the difference in the power source. Using the power tool provided on the existing joint replacement sets means that no electronics, batteries, or motors are required in the Ecopulse. This significantly reduces the weight and the raw materials used leading to much less carbon emissions. Additionally, it is likely that the manufacturing process for the Ecopulse is also more efficient due to the lack of motors and simplicity of the design. However, in this project we have been unable to quantify this cost. Zimmer-Biomet do offer an AC powered version of their pulse lavage which has the benefit of not

using batteries. This option has less carbon emissions then the battery-operated version but is still inferior to the Ecopulse.

The Ecopulse is primarily compatible with De Soutter power tools. The p31 series is also compatible with Stryker® power tools. Adaptors exsist to use the Ecopulse system with Linvatec®/Hall®, Aesculap® and Synthes® power tools. Although this encompasses most of surgical power tools on the market it may not be possible to use the Ecopulse in all trusts due to compatibility issues with existing systems. When it is not possible to use the Ecopulse, we strongly advocate the use of the AC powered pulse lavage systems.

Economic sustainability:

Based on a projected procurement of 2,500 pulse lavage kits per year and 95% use the Ecopulse saved an estimated £6,175 per year. Likely the cost saving comes from requiring less raw materials and a simpler manufacturing process.

Social sustainability:

De Soutter estimates that using the Ecopulse will provide a 2.5x increase in storage space. This will help create valuable space in operating theatres stores. This is demonstrated in the comparison between Figure 1 and 2. This improved storage space allows for more room for other important orthopaedic instruments and will allow us to keep more sets on site and reduce our loan kit requirements. This will have both economic and environmental benefits. Additionally, it makes it easier to move around in what is normally quite a tight storage making it easier for theatre staff.

During an operation there can be significant amount of noise, and this can sometimes make working in this environment difficult for staff. As the Ecopulse is quieter it should improve the working environment for the staff during the operation

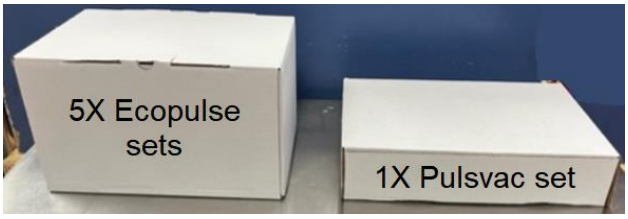


Figure 1. Packaging:

Ecopulse box (Left) containing 5 ecopulse sets, Pulsvac box (right) containing 1 pulsvac



Figure 2. Device:

Pulsvac Plus (Left), Ecopulse (Right)

Discussion:

Our project has shown that there is significant environmental and economic savings that can be made by using the Ecopulse compared to more commonly used battery powered pulse lavage systems such as the Pulsvac Plus.

The potential savings at our trust alone are significant, however it is important to project and consider the potential benefits nationally. Using data from Culliford et al. it is projected that in 2024 around 180,000 knee and hip replacements will be performed in the UK. Using our estimations, we predict that this would generate 778 Tonnes CO2e if battery operated pulselavage systems like the Pulsvac are used. By using the Ecopulse this figure will reduce to 304 Tonnes CO2e saving 450 Tonnes CO2e over a year. This is equivalent to nearly 1.3 million miles driven by the average passenger car.

Introducing new products into a surgical department is not always an easy process. Starting discussion early with all members of the surgical team can help identify potential stumbling blocks as early as possible. By calculating the carbon factors, it has helped put the environmental impact into perspective. This has certainly helped raise awareness on the issue and has helped gain support.

I have had excellent senior mentorship during this process, and this has helped guide me through the process and identified who are the key stakeholders that needed to be contacted and in agreement with the product. This was a very important aspect, and I would highly recommend that for those new to the process of procuring new surgical products that they look for an experienced mentor.

Lastly, not all “green” products will work for everyone. In this project our surgeon feedback highlighted that the inability to use both a mechanical brush to clear the femoral canal and the lavage system would not work for them. I think this type of situation is very common when looking at new surgical instruments. Fortunately, we had already identified a greener solution in the AC powered kit which ensured that we still could provide a more sustainable option for this surgeon. Taking time to do a thorough review of all the products available is important as it allows you to find other solutions that can work.

Conclusions:

The Ecopulse pulse lavage system produced by De Soutter medical Ltd. represents a significant opportunity to reduce the carbon footprint of joint replacement operations both locally, at our trust, and on a national level. By producing a product that is not only “green” but is cost efficient in comparison to its competitors we anticipate this will produce a lasting change at our trust.

The key learning points from this project are that “Green” teams should prioritise reviewing single use items used in high volume operations such as joint replacement surgery. There is a growing market for “green” alternatives in surgical instruments and it represents a significant opportunity to make carbon savings at your trust. Ensuring that the correct clinical governance is completed is very important when introducing new products. This ensures that the product is been reviewed and deemed safe to use by the trust. Often this can be a lengthy process and so starting this early is key to the success. Finding an experienced mentor to help guide this process is a crucial step and makes the process much clearer.

In the future we plan to do a formal review of disposable pulsatile lavage systems available in the UK. By publishing this work, we aim to spread the initiative outside of our trust and lead to a reduction in the carbon footprint of joint replacement surgery across the UK. We also plan a presenting this work at our regional orthopaedic meeting. The benefits seen by introducing this green product has certainly raised awareness across the department and should encourage future initiatives.

After fully implementing the Ecopulse in our hip and knee joint replacements at Cheltenham we hope to expand the initiative to our trauma service at Gloucester. We hope to use this product for our hip hemiarthroplasty for patients with fractured hips. We estimate there is around 200-300 additional cases that could use the Ecopulse and so will provide even greater savings.

References:

1. Breusch, S. J., Norman, T. L., Schneider, U., Reitzel, T., Blaha, J. D., & Lukoschek, M. (2000). Lavage technique in total hip arthroplasty: Jet lavage produces better cement penetration than syringe lavage in the proximal femur. *Journal of Arthroplasty*, *15*(7), 921–927. https://doi.org/10.1054/arth.2000.8098
2. Helwig, P., Konstantinidis, L., Hirschmüller, A., Miltenberger, V., Kuminack, K., Südkamp, N. P., & Hauschild, O. (2013). Tibial cleaning method for cemented total knee arthroplasty: An experimental study. *Indian Journal of Orthopaedics*, *47*(1), 18–22. https://doi.org/10.4103/0019-5413.106887
3. Seeger, J. B., Jaeger, S., Bitsch, R. G., Mohr, G., Röhner, E., & Clarius, M. (2013). The effect of bone lavage on femoral cement penetration and interface temperature during oxford unicompartmental knee arthroplasty with cement. *Journal of Bone and Joint Surgery*, *95*(1), 48–53. https://doi.org/10.2106/JBJS.K.01116
4. Brown, L. L., Shelton, H. T., Bornside, G. H., & Cohn, I. (1978). Evaluation of wound irrigation by pulsatile jet and conventional methods. *Annals of Surgery*, *187*(2), 170–173. https://doi.org/10.1097/00000658-197802000-00013
5. Culliford, D., Maskell, J., Judge, A., Cooper, C., Prieto-Alhambra, D., & Arden, N. K. (2015). Future projections of total hip and knee arthroplasty in the UK: Results from the UK Clinical Practice Research Datalink. *Osteoarthritis and Cartilage*, *23*(4), 594–600.
6. Greenhouse gas reporting: conversion factors 2022 - GOV.UK (www.gov.uk)

Appendices

Figure 3 Surgeon evaluation form

NHS Gloucestershire Hospitals NHS Foundation Trust

GENMED

De Soutter Power Tool Evaluation Form

Name: .....

Procedure done: .....

Is this product acceptable for clinical use? Yes / No

Please Circle tool used: TRAUMADRIVE / ORTHODRIVE

Poor ① Average ② Good ③ Very Good ④ Excellent ⑤

	1	2	3	4	5
Drill or Reaming Power and Speed					
Sawing performance					
Ease of use of Handpiece and attachments					
Ease of use for K-wiring					
Ergonomics during use					
Battery and Handpiece reliability during use					
Rep support during Trial					

Please leave any comments below:

The Centre for Sustainable Healthcare is registered as a company limited by guarantee in England & Wales No. 7450026 and as a charity No 1143189. Registered address 8 King Edward Street, Oxford OX1 4HL.

Figure 4 Ecopulse Carbon Footprint Data

ITEM				PACKAGING				TRANSPORT			DISPOSAL			TOTAL CARBON FOOTPRINT (kgCO2e)
Material	*Weight (T)*	*Emissions factor (kgCO2e/T)*	*Total item GHG emission (kgCO2e)*	*Packaging Material*	*Weight (kg)*	*Emissions factor (kgCO2e/T)*	*Total packaging GHG emissions (kgCO2e)*	*Distance of origin - NHS supply (Km)*	*Transport emissions factor (kgCO2e)*	*Total transport emissions (kgCO2e)*	*Weight (Kg)*	*Emissions factor (kgCO2e)*	*Total disposal emissions (kgCO2e)*	
Plastic PVC	0.00029	3,413.08	0.99	Paper	0.000007	919.4	0.0064	HGV - 107.8	0.22916	0.0101284	Item - 0.00033	1074	0.3561224	**1.61**
Plastic ABS	0.00004	3760.00	0.15	PET	0.000018	4,032.39	0.0726				Packaging - 0.00008	21.28		

Figure 5 Pulsvac Battery Carbon Footprint Data

ITEM				PACKAGING				TRANSPORT			DISPOSAL			TOTAL CARBON FOOTPRINT (kgCO2e)
Material	*Weight (T)*	*Emissions factor (kgCO2e/T)*	*Total item GHG emission (kgCO2e)*	*Packaging Material*	*Weight (T)*	*Emissions factor (kgCO2e/T)*	*Total packaging GHG emissions (kgCO2e)*	*Distance of origin - NHS supply (Km)*	*Transport emissions factor (kgCO2e)*	*Total transport emissions (kgCO2e)*	*Weight (T)*	*GHG emissions factor (kgCO2e)*	*Total disposal emissions (kgCO2e)*	
Plastic PVC	0.000265	3,413.08	0.9	Paper	0.00001	919.4	0.0092	Ferry - 290	0.016142	0.077115	Item - 0.000441	1074	0.60	**4.22**
Plastic ABS	0.000281	3760.00	0.66	PET	0.00015	4,032.39	0.6049	HGV - 405	0.22916		Packaging - 0.00035	21.28		
Battery	0.000192	4,633.48	0.889628								Battery - 0.000192	8.883		

Figure 6 Pulsvac AC Carbon Footprint Data

ITEM				PACKAGING				TRANSPORT			DISPOSAL			TOTAL CARBON FOOTPRINT (kgCO2e)
Material	*Weight (T)*	*Emissions factor (kgCO2e/T)*	*Total item GHG emission (kgCO2e)*	*Packaging Material*	*Weight (T)*	*Emissions factor (kgCO2e/T)*	*Total packaging GHG emissions (kgCO2e)*	*Distance of origin - NHS supply (Km)*	*Transport emissions factor (kgCO2e)*	*Total transport emissions (kgCO2e)*	*Weight (T)*	*GHG emissions factor (kgCO2e)*	*Total disposal emissions (kgCO2e)*	
Plastic PVC	0.000265	3,413.08	0.9	Paper	0.00001	919.4	0.0092	Ferry - 290	0.016142	0.077115	Item - 0.000441	1074	0.481082	**2.82**
Plastic ABS	0.000176	3760.00	0.66	PET	0.00015	4,032.39	0.6049	HGV - 405	0.22916		Packaging - 0.00035	21.28		