Using portable, single-use, canister-free, negative-pressure wound therapy for plastic surgery wounds

KEY WORDS
- Bed-management
- Efficiencies
- Negative-pressure wound therapy
- Pathway
- Plastic surgery
- Wounds

The Department of Plastic Surgery within Barts Health NHS Trust introduced a pathway to treat complex plastic surgery wounds using a single-use, negative-pressure wound therapy (NPWT) device. The pathway was developed in a response to the lack of acute beds. **Methods:** A retrospective review was conducted per financial year from 2012 to 2017, on all wounds within the department, treated using the pathway. The number of bed days released was calculated according to admission type.
Results: 213 wounds were reviewed. Median patient age was 50 years, with an even gender divide. Total calculated bed management efficiency, across five financial years, was £76,591.60. A total of 367 bed days were released during this period.

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The demand for beds in the NHS is at an all-time high (Pym, 2017). To meet this demand, the Barts Health NHS Trust Department of Plastic Surgery introduced a pathway where patients with complex plastic surgery wounds, were managed with a medical device, allowing for: reduction in patient length of stay; efficient bed management and wound management within an out-patient environment. Barts Health NHS Trust provides healthcare for a population of 2.5 million people in East London, of which the main Boroughs include: Tower Hamlets, Waltham Forest, Newham, City and Hackney. The Department of Plastic Surgery is based at the Royal London Hospital; where elective, trauma and cancer surgery is performed by 12 consultant surgeons, 20 junior doctors and supported by five specialist nurses. A dedicated nurse-led scar clinic, alongside dressing clinics, is managed by the Department of Plastic Surgery nurse specialists.

The pathways outlined in *Figures 1* and *2* are the standard of care for wound management within the Department of Plastic Surgery; describing the process for identifying if a patient is suitable to receive a single use, canister-free Negative Pressure Wound Therapy (NPWT) device (PICO™, Smith and Nephew, Hull, UK), for their wound. Patient suitability for pathway inclusion is always made by a clinician, in regard to contraindication for NPWT and patient concordance with the therapy. Patients attend dressing clinics (PDC) at the Royal London Hospital, as dictated by their treatment plan, where the wound can be reviewed, and the dressing changed, if required. Patients attend the PDC until their wound is healed and they are then discharged from the service.

The Department of Plastic Surgery care for and manage patients with a range of wound types, that can be categorised as open wounds (with or without cavity) or closed incisions. PICO™ is a small, lightweight, canister-free, portable negative pressure device which consistently delivers negative pressure wound therapy at a nominal level of -80 mmHg, over the wound surface (Saxena et al, 2004; Van der Velde and Hudson, 2005; Hurd, 2013; Hurd et al, 2014; Malmsjö et al, 2014; Smith and Nephew, 2015a; Smith and Nephew, 2015b; Hudson et al, 2015; Scalise et al, 2015; DS.16.009.R, 2016; DS.16.010.R, 2016; DS.16.344.R, 2016). The PICO™ kit consists of a single-use negative pressure pump and two dressings, which can manage up to of 300 ml of exudate. The exudate is managed via the dressing which is constructed of breathable film allowing the exudate to be evaporated, therefore negating the need for a canister (Roberts, 2011a; 2011b). *Figure 3* illustrates the design and components of the PICO™ device. The PICO™ device can be used to treat both open (with or without cavity) or closed incisions wounds.

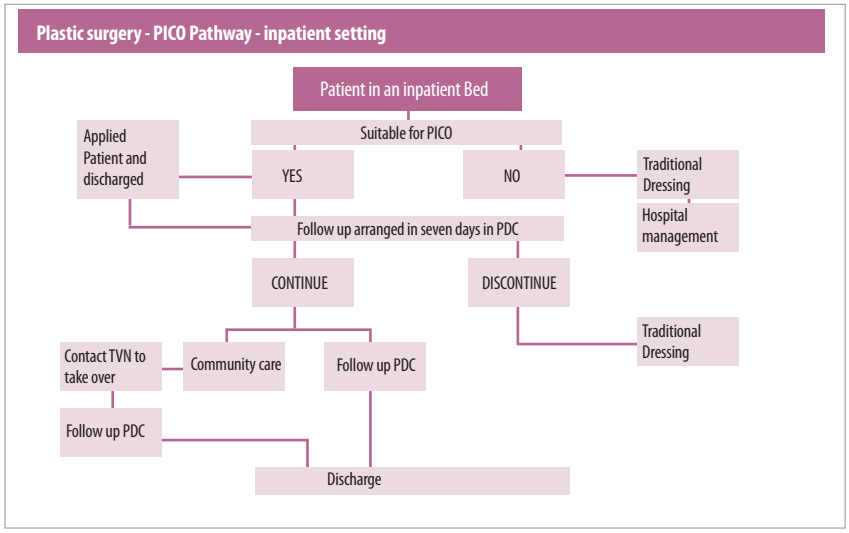

Figure 1. In-patient PICO™ Pathway for Department of Plastic Surgery at Barts Health NHS Trust

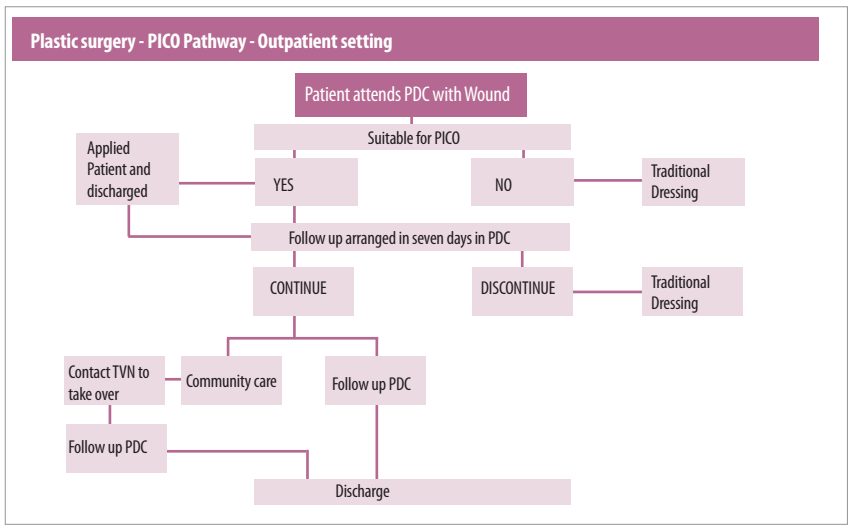

Figure 2. Out-patient PICO™ Pathway or Department of Plastic Surgery at Barts Health NHS Trust

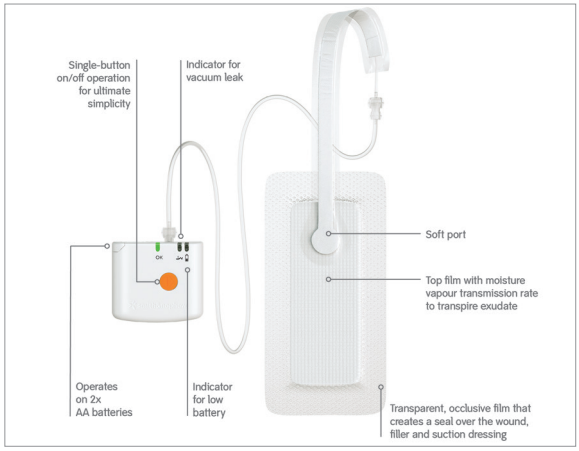

Figure 3. PICO™ Negative Pressure Wound Therapy Device (Smith and Nephew, Hull, UK) (Malmsjö, Huddleston and Martin, 2014)

There is a vast array of evidence which supports the mode of action of negative pressure wound therapy, for both closed incisions and also open wounds. There are six mechanisms for the mode of action of NPWT: micro-deformation (Saxena et al, 2004; Borgquist et al, 2010), macro-deformation (Ichioka et al, 2008; Borgquist et al, 2010), blood flow (Morykwas et al, 1997; Ichioka et al, 2008; Young et al, 2013), fluid removal (Argenta and Morykwas, 1997; Kilpadi and Cunningham, 2011), maintenance of wound homeostasis (Hyldig et al, 2016) and "splinting" of the wound (Galiano et al, 2014; Loveluck et al, 2016). These mechanisms are believed to be utilised by the PICO™ device to facilitate healing.

In an effort to gauge the effectiveness of the pathway on reducing hospital admission and allowing for early discharge, data were collected prospectively during each financial year to ascertain the number of bed days released in relation to the cost of using the PICO™ device. The objective of this work is to describe the process for utilizing a medical device to: manage complex plastic surgery wounds within an out-patient environment; bed management and subsequent efficiency saving to a surgical department within an NHS Trust.

METHOD

The use of a PICO™ device was recorded for each patient, concurrently at the time of treatment. Taking the data collected at the time of treatment, a retrospective, longitudinal review was conducted in 2017, on all patients' who received a PICO™ device for wound management. The review encompassed treatment which occurred per UK financial year from 2012 until 2017. A financial year in the UK runs from April to the following March. The following data variables reviewed for each patient: age, gender, wound type, wound location, open or closed wound, duration of PICO™ treatment and location of device application. No patient identifiable data was reviewed as part of the analysis.

The authors used local clinical practice and judgement to develop the categorisation described in *Table 1*; by comparing how many bed days a patient would require if their wound was treated with standard non-NPWT dressings compared to PICO™, therefore determining the number of bed days released to the department, when PICO™ is used. This enabled the pathways (*Figures 1* and *2*) to be developed, which

Table 1. Definitions for Patient Categorisation

Category	Definition	Procedure Example	Number of Bed Days Released back to the Department	Number of Bed Days Required if PICO™ was not used
Early Discharge	Patients who did require an inpatient bed, however, this was reduced as their wound was treated with PICO™ and subsequently were discharged home early.	Dehisced incision after abdominoplasty or flap donor sites	3	≥3
Day Case	Patients who did require a 2-night stay in hospital, however as their wound was treated with PICO™, an inpatient bed was not required and they were discharged home on same day.	Skin graft to close larger open wound	2	≥2
Outpatient	Patients who did require a 1-night stay in hospital, however as their wound was treated with PICO™ an inpatient bed was not required and they were discharged home on same day.	Manage wound exudate and prepare the wound for surgical closure	1	≥1

is unique to the plastic surgery speciality at Barts Health NHS Trust. A patient who is eligible to receive a PICO™ device does not require an inpatient hospital bed and can be managed as an outpatient within the plastic surgery dressing clinics. Patients with wounds treated with PICO™ were classified as follows: Early Discharge, Day Case and Outpatient. *Table 1* details the definitions of the above categorisations and the subsequent number of bed days released, including a typical procedure which would fall under this category.

The average cost of an acute bed, per day, in Barts Health NHS Trust is £400 (Barts Health NHS Trust, 2017). This was used to calculate the total cost attributed to bed days released when a PICO™ device was used to manage a wound. The weighted average cost of a PICO™ device for Barts Health NHS Trust was recorded as £147.82 (Smith and Nephew UKI, 2017). The weighted average cost price for a PICO™ device was calculated from Smith and Nephew sales data. Barts Health NHS Trust purchases PICO™ devices from NHS Supply Chain. The size of PICO™ applied to each wound was not recorded; therefore, the weighted average cost was applied for the calculations. This is important to note, as the cost of a PICO™ device can vary depending on size. There are ten different sizes of PICO™; the six larger dressing pad sizes (Multisite Small, Multisite Large, 10x40 cm, 15x30 cm, 20x20 cm and 25x25 cm) cost £153.20 per device, compared to the smaller dressing pad sizes (10x20 cm, 10x30 cm, 15x15 cm and 15x20 cm) which cost £144 per device. The prices are stated, including Value Added Tax (VAT), when purchased via NHS Supply Chain.

A dressing pad change, for a patient's wound treated with PICO™, can be completed in 30 minutes. Nursing resource for the plastic surgery dressing clinic is funded from the Department of Plastic Surgery budget, where an NHS band 5 nurse costs £23.42/hour; therefore, the cost for a 30-minute dressing pad change is £11.71. Within the dataset individual dressing changes, for each patient were not recorded. An assumption for nurse resource cost was made, where for every PICO™ used, two 30-minute dressing pad changes were required. The cost of running an outpatient clinic was not included in the analysis, as this cost is not payable by the Department of Plastic Surgery. The cost, in terms of facilities, is paid by the Outpatients Department of Barts Health NHS Trust. Therefore, this does not impact the overall cost efficiencies generated by the pathways implemented. The review of data was managed using Excel 2010 and 2016. Descriptive statistical analysis was carried out using Minitab version 16.

RESULTS

Wounds managed by the Department of Plastic Surgery and treated with a PICO™ device were analysed over five financial years. Overall, 213 wounds on to 213 patients were reviewed. PICO™ usage has increased year on year since the introduction of the pathway, with 2016/17 year usage increasing by more than 50%. There was no difference in patient gender (53.5% males; 46.5% females) of the wounds treated with PICO™. Median age was 50 years; with a wide age range (6–90

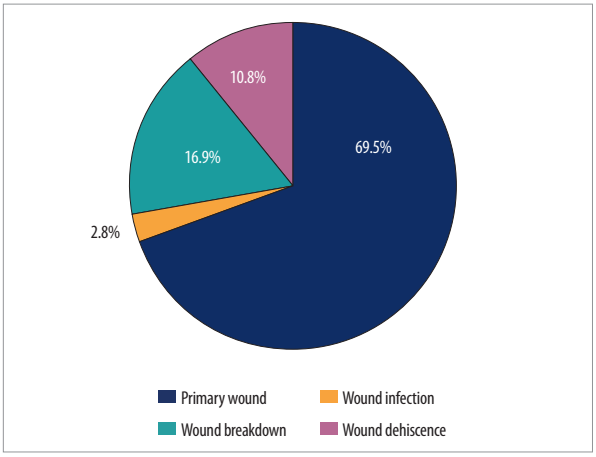

Figure 4. Types of wounds treated with PICO™ device

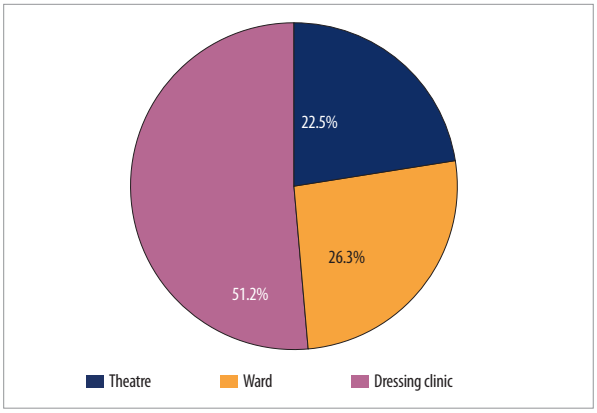

Figure 5. Location of PICO™ application

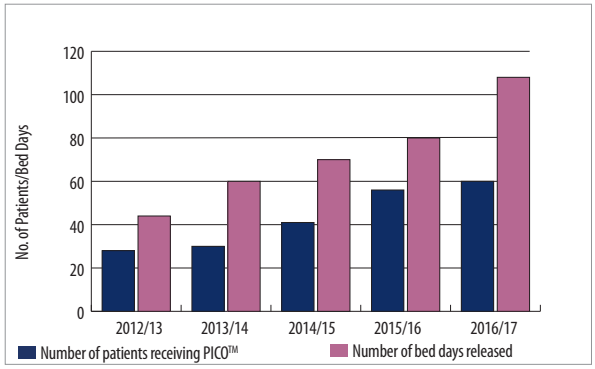

Figure 6. Comparison of the number of bed days released to the number of patients receiving PICO™ device

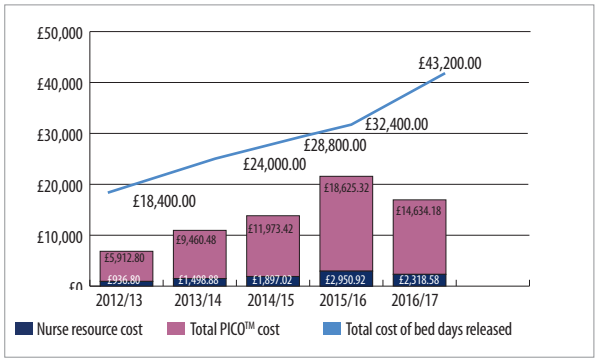

Figure 7. Total device, bed day release and cost efficiency to Department of Plastic Surgery per financial year, through utilizing the pathway

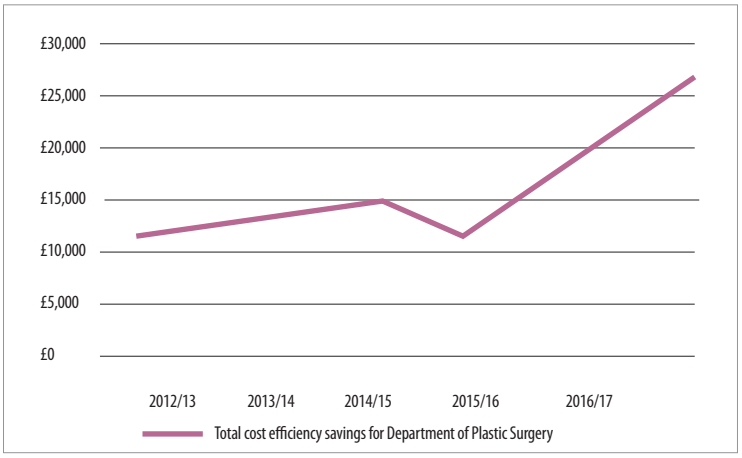

Figure 8. Trending cost efficiencies to Department of Plastic Surgery over 5 financial years

years), from paediatric to care of the elderly. This age range has remained consistent since the pathways commenced.

Figure 4 shows that PICO™ is predominately used for primary wound management, where the initial wound is caused by trauma, surgical intervention, open (with or without cavity), graft, burn and donor sites. The remaining 30.5% of the wounds reviewed and managed with PICO™ are wounds where infection, breakdown or dehiscence has occurred and PICO™ is being used to aid healing. *Table 2* lists the almost total inclusion of all anatomical areas where PICO™ has been used to manage wounds, with the lower leg being the most common. However, the table also highlights the incidence of wounds in more complex areas to treat: neck, scalp, hand, groin, genital and perineal areas. Of the 213 wounds managed with PICO™, a greater percentage were of open wounds (93.4%) compared to closed incisions (10.3%). As explained earlier, PICO™ can be used on both open wounds and closed incisions, as per the instructions for use (IFU). This data analysis is suggestive that the wounds which the Department of Plastic Surgery treat tend to be wounds, where there is not a closed incision and are either open wounds, which lack a suture line (e.g. skin grafts or donor sites) or are cavity wounds. As described earlier the main driver of the pathway and use of PICO™ was to enable patients to be managed as outpatients and therefore reduce inpatient admissions. As part of the data review, the application location of PICO™ was recorded for each wound. *Figure 5* reveals that the objectives of the pathway have been realised, with 51.2% of applications conducted in the plastic surgery dressing clinics. Furthermore, the applications which are completed in theatre (22.5%) and on the ward (26.3%) also allow for early discharge and day case management which again reduces the need for a patient to stay overnight in hospital. From a patient perspective, this has a positive impact on quality of life as the patient can return to their home, not be confined to a hospital bed and enable unrestricted mobility due to the lightweight portability of the PICO™ device.

PICO™ is a single-use device, which has the capacity to deliver negative pressure wound therapy to the wound bed for a period of 7 days (DS.16.003R, 2016; DS.16.009.R, 2016; DS.16.010.R, 2016). For each wound, the number of PICO™ devices used was captured, with median therapy duration of 7 days and range of 7–64 days. For the more complex wounds, a longer duration of PICO™ therapy was required, with one patient requiring 64 days of treatment. However, in terms of cost, this patient was managed as an outpatient in the PDC, with the device cost being £1330.38. In comparison,

Table 2. Locations of participants' wounds					
Location of wound	**Number of wounds**				
Number of wounds treated with PICO™ (n)	28	32	41	52	60
Age; years:					
Median (range)	52.5 (18–86)	47 (30–86)	49 (8–87)	50 (18–90)	52 (6–88)
Gender n (%):					
Male	14 (50)				
Female	14 (50)				
Wound categorization:					
n (%):					17 (28.3)
Trauma	7 (25)	4 (12.5)	12 (29.3)	14 (26.9)	2 (3.3)
Infection	1 (3.6)	-	1 (2.4)	2 (3.8)	8 (13.3)
Surgical	5 (17.8)	7 (21.9)	10 (24.4)	8 (15.4)	8 (13.3)
Open Wound	1 (3.6)	3 (9.4)	2 (4.9)	5 (9.6)	12 (20)
Graft	2 (7.1)	8 (25)	4 (9.8)	7 (13.5)	-
Burn	1 (3.6)	-	-	-	2 (3.3)
Surgical Incision Breakdown	1 (3.6)	3 (9.4)	6 (14.6)	3 (5.8)	3 (5)
Surgical Incision Dehiscence	3 (10.7)	3 (9.4)	1 (2.4)	13 (25)	4 (6.7)
Wound Breakdown	1 (3.6)	1 (3.1)	1 (2.4)	-	-
Donor Site	2 (7.1)	1 (3.1)	-	-	-
Donor Site Break	4 (14.3)	2 (6.2)	1 (2.4)	-	4 (6.7)
Graft Breakdown	-	-	3 (7.3)	-	
Wound location n (%):					
Scalp	-	-	1 (2.4)	-	1 (1.7)
Face	1 (3.6)	-	-	-	1 (1.7)
Neck	1 (3.6)	2 (6.2)	5 (12.2)	1 (1.9)	3 (5)
Upper arm	-	-	-	-	-
Arm	-	1 (3.1)	2 (4.9)	1 (1.9)	5 (8.3)
Hand	1 (3.6)	1 (3.1)	-	-	-
Axilla	-	1 (3.1)	1 (2.4)	-	2 (3.3)
Breast	2 (7.1)	6 (18.7)	4 (9.8)	4 (7.7)	5 (8.3)
Chest	4 (14.3)	2 (6.2)	-	3 (5.8)	1 (1.7)
Abdomen	7 (25)	3 (9.4)	2 (4.9)	6 (11.5)	3 (5)
Back	1 (3.6)	1 (3.1)	2 (4.9)	3 (5.8)	3 (5)
Sacrum	-	-	-	2 (3.8)	-
Buttocks	2 (7.1)	-	-	-	1 (1.7)
Groin	-	3 (9.4)	2 (4.9)	3 (5.8)	2 (3.3)
Genital Area	-	-	1 (2.4)	-	-
Perineal	-	1 (3.1)	-	-	-
Hip	-	-	1 (2.4)	-	-
Leg	3 (10.7)	2 (6.3)	8 (19.5)	13 (25)	7 (11.7)
Lower Leg	6 (21.4)	8 (25)	7 (17.1)	11 (21.1)	22 (36.7)
Ankle	-	1 (3.1)	-	-	-
Foot	-	-	5 (12.2)	5 (9.6)	1 (1.7)
Closed incision					
n (%)	12 (42.9)	5 (15.6)	5 (11.9)	0 (0)	0 (0)
Open wound					
n (%)	17 (60.7)	27 (84.4)	36 (87.8)	52 (100)	60 (100)
Location of application					
n (%):					
Theatre	7 (25)	7 (21.9)	5 (12.2)	9 (17.3)	20 (33.3)
Ward	8 (28.6)	11 (34.3)	13 (31.7)	10 (19.2)	14 (23.3)
Dressing Clinic	13 (46.4)	14 (43.8)	23 (56.1)	33 (63.5)	26 (43.3)
Duration of PICO™ Treatment (Days):					
Median (Range)	7 (7–21)	7 (7–14)	7 (7–49)	14 (7–64)	7 (7–42)

if this patient had to remain in hospital for the 64 days of wound healing duration, the bed cost alone, would be approximately £25,600. Over the 5-year review, a total of 410 PICO™ devices were used, at a cost to the department of £60,606.20. *Table 3* describes the yearly breakdown in terms of device usage and cost; nurse recourse and overall efficiency savings. *Figure 6* describes the correlation of the number of patients receiving PICO™ to the number of bed days released for other use per financial year. The utilization of PICO™ enabled a total of 367 bed days to be released over a 5-year period, which resulted in a bed management efficiency of £146,800. The resultant bed management efficiency to the Department of Plastic Surgery was £76,591.60 over 5 years, after subtracting the device and nursing resource cost from the total bed efficiencies released. A breakdown of the yearly device and nurse resource costs, along with the associated bed day release monetary values of the pathway are illustrated in *Figure 7*.

The review of the patients treated with PICO™ enabled not only the value calculation of the bed days released but also allowed the bed management efficiency to be tracked year on year. *Figure 8* illustrates the efficiency of the pathway as a trajectory. From 2012/13 to 2014/15 financial years, there was an increase in bed efficiency by 13%. Similarly, from 2013/14 to 2014/15 there was a 14% increase in bed efficiency, however, for 2015/16 there was a dip in efficiency of -28%. This was due to an increase in more complex wounds being treated for a longer period of time; therefore, requiring more PICO™ devices, which in turn increased device cost spend. However, it is still important to note that was 2015/16 there was still a bed management efficiency release of £10,823.76. From 2015/16 to 2016/17 the bed efficiencies increased at its highest rate 142%, again showing the positive effect of the pathway in terms of reducing admissions and the resultant release of bed days.

Table 3. Yearly Breakdown of PICO™ device cost, PICO™ device usage, nurse resource and overall efficiency savings						
	2012/13	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**Total**
Number of Patients Receiving PICO™	28	32	41	52	60	213
Number of Bed Days Released	46	60	72	81	108	367
Nurse Resource Cost	£936.80	£1,498.88	£1,897.02	£2,950.92	£2,318.58	£9,602.20
Total PICO™ Cost	£5,912.80	£9,460.48	£11,973.42	£18,625.32	£14,634.18	£60,606.20
PICO™ kits used	40	64	81	126	99	410
Total Cost of Bed Days Released	£18,400.00	£24,000.00	£28,800.00	£32,400.00	£43,200.00	£146,800.00
Total Cost Efficiency Savings for Department of Plastic Surgery	£11,550.40	£13,040.64	£14,929.56	£10,823.76	£26,247.24	£76,591.60

DISCUSSION

In total, the department has generated £76,591.60 in bed management efficiencies through the effective utilisation of the pathways. The release of bed days did not mean that a bed was left empty; it allowed the department to manage their acute beds in a more efficient way and keep up with the patient load of one patient discharged for one patient admission. The £76,591.60 generated is difficult to quantify in terms of how it can be reinvested, as the efficiency resulted from a pathway method, where the objective was to release beds for other patients to occupy. The Royal London Hospital is a major trauma centre and the Department of Plastic Surgery is an acute ward which includes beds for orthopaedic trauma patients, therefore the nature of admissions can be unpredictable. From the analysis of the data, 367 bed days were released and the impact of this on flow to these wards is clear and beneficial. Furthermore, the pathway also enabled accurate activity capture and ensuring that when PICO™ is applied on the wards or theatre or in the dressing clinic setting, it is clear that a negative pressure dressing was used in the patient medical notes. This data recording is identified by coders through Office of Population Census and Survey (OPCS) codes or Healthcare Resource Groups (HRG) codes, generated from an inpatient stay or outpatient visit. It is at the point that the department is able to quantify its value beyond efficiency savings and generate accurate medical records for coding and tariff reimbursement purposes. In terms of potential use of the efficiency income, this could include: additional elective procedures, reduce bed blocking, reduce waiting list times and most importantly allow patients to avoid unnecessary hospital stays.

This longitudinal retrospective review of plastic surgery wounds treated with PICO™ clearly highlights the efficiency of using a single-use NWPT device to manage complex wounds, without the need for a lengthy hospital admission. The data on the use of PICO™ was collected prospectively per financial year; however, the review of the entire data set was not completed on a year to year basis. Therefore, a mechanism for capturing additional data could have been implemented earlier; however, a suggestion of this work should be the regular review of the implemented pathway and associated efficiencies. Notably, it would have been helpful for the analysis to capture: size of PICO™ used, number of dressing pad changes, any wound complications during treatment and number of visits to the dressing clinic per patient. This would have allowed for nurse resource costs to be calculated, without the potential for an under or overestimation of this cost. Furthermore, the incidence of wound complications was not captured as part of this review, however, the patient was not discharged from the Department of Plastic Surgery until their wound was healed. Therefore, through capturing the duration of PICO™ treatment *(Table 1)* we can report the number of days a patient received NPWT treatment for their wound and subsequently discharged from Department of Plastic Surgery at the Royal London Hospital. It could be argued that the efficiency savings could

be overestimated as the PICO™ device cost could have been higher due to larger sizes being used and this not being reflected in the actual device costs. However, as a weighted average cost was applied to enable a calculation for the device expenditure, this reduces the potential for an overestimation of efficiency savings. The price difference between the smallest and largest PICO™ kit sizes is £9.20. By using the weighted average price of £147.82, this shows that Barts NHS Trust is purchasing a higher proportion of the smaller PICO sizes, as the average selling price for PICO™, across all 10 sizes is £149.52. Therefore, ensuring a more accurate expenditure assumption.

In terms of the data captured, efficiency outcomes can be clearly shown and communicated to a wider NHS stakeholder audience. The ability to manage complex wounds within an outpatient setting enables beds to be allocated to patients requiring inpatient care. This is acutely important as it enables patient flow to continue, reduces bed blocking and cancellation of procedures due to lack of beds. WUK

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Conflict of Interest

Mr Edwards and Mr Bourke are engaged in consulting agreements with Smith and Nephew UK and Ireland. Dr Murdoch and Mr Verma are employees of Smith and Nephew UK and Ireland

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