Application of quality improvement techniques to reduce parenteral nutrition wastage in a national intestinal failure unit

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ABSTRACT

Objectives Parenteral nutrition (PN) costs approximately £80 per day per bag. Unpredictable changes in patients' clinical condition, venous access loss or reasons related to the processes involved in administering PN can lead to PN wastage. Cost efficiencies are imperative to optimise limited resource utilisation in all current healthcare economies. We undertook a quality improvement (QI) project to reduce PN wastage in an adult acute hospital setting. The project SMART's (specific, measurable, achievable, realistic, time-based) objective was reducing in-patient PN wastage by 10% in 9 months using QI methodology on a national intestinal failure unit (IFU).

Method Wastage reasons were evaluated through pareto charts to target waste reduction using 'Plan, Do, Study, Act' (PDSA) cycles. Variation was mapped using c-charts.

Results 12-week baseline wastage data predicted 1000 bags wasted per annum (p.a.). PDSA cycles actioned included: regular enhanced clinical team awareness of wastage; unused PN bags redistributed within expiry date; stock bag rotation; critical path analysis of PN bag journey; enhanced discharge planning/coordination; reorganisation of fridge PN storage according to weekday; changing ordering frequency and bag type (from tailored to standard) to increase flexibility around discharge date and PN weaning. Implementation of PDSA cycles led to a 34% reduction in PN wastage in 9 months.

Conclusion In a high-use IFU, PN wastage is common and costly. Using a QI approach with concurrent PDSA cycles and a motivated multidisciplinary team, high levels of wastage reduction are possible with associated significant cost savings and from this study a predicted cost saving of approximately £30 000 p.a.

INTRODUCTION

Malnutrition is the third largest cost facing the National Health Service (NHS); as such, there is an increasing need to recognise and treat this condition.¹ Intestinal failure (IF) occurs due to a spectrum of conditions resulting in a severe form of malnutrition, whereby there is '... reduction of gut function below the minimum necessary for the absorption of macronutrients and/or water and electrolytes, such that intravenous supplementation, using parenteral nutrition (PN), is required to maintain health and/or growth'.²⁻⁴ However, the provision of PN is not only costly, it can be associated with waste for a variety of reasons, such as sudden

changes in the clinical condition of the patient, loss of venous access and/or reasons related to the processes involved in administering PN. Because patients with IF have complex medical, surgical and psychological needs that vary on a day-to-day basis,⁵ it can be difficult to predict PN needs and deliver PN in a routine manner, such that wastage of PN can be high in this group of patients. In addition, the current economic climate in the UK has caused efficiency savings within the NHS to become priority through both government policy⁶ and operational productivity.⁷ PN is manufactured in an aseptic unit, either locally within the Trust or in a commercial unit, and nationally there is reduced aseptic capacity so prevention of wastage is critical to ensure aseptic capacity is used appropriately. We undertook a rigorous assessment of wastage of PN within a national IF Unit (IFU) and used a quality improvement model to bring about reduction in waste. The applicability of this work goes further than a national IFU and would also apply to both nutrition support teams caring for patients with all types of IF and to centres providing aseptically produced medication, such as chemotherapy.

METHODS

Context

Salford Royal NHS Foundation Trust is a large (850 beds) acute university teaching hospital in northwest England providing inpatient care to over 3 00 000 patients per year. Alongside other tertiary care, Salford Royal currently provides one of the two national IFUs with adult patients referred from all over the UK and beyond, and provides specialist medical, surgical and allied health professionals' care to these patients in a multidisciplinary setting. This project was run as part of an ongoing commitment by the IFU and hospital to QI work. The PN bags that are used on the unit include both standard bags and tailored bags for an individual patient; wastage occurred for both bag types.

Interventions

The project was carried out using QI methodology: asking the questions about what was trying to be accomplished, how a change would be recognised as an improvement and what changes can be made that will result in an improvement.⁸ The team consisted of nurses, pharmacists, dieticians, doctors and a project manager; together we drew up a driver diagram to articulate the aim of the project and develop strategies for measurement and from

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Figure 1 Driver diagram used to understand mechanisms for reducing waste. These are the key areas that need to be tackled to ensure success of the project (primary drivers) and the detailed problems or potential problems causing the primary driver (secondary driver). PN, parenteral nutrition; MDT, multi-disciplinary team.

the secondary drivers developed areas to test change using plan-do-study-act (PDSA) cycles.⁹ The team met on a fortnightly basis to review data and tests of change to ensure tests became implementable solutions.

The four primary and secondary drivers for change to reduce wastage were determined (figure 1). First, 'Communication': the areas to be targeted included daily team meetings where all patients' current clinical needs and future plans were discussed including the main PN round, where patients' daily requirements were discussed and orders submitted for the following days' prescriptions. In addition, communication with patients and families was enhanced to facilitate changes in prescription and/or direction of care. Second, 'Education and Training': the wider clinical team needed education about the wastage, the role everyone had in reducing waste including using patient and family assistance ('Patient Family triggers') in maintaining therapeutic concordance with the PN prescription. Due to the psychological burden that IF places on a patient, demotivation to keep to strict food/ fluid intakes or to keep exemplary line care risks harm for the patient; however, motivation can be reinvigorated by timely support from family or friends. Third, 'Process Reliability': we needed to undertake a critical path analysis of the entire PN process from reporting of changes in a patient's clinical/biochemical parameters through all the relevant steps to safe administration of the correct PN bag to the correct patient, or to stop PN if indicated. Finally, 'Data and Measurement': the team sought to improve the recording of wastage (ruination). These then informed the improvement work by guiding PDSA cycle development (table 1).

The underlying aetiology of waste was determined through collecting baseline data. The waste was collected using the bag

sleeves that were left in a labelled bin to collect the wastage as it happened in the PN preparation room. The staff nurses were also instructed to write on the sleeve why the wastage occurred. Once the reasons for baseline waste were identified, these were subdivided into nine groups to give meaningful overarching data streams to measure.

Group 1: 'Not on ward'. This included patients discharged, self-discharged, died, on home leave, on a night off PN, transferred to another hospital or had had a delayed admission.

Group 2: 'Weaned off PN'. This included those patients to whom PN was supplied although it had been deemed this was no longer clinically indicated.

Group 3 included 'Clinical issues' such as electrolyte abnormalities that necessitated a prescription change.

Group 4: 'Operational'. This included cases where the PN had not been prescribed by the medical team, an error with the PN prescription, the PN had expired or a duplicate bag had been removed from the fridge so it could not be returned to the fridge.

Group 5 included all 'Catheter complications' from infection to occlusion, fracture or loss of peripheral access, whereby the PN could not be administered.

Group 6: 'Equipment or human error'. This included events such as equipment failure, faulty bags or pumps or inadequate refrigeration.

Group 7 included 'Clinical events' that prevented PN from being administered, for example an acutely unwell patient, where it was deemed unsafe to administer PN.

Group 8: 'Refused'. This included cases where the patient had refused to receive PN.

Group 9: 'Unknown'.

Table 1 PDSA cycles attempted according to the time of trial and driver category

Month	Driver			
	Communication	Education and training	Process reliability	Data and measurement
13 November		Awareness and additional waste recording	PN stock rotated in fridge	Stratification of data into significant categories
13 December			Identification of potential script changes	Regular review meetings commenced
14 January	PN waste discussed at daily PN meeting		Bloods list available for review at daily meetings	
14 February	Daily review of patients for potential script changes		PN wastage discussed at twice weekly bed planning meetings	
14 March	Evaluation of all script changes (Can existing stock be used up first?)		Weekday activity scheduled with key MDT leads	Productive PN meetings
14 April	Relabelling unused bags where appropriate	Progress report provided as part of nurse away days	Use of stock bags for appropriate/stable patients weaning off PN	
14 May				Regular data distribution
14 June	PN waste discussed at daily safety rounds			
14 July		Critical path analysis of PN bag journey	Ward staff cross-referencing with daily PN requirements	
14 August			Organisation of PN into weekday sections in fridge	
14 September			Pharmacy confirming advanced PN ordering (>3 days) with IFU medical team PN delivery team rotating stock bags (oldest to top)	

The dates are months of the project and what PDSA cycles occurred in each month. The columns are then the PDSA cycles that occurred within each of the four main drivers from the driver diagram.

IFU, intestinal failure unit; PDSA, plan-do-study-act; PN, parenteral nutrition.

Study of the interventions

The primary outcome (SMART objective) was a reduction in wastage of PN bags by 10% between March 2014 and December 2014. The 12-week baseline took place from 14 October 2013 to 5 January 2014, but due to better clarity with results, we have used 2-week data. To provide background data on system variation 8–12 data points have been used, hence the extension of the ‘baseline’ to March 2014. This has not impacted the data as no change in the variation was observed during the first 6 months. In addition, this was despite commencing three initial steps (hence the commencement of PDSA cycles in November 2013) to ensure robustness of data collection. The majority of PDSA cycles occurred from 6 January 2014 until December 2014. To capture changes in waste within the system and in a way that reduced the risk of bias that any particular patient could have exerted, the pareto charts (figures 2A,B) covered two disparate groups of dates as specified. The extension of the data beyond the time of the period of study has demonstrated sustained waste reduction rather than finishing at the end of the project and seeing a return to baseline.

Using Excel (Microsoft) spreadsheets, data were continuously collected, collated and reported using Statistical Process Control (SPC) charts. The latter provided overview of system variation and enabled the recording of extreme variation, termed ‘special cause variation’.¹⁰ Key data collected included number of bags wasted and reason for wastage. Balancing measures of inpatient length of stay and readmission rate were used to ensure that changes made did not adversely impact the running of the IFU (see online supplementary figures 1 and 2).

Data analysis

QI Macros (KnowWare International, Denver, Colorado, USA) was used to create SPC charts. Standard control chart methods were used to interpret patterns of variation in data over time.

Non-random patterns (special cause variation) were predetermined using standard definitions.¹¹ SPC charts were used to record data where high scores reflected poor waste management, but lower scores demonstrated improved waste management. Shifts in mean data were determined a priori using standard operating principles.

Ethical considerations

As this was a QI project, aimed at service improvement, ethical approval for the study was not necessary, as no direct patient data were recorded, and this was an assessment of processes within a system.

RESULTS AND EFFECTS OF CHANGE

Over 12 weeks, baseline data provided indicative results for the the most common causes of wastage. Having identified the nine primary reasons for wastage (see earlier), a pareto chart, figure 2A, was used to determine the the most common reasons for wastage, which, if tackled, could provide the highest gains in reducing waste. In 76% of episodes, ruination was caused by four categories: ‘Not on ward’ (Group 1); ‘Operational’ (Group 4); ‘Clinical issue’ (Group 3) and ‘Unknown’ (Group 9). Cases where the reason for waste was not recorded were placed in the ‘Unknown’ category (Group 9); we anticipated that by targeting high cause reasons, the unknown category would likely contain some of those too so would naturally reduce, which was demonstrated in figure 2B.

A 34% reduction in total wastage from an average of 24.9 bags to 16.5 was achieved, exceeding the original targeted reduction (figure 3). The significant reductions in causes of wastage that resulted in a shift in the mean wastage were as follows (figure 4): reducing wastage for ‘Clinical issues’

Figure 2 Pareto chart of aetiology of waste (A) prior to onset of project and (B) during project. This graph depicts each of the causes of waste and what proportion of the total each made up. It provides a pictorial information as well as numerical. IFU, intestinal failure unit; PN, parenteral nutrition.

(Group 3) resulted in a 67% reduction in waste, from 3.1 bags to 1.0. 'Operational issues' (Group 4) had a 73% reduction, from 2.82 to 0.75 bags. The rate of wastage recorded as 'Unknown' (Group 9) also reduced by 74%, from 6.40 to 1.68 bags. In contrast, wastage occurring as a result of 'Not on the ward' (Group 1), 'Weaned off PN' (Group 2), 'Catheter complications' (Group 5), 'Equipment/human error' (Group 6), 'Clinical events' (Group 7) and 'Refused' (Group 8) were not observed to change during the project.

DISCUSSION

Summary

The cost of providing PN for patients with intestinal failure is high, due to long periods in hospital recovering from, sometimes, catastrophic life events.⁵ This is the first publication of an attempt to

reduce this cost by reducing wastage of PN bags by using QI methodology. The key interventions leading to a successful reduction of wastage included effective communication, efficient organisation of the flow of PN bags and effective multidisciplinary working. The application of this waste reduction reaches further than just to PN for patients with IF but could also be applied to central cytostatic preparation or other aseptically prepared medicines. In addition, as this project was completed within normal working hours, without any additional staff recruitment and was given the opportunity to present the data to members of the trust executive, implementing QI methodology should be facilitated wherever possible.

Interpretation

While the individual PDSA cycles were not solely responsible for observed waste reduction, three key strategies will be

Figure 3 SPC chart assessing overall ruination. This is the run chart looking at a change in waste over time. It has mean with 1–3 SD from the mean. There is a reduction in the mean once there are sufficient points below the mean to demonstrate a change in outcome. IFU, intestinal failure unit; PN, parenteral nutrition; SPC, Statistical Process Control.

highlighted. First, we implemented a very simple organisational change of the PN fridge: PN had previously been placed in a random way within the fridge on delivery but subsequently was segregated into day of administration. This reduced time finding bags both for nurses during administration preparation and for pharmacists to find unused bags for relabelling if appropriate to be used for another day. This change also reduced the risk of preparing an inappropriate bag for administration. Although this required more time on delivery of the PN bags, this extra time was markedly offset by both time saved during daily PN preparation and the number of bags wasted.

The second key change involved improved communication surrounding anticipated discharge date. Due to the complex nature of the patients' clinical needs, patients' mean length of stay was relatively long at 44 days,¹² such that the anticipated discharge date could move multiple times prior to final discharge, placing excessive burden on the local PN pharmacy compounding unit having to make daily bags rather than pre-ordering PN for a number of days. As patients' conditions stabilised and discharge was planned, PN prescriptions were proactively changed to standard bags, liberating compounding slots for other patients and providing greater flexibility in discharge planning without compromising patient safety or wastage.

The third key change was using the wider MDT. This strategy took many different forms: daily multidisciplinary prescription meeting required all healthcare professionals to be represented (doctors, nurses, dieticians and pharmacists); the twice weekly bed planning meetings were used to discuss admissions and plan for suitable discharges by senior members of the medical and nursing teams and unit manager; PN wastage was highlighted at the daily midafternoon nursing shift safety board rounds. This MDT approach provided multiple layers to cross-check that the correct PN prescription was for the correct patient at any given moment, incorporating their current health status as well as

biochemical and physical parameters to ensure that PN was not wasted. In addition, the regular MDT review provided useful insight as to the success, or not, of tested PDSAs.

In addition to these key points, although overall waste may see a reduction from April 2014, at the individual level for each of the causes this may not reach a statistical significant result, that is at least eight points below the mean, until a later date at which point a change in the mean can be observed. This results in the disparity of the data for the different groups as observed in figure 4.

Limitations

One of the key limitations within QI projects is the impact that studying a topic has on human behaviour: if people know data collection on wastage is occurring they may change what they do to either reduce wastage reported due to either being more reluctant to record wastage or to acknowledge wastage occurs or they may try hard to reduce wastage outside of the PDSA cycles being implemented. This creates a risk of bias within the observation of what works. The changes described here are not to be taken as a formulaic list of changes. Instead, implemented changes were seen as part of the whole improvement strategy made up of multiple steps. While the changes outlined here are specific for our service, and may well be applicable to other units, each centre should test the changes locally. The key to delivering this QI project was motivated staff who shared a common goal of improving patient care. Special cause outliers, that is, sudden unexpected events that are out with normal variation,¹¹ will continue to exist within this system. This is because the interventions undertaken would not remove these, and by nature of the fragility of intestinal failure patients, unexpected exceptions will occur that result in higher than anticipated wastage, such as the temporary increase in patients' refusals to receiving PN. Further

Figure 4 SPC charts for each category of waste. These individual charts provide the information for each of the categories of waste and demonstrate which ones had a successful reduction in wastage. PN, parenteral nutrition; SPC, Statistical Process Control.

work is ongoing to further reduce PN wastage, particularly in those areas where ruination did not change in this project (eg, enhanced communication to ensure waste does not occur when the patient is 'not on the ward' and enhanced understanding that every blood result change does not necessitate a new bag for 'clinical issues'), recognising that some factors leading to wastage

(eg, clinical events, catheter complications, patient refusal) are less readily affected by the clinical team.

CONCLUSION

This project has demonstrated that QI methodology is an appropriate mechanism to reduce PN wastage and in our unit. Further work is ongoing to sustain and further reduce PN wastage. The key components in reducing waste relied on enhanced communication, building team ownership through regular meetings to review data and plan changes and through feedback to the wider MDT of the results of changes made. The strategies adopted in this study could be applied to other IFUs and to units handling individualised treatments where the cold chain is imperative, such as chemotherapeutic agents.

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Contributors SL, MT and PJA conceived the project; PJA, AR, MT, CG and CH devised and performed tests of change; MT collected the data; PJA, AR, MT, CG and CH analysed data; PJA wrote the manuscript; SL and LH edited the manuscript.

Competing interests PJA has been a consultant for Abbvie and Bresmed, he has received educational grants for travel to conferences from Norgine, Abbvie and NPS Pharma. The other authors have no competing interests to declare.

What this paper adds

What is already known on this subject

- ▶ Parenteral nutrition provision is costly.
- ▶ Ruination of parenteral nutrition occurs commonly.

What this study adds

- ▶ Quality improvement methodology can reduce parenteral nutrition ruination.
- ▶ Communication: Key to quality improvement.
- ▶ Team ownership: Regular team meetings to review data and plan changes led to improved wider team feedback.
- ▶ Wider team feedback: Visible improvements and feedback to wider team resulted in increased awareness and enthusiasm for project.

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