Original Article

Journal of Infection Prevention

Journal of Infection Prevention
1–7

DOI: 10.1177/1757177418780986
jip.sagepub.com
SAGE

Retrospective analysis of the Photo at Discharge scheme and readmission for surgical site infection following coronary artery bypass graft surgery

Melissa Rochon, Sian Jenkinson, Reeshma Ramroop, Alexia Deakin, Padma Rai, Katie Healy, Russel Lukban, Alison Soppa, Kavita Bhugun, Cheryl Lavack, Nikki Fuller, Carlos Morais and Shahzad G Raja

Abstract

Background: Surgical site infection (SSI) is a costly and devastating complication of surgery. Many cardiac SSIs develop after the patient leaves hospital, but evidence demonstrating the benefit of patient/carer involvement in the process of monitoring and promptly identifying SSI post-discharge is limited. This study estimates the probability of readmission for SSI for coronary artery bypass graft (CABG) patients receiving the Photo at Discharge (PaD).

Methods: Trained personnel undertook continuous, prospective SSI surveillance using Public Health England protocol between January 2013 and December 2016. Baseline covariables were collected for 1747 CABG-only procedures. As a quasi-randomised design, we adjusted for non-random PaD assignment using retrospective propensity score (PS)-matching based on 12 variables of interest, assessed whether the model had been adequately specified and performed an outcomes analysis.

Results: A total of 568 patients with PaD were PS-matched with 568 controls. The probabilities of SSI readmission were 0.352 (2/568) and 1.761 (10/568), respectively. The difference in risk of readmission for SSI was significant (relative risk = 0.2, 95% confidence interval = 0.04–0.91; P = 0.04).

Conclusion: Findings from this single-centre observation study suggest the PaD is associated with a reduction in CABG readmission for SSI and a further study is warranted to verify the efficacy of this strategy.

Keywords

Surgical site infection, patient experience, CABG, readmission, photograph, SSI prevention

Date received: 28 March 2018; accepted: 18 April 2018

Background

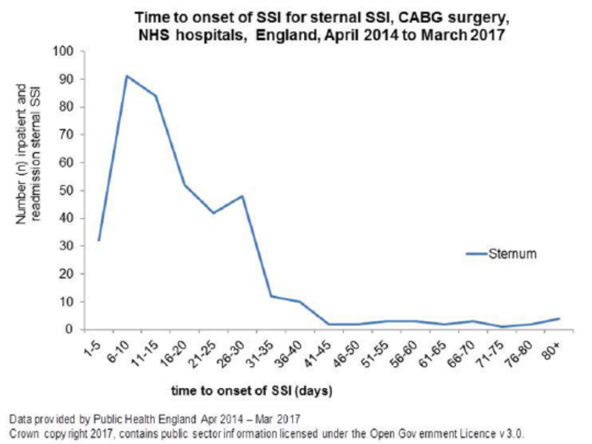
Surgical site infection (SSI) is a devastating complication, associated with increased mortality and morbidity, as well as distress, pain and suffering (Tanner et al., 2012). Patients with SSI are five times more likely to be readmitted to hospital and cost the global economy billions (World Health Organization [WHO], 2016). Additionally, SSI may result in litigation, impact on public perception of care and/or impact on hospital reputation (Birgand et al., 2013). For these reasons, SSI are considered a significant quality and cost control metric for clinicians, hospitals and policy/strategy makers (Merkow et al., 2015).

Importantly, approximately 60% of SSI appear after the cardiac patient leaves hospital (Woelber et al., 2016), typically presenting within first two weeks (Sanger et al., 2017). This is reflected in the national surveillance data on sternal SSI. Public Health England ([PHE], 2013) protocol

Royal Brompton and Harefield NHS Foundation Trust, Harefield, UK

Corresponding author:
Melissa Rochon, Surveillance Team, Royal Brompton & Harefield NHS Foundation Trust, Harefield Hospital, Hill End Road, Harefield UB9 6JH, UK.
Email: m.rochon@rbht.nhs.uk

Figure 1. Time (days) to onset of SSI for sternal SSI, CABG surgery.



records superficial sternal SSI up to day 30 and deep or organ-space SSI up to one year, as sternal wires are considered implants requiring extended period of surveillance due to presence of foreign material. The PHE data suggests that 1.7% of coronary artery bypass graft (CABG) patients are readmitted with sternal SSI (323/18,491, April 2014 to March 2017 CABG module) (Figure 1).

The occurrence of post-discharge infection may be due to the time it takes for bacteria to elicit host response (i.e. signs of infection to appear) (Weston, 2010), delay in seeking treatment, and/or as a result of the fragmented communication shared between acute and community care (Clinton and Obama, 2006), all of which could lead to potentially avoidable readmission (Sanger et al., 2017).

However, evidence for patient education on reducing SSI risk is lacking (National Institute for Health and Care Excellence [NICE], 2013). An Australian randomised controlled trial reported that patients who received verbal and pictorial education on SSI, over-reported infections as compared with the non-educated group (Whitby et al., 2007). The practical implication of the study was to keep patient-reported SSI distinct from 'standard' SSI surveillance data of detection on primary admission or on re-admission. Readmission rates for SSI were not considered in the Whitby study and information on patients readmitted was not provided. A primary driver for the Photo at Discharge (PaD) is to improve the quality of information given to patients and carers on infection prevention and assistance to monitor for wound change.

An example of PaD is provided in Figure 2. Each patient receiving a colour picture of their surgical wound on the day of discharge, as distinct from generic information generally given on SSI prevention. PaD is a practical tool to help determine whether the wound is improving or deteriorating, potentially helping to persuade patients to take action if wound deteriorates (Coleman et al., 2004; Trimble, 2016). We have previously reported positive patient feedback on the scheme and used a quality improvement approach to demonstrate a reduction in readmission SSI in CABG and general cardiac patients (Rochon et al., 2016).

The aim of this observational cohort study was to use propensity score (PS)-matching to compare outcomes of those who received the PaD with a similar group of patients who did not receive the intervention and determine if PaD reduces readmission for SSI and inform our clinical practice. PS matching creates matched sets of treated and untreated individuals with similar PS values and reduces selection bias (Austin, 2011).

Methods

This study comprised a retrospective analysis of a prospectively collected cardiac surgery data (PATS; Dendrite Clinical Systems, Ltd, Oxford, UK) as well as continuous, active surveillance data of cardiac surgical patients at one hospital site.

Between January 2013 and December 2016, data from 1757 CABG surgery (i.e. no additional surgical procedure) adult patients were collected for the PaD, a registered quality improvement project with the Trust. All CABG-only cases were included. The study was approved by the institutional ethics committee and informed consent was waived for this study due to its retrospective nature; however, consent for PaD was obtained from all patients who received the intervention. The data for all measured baseline covariates were collected and reported in accordance with the Society for Cardiothoracic Surgery in Great Britain & Ireland database criteria. Patients in the control group did not receive PaD for one of the following reasons: the intervention was not available (staff not trained), patient declined intervention, (three patients) or technical difficulties (photo could not be taken and/or uploaded to be given to the patient). The data on SSI were gathered prospectively via continuous surveillance process, by trained surveillance nurses using the PHE surveillance protocol for sternal SSI (PHE, 2013)

As advised by Olmos and Govindasamy (2015), we assessed the crude data using an outcome model based on the treatment variable only (t test). Next, ten operations were removed from 1757 CABG operations due to missing variables (Rankin, 2014). We used a logistic regression model to estimate PS associated with PaD at primary discharge versus no PaD on primary discharge as dependent variable and all covariates as independent variables. Twelve variables of interest were identified as relevant to CABG SSI (Korol et al. 2013) (listed in Table 1) and checked using multiple regression; the final model included all the variables (significant and non-significant) (Olmos and Govinasamy, 2015).

Figure 2. Example of Photo at Discharge (PaD).

A lifetime of specialist care

Royal Brompton & Harefield NHS

NHS Foundation Trust

Mr J Blogg XX-XXX
NHS NUMBER XXX XXX XXX

29/7/2015 no outstanding sternal swabs at discharge. Normal swelling at the top of wound which will resolve over a few weeks. Sternal wound is clean and dry on the day of discharge. Drain sutures to be removed DD/MM/YY and clips to legs to be removed DD/MM/YY.

Advice to Mr Blogg

*Full, daily shower with liquid soap. Water and liquid soap is fine to roll over wound bed, but avoid very hot water and/or soaking the wound and do not rub wound (there is a bit of dried blood/scab, which will come away over time). Pat the sternal wound dry with clean towel gently first, then dry rest of body. If present, incision(s) on the leg are also surgical wounds and need to be treated in the same manner, using a separate towel to dry.
*Support your wound when coughing and if possible, turn your head so that coughing directly over the wound is avoided.
* The bottom of the wound is particularly vulnerable due to heat used during surgery. Good posture and regularly standing will reduce pressure on the area.
*Protect the sternal wound with careful movement; when possible please sleep on your back, avoid over-reaching/stretching (including during hair wash) and use your arms for balance when moving to standing position, rather than pushing /supporting weight.
***Wash hands frequently and avoid touching wound.** A healing wound may be itchy (especially if there is hair regrowth) but avoid urge to scratch. Regular hand washing will reduce the risk of infection

PLEASE USE THIS PHOTO TO MONITOR for any signs of infection, including new or increasing heat, redness, pain or swelling around the wound or any gaping or fluid leaking from the wound. Sternal 'clicking' or high temperature should also be reported.

Please contact your GP or Mr Surgeons' secretary (XXXXXXX XXXX) **immediately** if you think your wound might be infected. Treating an infection early helps stop it from becoming worse or lasting longer than it should. If your doctor suspects you have an infection, take the antibiotics as advised. If you don't take antibiotics at the right time or complete the course of antibiotics there is a risk that the bacteria will become stronger and harder to treat. If your wound concern does not appear to be improvement despite a course of treatment, please contact us. **This information does not replace advice or assessment by surgical team or other Health Care Worker.** If you are prescribed antibiotics for a wound infection and the wound does not appear to be improving after a few days, contact your surgical team in hospital.
Colour copy of this information to the patient. Electronic copy on EPR.

BHIS

Consent for photo______________________________(patient or guardian signature)

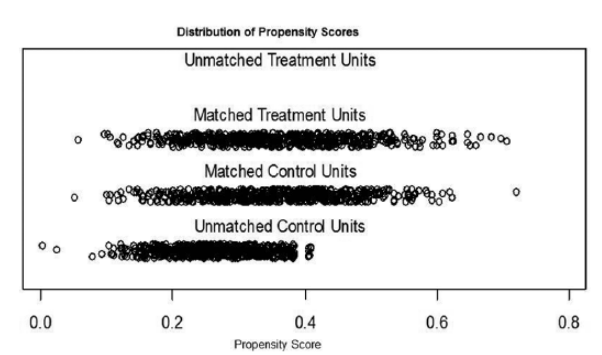
PS matching analysis was performed using R (http://CRAN.Rproject.org/package=nonrandom) and MatchIt package (Ho et al., 2011). PS matching was performed using the 'nearest neighbour' matching algorithm with a specified calliper distance of 0.25 and a 1:1 ratio of unexposed to exposed without replacement. Next, the characteristics of excluded cases were checked to ensure the matched sample was representative. Following on from this assurance, the distribution of propensity scores for each group was examined for balance. The quality of the match was assessed by comparing selected variables in PS — matched patients using the standardised mean difference (SMD), by which an absolute standardised difference > 10% is suggested to represent meaningful covariate imbalance

Table 1. Unmatched and matched variables with standardised mean difference.

	Unmatched			Matched	
Variable	PaD (n = 568)	No PaD (n = 1179)	SMD	No PaD (n = 568)	SMD
Vein (mean (SD))	1.07 (0.42)	1.15 (0.42)	0.205	1.07 (0.39)	0.004
Gender (mean (SD))	0.17 (0.38)	0.18 (0.38)	0.019	0.17 (0.37)	0.014
Age, years (mean (SD))	65.34 (10.19)	65.73 (10.30)	0.038	65.38 (10.63)	0.004
Diabetes (mean (SD))	0.79 (1.12)	0.72 (1.09)	0.057	0.77 (1.12)	0.017
Smoking (mean (SD))	0.74 (0.67)	0.76 (0.63)	0.022	0.78 (0.63)	0.052
Emergent surgery (mean (SD))	0.45 (0.55)	0.45 (0.56)	0.006	0.45 (0.57)	<0.001
Renal function (mean (SD))	0.58 (0.67)	0.55 (0.64)	0.035	0.57 (0.64)	0.008
CPB (mean (SD))	0.61 (0.49)	0.71 (0.46)	0.208	0.61 (0.49)	0.004
IMA (mean (SD))	1.13 (0.61)	1.12 (0.47)	0.018	1.11 (0.43)	0.027
BMI (mean (SD))	0.12 (0.32)	0.11 (0.31)	0.03	0.11 (0.32)	0.011
DurOp, min (mean (SD))	221.62 (63.88)	238.97 (69.91)	0.259	223.96 (65.00)	0.036
Stay, days (mean (SD))	9.53 (7.49)	10.16 (7.74)	0.083	9.77 (6.53)	0.034

SMD, standardised mean difference; vein, open or endoscopic vein harvest; CPB, cardiopulmonary bypass; IMA, internal mammary arteries; BMI, body mass index; DurOp, duration of operation; Stay, length of primary hospital stay.

Figure 3. Distribution of propensity scores.



(Normand et al., 2001). As SSI readmission is a binary outcome, we used relative risk and confidence interval to measure the association from the structure, and finally we calculated Number Needed to Treat (NNT).

Results

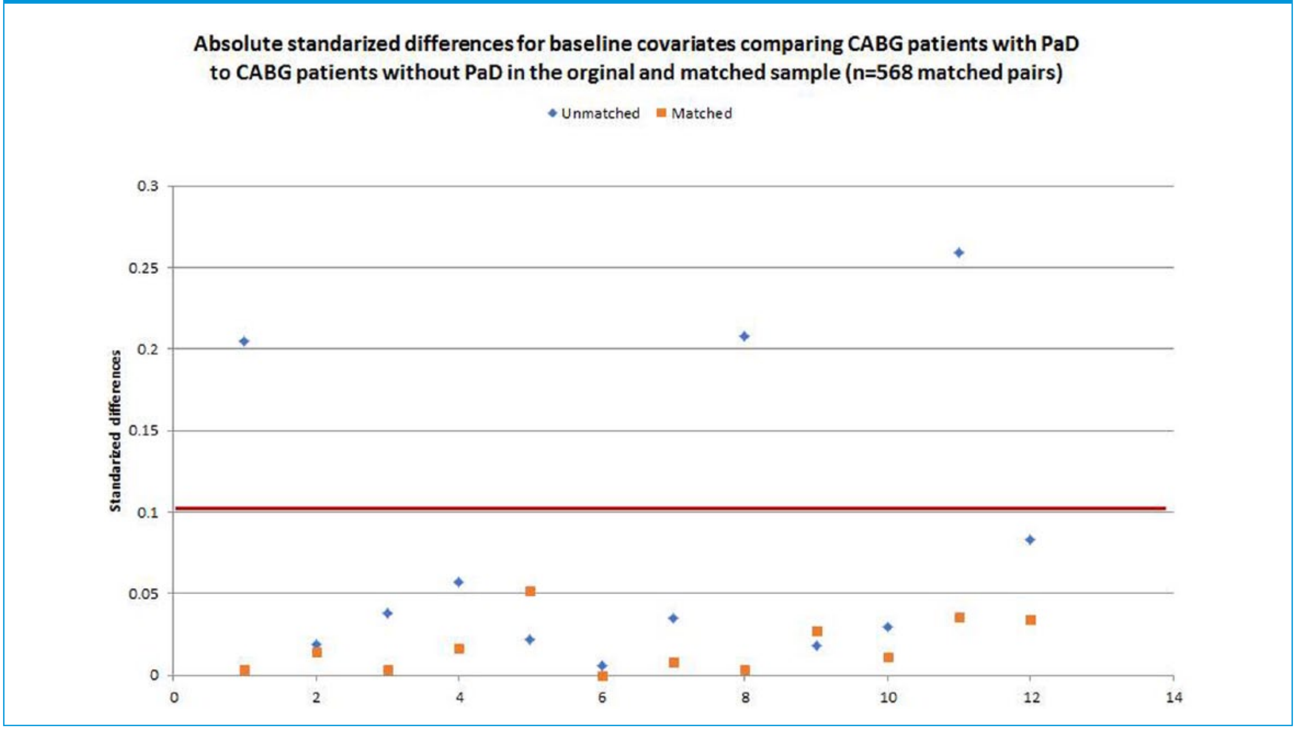
A total of 568 CABG patients who received PaD on the day of discharge were matched with 568 CABG patients without PaD. Potential confounders were assessed. Variables in the treated and control units were almost identical and p values demonstrated that differences were not significant. Figure 3 shows that most of the non-matched individuals were in the lower part (0.1–0.4) of the propensity scores, with none in the higher range (⩾ 0.5). Figure 4 (graphical approach) and Table 1 (statistical approach) shows that all the critical variables have been balanced, i.e. the matched sample had standardised differences for each covariate < 0.10. Thus, the study design is adequately specified. Without assuming normal distribution, the paired dependent data were confirmed as non-significant using McNemar's test for sensitivity analysis and the null hypothesis was accepted for the matched data structure (Austin, 2011).

In this matched sample, two PaD participants and ten non-PaD participants were readmitted for confirmed sternal SSI as per PHE protocol. The probabilities of SSI readmission were 0.00352 (2/568) and 0.01761 (10/568), respectively. The absolute reduction in the probability of sternal SSI readmission following CABG was 0.01408. There was a significant difference in risk of readmission for SSI (relative risk = 0.2, 95% confidence interval [CI] = 0.04–0.91). This suggests that PaD reduced the risk of SSI readmission by 80% and that this was statistically significant ($p = 0.037$). The NNT, the reciprocal of the absolute risk reduction, was 71. Thus, 71 patients would need to receive PaD in order to avoid one SSI readmission. This analysis suggests that the provision of PaD reduced readmissions for sternal SSI in CABG patients at our hospital site.

Discussion

We have used PS matching on observational data to estimate or infer a causal effect and our findings suggest that

Figure 4. Absolute standardised differences for baseline covariates.



PaD at the time of discharge (CABG primary admission) reduces the risk of readmission for SSI. Important considerations in this study are that the PS model had been adequately specified, that there was sufficient overlap between the two groups and that there were no systematic differences in the distribution of covariates between the groups, as assessed by the standardised difference and graphical methods (Austin, 2011). The model was developed independently of the outcome (SSI readmission) (Olmos and Govindasamy, 2015). We have included baseline variables which do not affect exposure (and are not influenced by it) but which empirical evidence suggests affect outcome. This approach aims to reduce selection bias and over-estimating the treatment effect (Austin, 2011). We have attempted to determine all the reasons why participants may or may not have received PaD to achieve as full an account as possible in order to include variables for CABG SSI before undertaking PS matching.

This analysis supports our previously published work on PaD which suggested that patients find having the photo reassuring (it increases their confidence in caring for the wound) and that the photo is used to help determine changes/prompt action (Rochon et al., 2016). Our audit data suggest that the majority of patients find the scheme useful. In addition, we obtained general practitioner (GP) feedback from GPs: 95% of GPs (18/19) said that PaD was useful and 36% of GPs (7/19) indicated that PaD may help them with decision-making for antimicrobial therapy (registered audit, CIRIS Project ID:002197).

It may be difficult for patients with a median sternotomy to view the length of their wound while in hospital, either due to a lack of full length mirrors and/or the increasingly frequent practice of covering the wound up to day 5 (cardiac patients typically have some degree of exudate due to increase fluid weight gain up to day 4) or discharge. A photo and accompanying electronic assessment can be reviewed with the nurse at the time of discharge and explained so that the patient is familiar with the wound appearance and assessment (for example, please see Web appendix 1). Elsewhere, we have reported the importance of quality control and monitoring of the photos to ensure usability and quality of the images (Rochon et al. 2017). Multiple studies suggest that photos can help to accurately identify SSI and more so in excluding SSI (Engel et al., 2011; Murphy et al., 2006; Sanger et al., 2017; Saunders et al., 2016; Wirthlin et al., 1998; Wiseman et al. 2015). Interestingly, from the studies the wound characteristic most difficult to accurately identify in photos is redness/erythema. It may be that without in-person assessment, it is difficult to assess skin temperature or induration (Wirthlin et al., 1998). Wiseman et al. (2015) suggest that this may be due to pre-existing skin appearance, including dependent rubor, normal discolouration of healing process or venous statis changes. We postulate that a baseline photo (i.e. at discharge) may help to reduce this difficulty.

SSI prevention strategies need to consider their role in reducing avoidable demand for emergency admissions (NHS England, 2014), as well as demonstrate their impact on quality and productivity within the *Getting It Right the First Time* (GIRFT) programme. However, a systematic review in 2011 identified multiples challenges in reducing 30-day re-admission (Hansen et al, 2011). Sanger et al. (2017) suggest that patients report that they are poorly served by standard discharge advice to identify wound concerns. PaD is a simple idea which aims to address the insufficient information on SSI and inadequate post-discharge information on the wound (Pieper et al., 2007; Seaman and Lammers, 1991; Tanner et al., 2012) and instead capitalise on the pivotal role the patient plays in SSI prevention between acute and community care.

This work has several important limitations. First, the work arises from a single hospital site and this may impact on the generalisability of the findings. PS matching does result in a loss of sample size: 35% of the total sample were not matched due to the total number of patients with PaD. However, we did not have a sample size several times larger than the number of individuals in the PaD group to increase the matching (m-to-1 matching). We are reassured that < 1% of analytic sample was excluded due to missing values on covariates but in future, multiple imputation methods will be explored to minimise the impact of missing data. Although our surveillance programme has continuously and prospectively collected SSI identified on readmission, we do not collect data on patient-reported SSI as our experience suggests this approach does not significantly alter our SSI rates (Rochon and Morais, 2013). We are unable to determine how much the change in rate of readmission for sternal SSI was influenced by changes in surgical technique or practice, prompted by the knowledge that the photo would be taken following the surgery. Web appendix 2 and Web appendix 3 demonstrate trends which can be detected with PaD).There may be unmeasured confounders not taken into account and this can affect the accuracy of causal relationships. Smith et al. (2000) point out that there are still gaps in knowledge as to how microbes cause SSI, as many of the SSIs which develop after discharge do not always reflect traditional risk factors. Finally, retrospective analysis is no replacement for randomised control trial. We have attempted to draw from a reasonable time period (three years) to appraise the performance of the PaD intervention.

In this study, we have estimated the PS using logistic regression before using a matching algorithm. Covariate balance was assured via two methods (observationally and using standardised absolute difference), and from the matched data we were able to estimate the treatment effect using relative risk and accompanying confidence intervals. To our knowledge, this study is unique in its analysis of PaD.

NICE guidance (74) and accompanying Quality Standard (49, statement 5) recommend that patients and carers are provided with information on their wound and wound care, signs and symptoms, and appropriate contact details to report concerns. Wiseman et al. (2015) suggest that the use of wound images is transitioning 'from informal clinical communication to becoming part of the standard care'. Our study suggests that a colour picture of the patient's own surgical wound at the time of discharge helps to provide a baseline for monitoring, which contributes to a reduction in severity and duration of SSI.

Conclusion

PaD is a novel strategy to reduce avoidable non-elective readmissions for SSI in the health service and organisation. Our findings suggest that the PaD is associated with a reduction in CABG readmission for SSI. However, a further study is needed to investigate how the PaD is used in the community if it contributes to antibiotic stewardship and if these results can be replicated in other patient groups.

Acknowledgements

The authors thank the surgical colleagues and nursing staff for their work on the Photo at Discharge scheme. The authors would also like to thank Public Health England for the contribution of data and Figure 1.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Peer review statement

Not commissioned; blind peer-reviewed.

ORCID iD

Melissa Rochon https://orcid.org/0000-0002-1101-2256

References

Austin PC. (2011) An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behavioral Research* 46(3): 399–424.

Birgand G, Lepelletier D, Baron G, Barrett S, Breier A-C, Buke C, Markovic-Denic L, Gastmeier P, Kluytmans J, Lyytikainen O, Sheridan E, Szilagyi E, Tacconelli E, Troillet N, Ravaud P and Lucet JC. (2013) Agreement among healthcare professionals in ten European countries in diagnosing case-vignettes of surgical site infections. *PLoS One* 8(7): e68618.

Coleman EA, Min SJ, Chomiak A and Kramer AM. (2004) Posthospital care transitions: patterns, complications and risk identification. *Health Services Research* 39: 1449–1465.

Clinton HR and Obama B. (2006) 'Making patient safety the centrepiece of medical liability reform'. *New England Journal of Medicine* 354: 2005–2208.

Engel H, Huang JJ, Tsoa CK, Lin C-Y, Chou P-Y, Brey EM, Henry SL and Cheng MH. (2011) Remote real-time monitoring of free flaps via smart phone photography and3G wireless internet: a prospective study evidencing diagnostic accuracy. *Microsurgery* 31(8): 589–595.

Hansen LO, Young RS, Hinami K, Leung A and Williams MV. (2011) Interventions to reduce 30-day rehospitalization: A systematic review. *Annals of Internal Medicine* 155: 520–528.

Ho DE, Imai K, King G and Stuart EA. (2011) MatchIt: Nonparametric preprocessing for parametric causal inference. *Journal of Statistical Software* 42(8): 1–28.

Korol E, Johnston K, Waser N, Sifakis F, Jafri HS, Lo M and Kyaw MH. (2013) A systematic review of risk factors associated with surgical site infections among surgical patients. *PLoS One* 8(12): e83743.

Merkow RP, Ju MH, Chung JW, Hall BL, Cohen ME, Williams MV, Tsai TC, Ko CY and KY Bilimoria. (2015) Underlying reasons associated with hospital readmission following surgery in the United States. *JAMA* 313(5): 483–495.

Murphy RX Jr, Bain MA, Wasser TE, Wilson and Okunski WJ. (2006) The reliability of digital imaging in the remote assessment of wounds: defining a standard. *Annals of Plastic Surgery* 56: 431–436.

NHS England. (2014) *NHS Five Year Forward View*. Available at: https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf.

NICE. (2013) *Surgical site infection: evidence update 43*. *June 2013*. London: NICE.

Normand SLT, Landrum MB, Guadagnoli E, Ayanian JZ, Ryan TJ, Cleary PD and McNeil BJ. (2001) Validating recommendations for coronary angiography following an acute myocardial infarction in the elderly: A matched analysis using propensity scores. *Journal of Clinical Epidemiology* 54: 387–398.

Olmos A and Govindasamy P. (2015) Propensity scores: a practical introduction using R. *Journal of Multidisciplinary Evaluation* 11(25): 68–88.

Pieper B, Sieggreen M, Nordstrom CK, Freeland B, Kulwicki P, Frattaroli M, Sidor D, Palleschi MT, Burns J and Bednarski D. (2007) Discharge knowledge and concerns of patients going home with a wound. *Journal of Wound, Ostomy and Continence Nursing* 34: 245–253.

Public Health England (PHE). (2013) *Public Health England. Protocol for the surveillance of surgical site infection*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/364412/Protocol_for_surveillance_of_surgical_site_infection_June_2013.pdf.

Rankin K. (2014) Analytic methods for evaluation: propensity score matching. Available at: http://www.citymatch.org/sites/default/files/documents/MCHEPITraining/Rankin_PropensityScoreMatching_WedsLateAfternoon.pdf (accessed 20 December 2017).

Rochon M, Makecha S, Morais C, Luff D, Richardson L, Persaud-Rai B, Tibbles S, Joseph D, Sriram V, Cowell G, Roberts A, Trimlett R, Yadav R, Raja S and Desouza A. (2016) A. Quality improvement approach to reducing readmission for surgical site infections. *Wounds UK* 12(2): 26–31.

Rochon M and Morais C. (2013) Response. RE: English hospitals under-report surgical site infections, survey shows. *BMJ* 346: f345.

Rochon M, Sanders J and Gallagher R. (2017) Service design: a database approach for the management of digital images of surgical wounds in the hospital setting. *Wounds UK* 12(4): 41–49.

Sanger P, Simianu VV, Gaskill CE, Armstrong CAL, Hartzler AL, Lordon RJ, Lober WB and Evans HL. (2017) Diagnosing surgical site infection using wound photography: a scenario-based study. *Journal of the American College of Surgeons* 224: 8–15.

Saunders RS, Rathouz PJ, Yamanouchi D and Kent KC. (2016) Inter-rater agreement and checklist validation for postoperative wound assessment using smart phone images in vascular surgery. *Journal of Vascular Surgery: Venous* and *Lymphatic Disorders* 4(3): 320–328.

Seaman M and Lammers R. (1991) Inability of patients to self-diagnose wound infections. *J Emerg Med* 9: 215–219.

Smith JMB, Payne JE and Barne TV . (2000) *The Surgeon's Guide to Antimicrobial Chemotherapy*. London: Arnold.

Tanner J, Padley W, Davey S, Murphy K and Brown B. (2012) Patients' experiences of surgical site infection. *Journal of Hospital Infection* 13(5): 164–168.

Trimble C. (2016) The best way to improve health care delivery is with a small, dedicated team. *Harvard Business Review*. Available at: https://hbr.org/2016/03//the-best-wayto-improve-health-care-delivery-is-with-a-small-dedicated-team.

Weston D. (2010) The pathogenesis of infection and immune response. *British Journal of Nursing* 19(16): S4–11.

Whitby M, McLaws M-L, Doidge S and Collopy B. (2007) Post-discharge surgical site surveillance: does patient education improve reliability of diagnosis? *Journal of Hospital Infection* 66: 237–242.

Wirthlin DJ, Buradagunta S, Edwards RA, Brewster DC, Cambria RP, Gertler JP, LaMuragliam GM, Jordan De, Kvedar JC and Abbott WM. (1998) Telemedicine in vascular surgery: feasibility of digital imaging for remote management of wounds. *Journal of Vascular Surgery* 27(6): 1089–1099.

Wiseman JT, Fernandes-Taylor S, Barnes ML, Tomsejova A, Saunders RS and Kent KC. (2015) Conceptualizing smartphone use in outpatient wound assessment: patients' and caregivers' willingness to use technology. *Journal of Surgical Research* 198(1): 245–251.

Woelber E, Schrick EJ, Gessner BD and Evans HL. (2016) Proportion of surgical site infections occurring after hospital discharge: a systematic review. *Surgical Infections* 17(5): 510–519.

World Health Organization. (2016) *Global guidelines on prevention of surgical site infection*. Geneva: WHO. Available at: http://www.who.int/gpsc/ssi-prevention-guidelines/en/ (accessed 03 November 2016).