Implementing smartphone technology in practice using the Collaborative for Surgical Site Infection Surveillance (CASSIS) project: preliminary findings

KEY WORDS

- Community data collection
- Photo at discharge
- Postoperative infection
- Surgical site infection

Background: Understanding the burden of surgical site infection (SSI) requires comprehensive, reliable and comparable data. However, many hospitals do not routinely collect information on wound healing after the patient leaves hospital. **Aim:** To evaluate five post-discharge surveillance strategies that collect patient/carer reported outcomes on wound healing following adult and paediatric surgery. **Method:** Between March 2020 and February 2021, colleagues from five specialist hospitals in England collaborated to collect baseline and compliance data for the different methods of post-discharge surveillance. The five methods included were telephone follow-up; postal questionnaires; postal questionnaires and contacting non-responders by telephone to asking patients to install a postoperative app on their personal smartphone (Medopad, Huma) and using a SSI surveillance text link, which did not need to be installed (Isla, Islacare Ltd). **Results:** Overall, 1432 patients out of 2116 patients provided information about their wound after discharge. The group of patients who were asked to install an app on their smart device had the lowest return rate for information on their wound, while the system that used a text link and did not need to be installed had one of the highest return rates. **Conclusion:** Understanding baseline practice and evaluating different methods of discharge surveillance may help to drive improvement in this area. Our early findings suggest that in practice, a SSI surveillance approach using a text link and photos, such as Isla, which is used in hospital before discharge by staff and post-discharge by patients warrants further attention.

Wound infections following surgery, commonly known as surgical site infections (SSI), range from a superficial concern confined to the skin, to life-threatening complications requiring prolonged intensive care and hospital stays, further operations, readmissions to hospital or extended outpatient care and surgical sepsis (Cardiothoracic Interdisciplinary Research Network [CIRN] et al, 2020). The definition and classification of SSI by Public Health England (PHE now UK Health Security Agency) can be seen in *Box 1* (2013). SSIs are among the most costly type of healthcare-associated infection, with more severe types estimated at £100,000 per patient (Getting It Right First Time, 2019). A significant proportion of SSI are believed to be preventable (Schreiber et al, 2018), thus reducing this source of infection is a global priority in order to preserve antibiotic efficacy (approximately 51% of SSI pathogens are resistant), prevent hospital admissions and improve patient care (World Health Organization [WHO], 2015).

SSIs are mainly caused by bacteria that commonly enter a wound at the time of surgery or through attachment to unhealed or unhealthy tissue along the surgical incision. Over time the bacteria multiplies and spreads to a point that causes an activation of the body's immune system, leading to signs, such as pus, or symptoms, like increasing pain or fever (Rochon, 2012). Many symptoms and signs develop a few weeks after surgery, by which time many patients have already been discharged from hospital (Woelber et al, 2016; PHE, 2019).

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Box 1. SSI Definition and Classification (Public Health England, 2013)

Surgical site infection (SSI) occurs within 30 days of surgery (recorded up to one year if there is an implant). Superficial or deep incisional SSI may exude pus, swab positive for organism(s), and/or have new or increasing pain, localised (specific to site) swelling, redness or radiating heat. Superficial SSI may include managed dehiscence (debridement); deep incisional SSI criterion can include spontaneous and managed dehiscence or high temperature (38ºC). Organ/space SSI rely on clinician diagnosis or interpretation of invasive (e.g. wound revision) or non-invasive investigations (such as computerised tomography [CT] scan).

Not considered SSI: early post-operative inflammation, 'clean' dehiscence, erythema (normal discoloration associated with healing), and stitch abscess (small area of suture material affected).

Box 2: The photo at discharge (PaD)

PaD is an enhanced patient discharge strategy to improve patient and carer confidence in caring for their wounds and monitoring for any signs of SSI (Rochon et al, 2018). A core input of PaD is that a healthcare professional takes a digital image of the wound, after gaining consent from a patient, and completes the e-assessment. The completed colour form is given to the patient/carer, which includes a picture of the wound and wound care advice (Rochon et al, 2020).

SSI surveillance

A clinical audit examines a process or practice compliance against an existing standard, usually over a specific time period or number of activities. In contrast, surveillance collects and analyses data for defined public health goals and priorities (Public Health Agency [Northern Ireland], 2014). This approach allows for comparison over time (of own performance), as well as for benchmarking nationally, or with other centres (PHE, 2019).

Some hospitals use SSI as a quality indicator and monitor patients at 30 days postsurgery to discover if the wound has healed or not. However, due to timings of SSI signs and symptoms developing, a significant proportion of hospitals do not know their SSI rates and more still do not know their SSI rates at 30 days (PHE, 2019). There are many reasons for this being the case, one of the main reasons in England is that primary care services usually manage the care and costs for surgical wound infections (Guest et al, 2017). This information is then typically not provided to the operating hospital unless a readmission is needed. Furthermore if the readmission is to any hospital other than the operating institution, it is likely that the latter would remain unaware of the readmission. An additional challenge is that studies have found patient self-reporting of SSI fairly unreliable (Whitby et al, 2007; Tanner et al, 2013a), which in itself may act as a deterrent to centres considering patient reported post-discharge surveillance. These factors lead to operating institutions not having a clear understanding of their patients' outcomes, which in turn leads to the loss of opportunity to introduce measures to improve patient safety.

Arguably, the period after the primary hospital discharge provides the greatest opportunity to improve patient outcomes and reduce variation in practice in relation to SSI surveillance. Therefore, our collaborative approach reviewing post-discharge surveillance practices specifically targets these uncertainties and challenges in this discharge period.

Balasubramanian et al (2015) propose Learning Evaluation (LE) as a way evaluate change initiatives for quality improvement projects. LE 'real-world' implementation methodology is guided by principles that encompass data collection (what and how of change, process and outcome data), analysis (multi-level, contextual factors) and application. LE was selected because we wanted to work with multiple organisations to develop common strategies and inform and accelerate quality improvement and implementation for post-discharge surveillance (Meadows, 2005). This service evaluation focuses on the first LE priniciple, collecting detailed baseline data.

Aim

The aim of this service evaluation was to obtain and share baseline and compliance rates for different methods of post-discharge surveillance. The five approaches were:

1) Sending the patient-reported wound healing questionnaire (PDQ) by post with a self-addressed return envelope
2) Follow-up by telephone
3) PDQ by post with telephone follow-up for non-responders
4) Asking patients to download and install a post-discharge app (Medopad, Huma; this service evaluation covers information on wound healing only not other post-discharge information), which requires smart device e.g. mobile or tablet. Patients or carers are able to submit a photo of the wound securely
5) Sending a text link via the SSI surveillance platform (Isla) (requires patient or carer to have a smart device). Patients or carers are able to submit a photo of their wound securely.

Our two main objectives were to determine patient preference and to determine return rates for each of the five methods.

METHODS

Between March 2020 and February 2021, five hospitals in England that provide Photo at Discharge ([PaD], *Box 2*) were contacted via email. The five hospitals agreed to collect aggregated baseline and compliance data. Hospital site 1–4 were able to collect data on return rates for the various methods. Hospital 5 was not able to trial any of post-discharge methods due to workload/pressures arising from the COVID-19 pandemic but was able to implement Isla in July 2021.

Each hospital used a Word-based survey to collect data on patient preferences, which was first

Table 1. Baseline information for each hospital site

Site specific information	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Hospital 5
Paediatric cardiac surgery cases performed in 2020 (n)	150				
Adult cardiac surgery cases performed in 2020 (n)	849	1088	1679	1805	466
Adult thoracic surgery cases performed in 2020 (n)	948				
Year PaD commenced	2020	2015	2018	2020	2020
PaD compliance	55%	100%	93%	71%	90%
Continuous post-discharge surveillance?	No	No	Yes	No	No

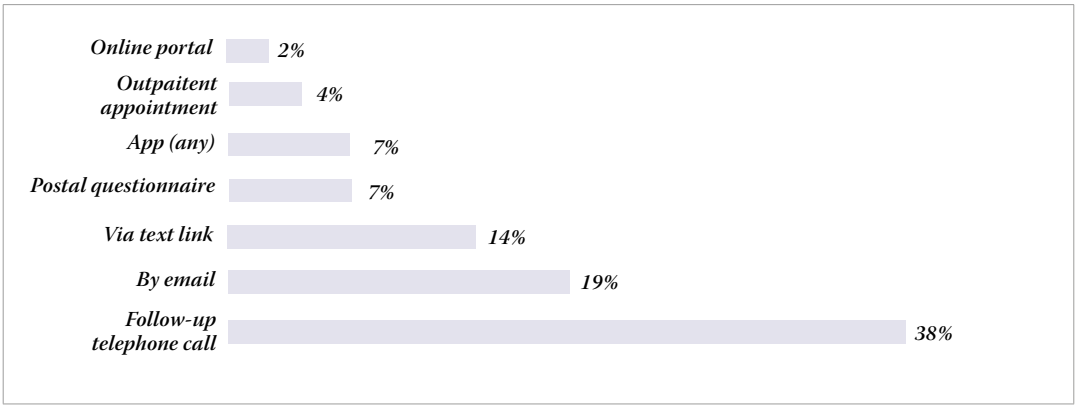

Figure 1. Patient preference survey most preferred option. Answered by 157 adult patients and 20 parents/carers of paediatric patients

piloted at Hospital 2. After minor grammatical amendments, the final patient preferences survey consisted of eight options and patients were asked to rank the options for post-discharge surveillance in terms of most preferred and any options that they would prefer not to be used or disliked. No patient-identifiable data were collected. Data were collated on Microsoft Excel and simple descriptive analysis was performed. Response rates for post-discharge surveillance (i.e. actual discharge data collection) was obtained if the hospital had conducted one of the five methods. Rates were calculated from the number and percentage of patients of eligible and successfully returned submissions. A response rate of 75% or above was accepted as good (Bowling, 2014).

The study was not considered research according to the UK Policy Framework for Health and Social Care Research by the NHS Research Authority and ethical approval was not required. The service evaluation was registered (CIRIS 004182).

RESULTS

The baseline hospital information is provided in *Table 1*. Only one of the five centres conducted continuous post-discharge surveillance. Hospital compliance with PaD ranged from 55–100%.

A total of 157 surgical patients from the five hospitals (91 from adult cardiac, 40 from adult thoracic, 6 from the other category) and 20 parents/carers (for paediatric cardiac surgery) provided their preference for post-discharge surveillance. Follow-up by telephone was the most preferred option (59/157; *Figure 1*).

Figure 2 shows patient/carer feedback on the options they preferred not to be used. Providing information via an app was the least popular option (25%), followed by postal questionnaire (17%). Submitting information via a text link was selected by 5% of respondents.

Table 2 shows the actual patient response rates for the five different methods of actual post-discharge surveillance, which ranged from 9% to 90%. The

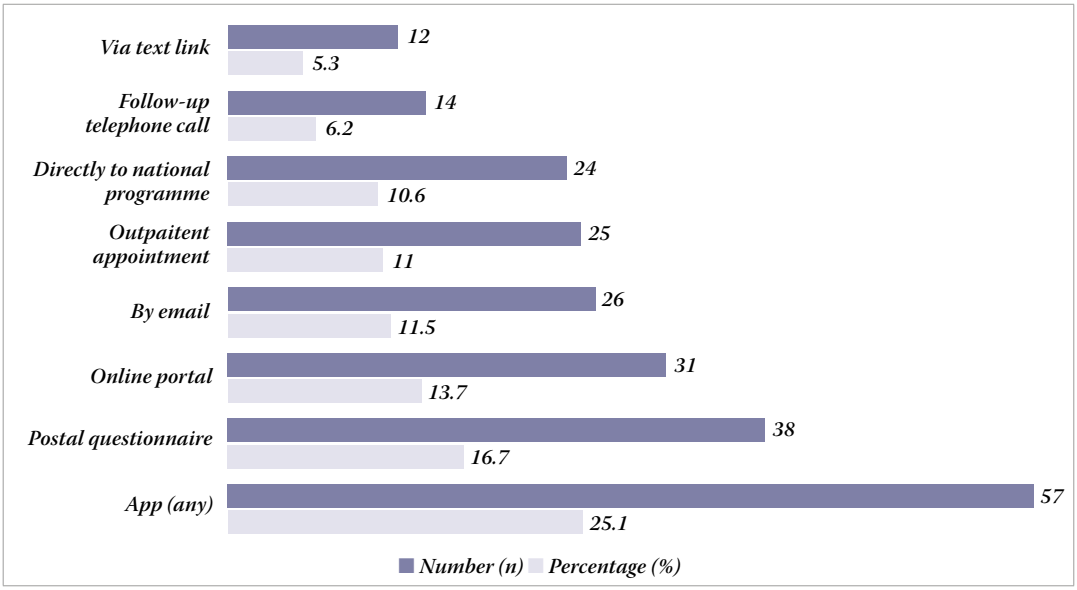

Figure 2. Patient preference survey least preferred option

Table 2. Post-discharge wound monitoring for surveillance

Method	Responses (n)	Eligible (n)	Return (%)	Period
Postal questionnaire	17	43	39.5	January – February 2020
Telephone follow-up	83	92	90.2	August – September 2020
Postal questionnaire with telephone follow-up for non-responders	1259	1679	75.0	January – December 2020
App downloaded and installed on patient's device (post discharge; Huma, wound information only)	24	244	9.8	August 2020 – January 2021
Surgical site infection surveillance app using a weblink sent by text (Isla)	49	58	84.5	December 2020 – February 2021
Overall	**1432**	**2116**	**67.7**	

highest responding was telephone follow-up and the lowest responding was downloading the smart phone app. Interestingly clicking on the text link to the secure Isla platform' gave the second highest return.

DISCUSSION

Of the five cardiac hospitals included in this work four did not routinely collect post-discharge surveillance data. This is similar to a survey conducted in the UK that found 58% of cardiac hospitals had no system in place to identify SSI post-discharge (CIRN, 2020). This is a concern since limiting SSI rates to only hospitalised patients may underestimate the true SSI rate (Tanner et al, 2013b). For example, Lamagni et al found that 'in hospital' surveillance detects only around a third of the overall cardiac SSI burden (Lamagni et al, 2020).

Establishing data on compliance for the different methods of post-discharge surveillance and leveraging patient preference is an important step in the design and planning of quality improvement (Dixon-Woods et al, 2012). As a first step, our collaborative approach has necessarily focused on the first principle of LE, detailed description of the baseline activity. In this service evaluation, we have focused on post-discharge surveillance using different methods for capturing patient reported

SSI. Post-discharge surveillance via telephone follow-up was popular with our patients in the survey of patient preferences and had the highest return rate in actual post-discharge data collection. The link between patient preference and return rates was similarly observed for the two least popular approaches (installing a postoperative app and postal questionnaire), which failed to meet the 75% response rate and were the most disliked options in the patient survey (25.15 and 16.7%, respectively)

Nguhuni et al (2017) found that telephone surveillance had moderate sensitivity (i.e. SSI were correctly identified) and high specificity (i.e. non-SSI were correctly excluded) when compared with the 'gold standard' of direct clinical review (Whitby et al, 2007).

Similarly, a scenario-based study from the US suggest that colour photos can accurately identify SSI, and are also more useful to rule out SSI (Sanger et al, 2017). Interestingly, our findings suggest that there was an important difference in compliance between our two 'app-based' approaches. Patient/carer submission of their digital wound image and wound healing information was higher when the app did not need to be downloaded and installed on their device (i.e. 85% patient return rate using a text link versus 10% when an app needed to be added to the smartphone). It is interesting that this practical trend was mirrored by patient/carer feedback: 5% of respondents preferred the text link not to be used as compared with 25% suggesting they would dislike an app. The Isla SSI surveillance approach allows clinicians to use mobile devices to securely capture an image of a wound, add clinical information and schedule patient submissions for post-discharge surveillance. Patients do not need to install an app; they submit their post-discharge surveillance data via reply to a link sent to their smart phone (*Figure 3*), with the additional functionality of data collection via email available.

Recommendations

In the UK, research has been conducted to improve the acceptability and compliance of post-discharge patient reported wound healing (Macefield, 2020). A randomised control trial examining patients taking and transmitting wound images on their own device following emergency general surgery has had favourable results in terms of early days to diagnosis of SSI, reduced attendances in primary care without increasing hospital attendance and patient satisfaction (McLean et al, 2021). Our 'real world' experience similarly has positive findings but may be distinguished from other post-discharge SSI surveillance evaluations as it spans acute and community care (Evans et al, 2019). The same Isla SSI app was used for the PaD (taken by hospital staff) as well as for the patient/carer post-discharge

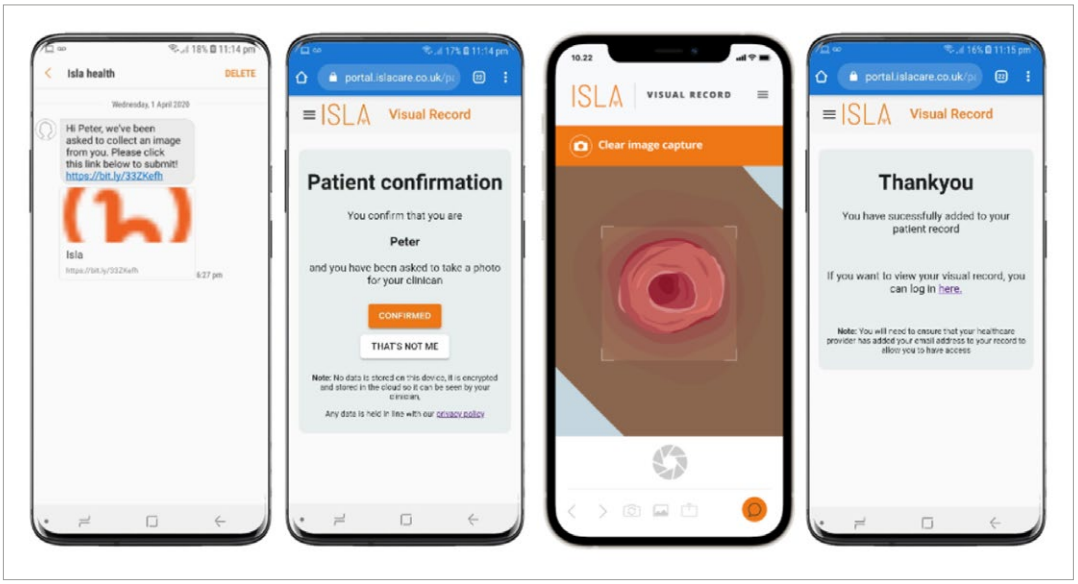

Figure 3. Illustrated example of link-based application. Image courtesy of Isla (Islacare Ltd)

submission. We feel a baseline (initial) image is important for the purposes of detecting wound changes but also for determining characteristics of normal healing or signs of infection. Previous research studies using digital images for SSI diagnosis found it difficult to determine whether 'redness' was skin discolouration associated with normal healing or 'new and/or increasing redness', which is one of the hallmarks of infection (Sanger et al, 2017; Totty et al, 2018) and PaD may help assist in this respect (Rochon et al, 2018).

Limitations

There are some important limitations to this evaluation. First, we relied on convenience sampling, which means the findings may not be generalisable (Walker and Almond, 2010). Second, the hospitals included were actively engaged in PaD, which means that approximately ⅓ of respondents from an SSI practice survey indicated that they use PaD in the UK (CIRN et al, 2020) but those without surveillance approach that already incorporates a digital image may have a different experience and outcome. In addition, most of the compliance data were based on pilot experience, rather than a systematic and sustained programme thus findings should be interpreted with caution. Finally, due to the pressures of the COVID-19 pandemic in our cardiac centres, data could only be provided from different time periods and one centre was not able to trial any of the post-discharge methods.

National Strategy

Nevertheless, the value of post-discharge data as part of a quality improvement measure makes it an exciting area of study. Increasingly, national bodies such as Getting It Right First Time (GIRFT) and the National Wound Care Strategy Programme (NWCSP, 2021) are calling for urgent attention to reduce the risk of SSI and surgical wound breakdown through multidisciplinary working. Particular attention is paid to early identification and prompt and appropriate action. Following the competitive tender process, we continue to assess the Isla SSI app in a 'real world' setting. To date four of the five hospitals are using Isla, with over 6000 submissions (response rate 77%). 'Proactive surgical wound surveillance' is a new concept and may be defined as personalised, real-time wound monitoring. It incorporates a visual record with the explicit intention of providing the patient with reassurance (no action necessary), advice, referral (to primary or hospital services) or readmission for infected and non-infected wound concerns, as well as data collection for analysis and reporting. Continuing our front-line initiative and collaborative approach, we hope to promote a standard of care quality in post-discharge surveillance by helping patients/carers share visual information about their wounds in a way that is manageable and meaningful for healthcare providers.

CONCLUSION

There is a significant gap in knowledge about SSI rates after primary discharge and how best to capture this information. For the healthcare service, Isla SSI surveillance solution is a low-friction method of collecting post-discharge wound information using a text weblink. More widely, we hope our experience may influence nurse practice in selecting approaches and/or technology for remote wound assessment and surveillance. WUK

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DECLARATION OF INTEREST:

Melissa Rochon is an (unpaid) clinical advisor for Isla

REFERENCES

Balasubramanian BA, Cohen DJ, Davis MM et al (2015) Learning Evaluation: blending quality improvement and implementation research methods to study healthcare innovations. *Implement Sci* 10:31. https://doi.org/10.1186/s13012-015-0219-z

Bowling A (2014) Techniques of questionnaire design. In: Bowling A & Ebrahim S (eds) Research Methods in Health: Investigating health and health services. (4th edn) Open University Press.

Cardiothoracic Interdisciplinary Research Network (CIRN), National Cardiac Benchmarking Collaborative, Public Health England (PHE) (2020). National survey of variations in practice in the prevention of surgical site infections in cardiac surgery, United Kingdom & Ireland. *J Hosp Infect* 106(4):812–9. https://doi.org/10.1016/j.jhin.2020.09.016

Dixon-Woods M, McNicol S, Martin G (2012) Ten challenges in improving quality in healthcare: lessons from the Health Foundation's programme evaluations and relevant literature. *BMJ Qual Saf* 21(10):876–84. https://doi.org/10.1136/bmjqs-2011-000760

Evans HL and ASSIST Investigators (2019) Executive summary of the Assessing Surgical Site Infection Surveillance Technologies (ASSIST) Project. *Surg Infect (Larchmt)* 20(7):527–9. https://doi.org/10.1089/sur.2019.171

Getting It Right First Time (2019) Surgical site infection audit. https://tinyurl.com/2csb3r6k (accessed 20 January 2022)

Guest JF, Ayoub N, McIlwraith T et al (2017) Health economic burden that different wound types impose on the UK's National Health Service.

Int Wound J 14(2):322–30. https://doi.org/10.1111/iwj.12603

Lamagni T, Cooper K, Wloch C, Harrington P (2020) The epidemiology of cardiac surgical site infection in England, 2018/19. 30th European Congress of Clinical Microbiology and Infectious Diseases. (virtual conference), 18-21 April 2020. Abstract 4444. Paris, France: *Clin Micriobiol Infect*

Macefield R (2020) Surgical site infection: development and evaluation of methods for improved outcome assessment. University of Bristol. https://tinyurl.com/dxejf857 (accessed 20 January 2022)

McLean KA, Mountain KE, Shaw CA et al (2021) Remote diagnosis of surgical-site infection using a mobile digital intervention: a randomised controlled trial in emergency surgery patients. *npj Digital Medicine* 4:160. https://doi.org/10.1038/s41746-021-00526-0

Meadows KA (2005) So you want to do research? 1. an overview of the the research process. *Br J Community Nurs* 8(8):369–75. https://doi.org/10.12968/bjcn.2003.8.8.11567

National Wound Care Strategy Programme (2021) Recommendations for surgical wounds. https://tinyurl.com/2p9afu7y (accessed 20 January 2022)

Nguhuni BA-O, De Nardo P, Gentilotti E et al (2017) Reliability and validity of using telephone calls for post-discharge surveillance of surgical site infection following caesarean section at a tertiary hospital in Tanzania. *Antimicrob Resist Infect Control* 6:43. https://doi.org/10.1186/s13756-017-0205-0

Public Health Agency (Northern Ireland) (2014) Surgical Site Infection Surveillance in Northern Ireland. https://tinyurl.com/f7sbxj9t (accessed 20 January 2022)

Public Health England (PHE) (2019) Surveillance of surgical site infections in NHS hospitals in England, April 2018 to March 2019.: Public Health England. https://tinyurl.com/9bcz7axz (accessed 20 January 2022)

PHE (2013) Protocol the surveillance of surgical site infection. https://tinyurl.com/4njw2j39 (accessed 20 January 2022)

Rochon M. Chapter 7: Wound healing and surgical site infection. In: Woodhead K. Fudge L (eds) Manual of Perioperative Care: An Essential Guide. Wiley-Blackwell, 2012

Rochon M, Jenkinson S, Ramroop R et al (2018) Retrospective analysis of the Photo at Discharge scheme and readmission for surgical site infection following coronary artery bypass graft surgery. *Journal of Infection Prevention* 19(6):270–6. https://doi.org/10.1177%2F1757177418780986

Rochon M, Magboo R, Barlow C et al (2020) Implementation of Enhanced Patient Education for Surgical Site Infection (SSI) Prevention in Cardiac Surgery: Survey Findings from Three English Hospitals. *Br J Nurs* 29:994–1002. https://doi.org/10.12968/bjon.2020.29.17.994

Sanger P, Simianu V, Gaskill C et al (2017) Diagnosing surgical site infection using wound photography: a scenario-based study. *J Am Coll Surg* 224(1):8-15.e1. https://doi.org/10.1016/j.jamcollsurg.2016.10.027

Schreiber PW, Sax H, Wolfensberger A et al (2018) The preventable proportion of healthcare-associated infections 2005–2016: Systematic review and meta-analysis. *Infect Control Hosp Epidemiol* 39(11):1277–95. https://doi.org/10.1017/ice.2018.183

Tanner J, Padley W, Davey S et al (2013a) Patient narratives of surgical site infection: implications for practice. *J Hosp Infect* 83(1):41–5. https://doi.org/10.1016/j.jhin.2012.07.025

Tanner J, Padley W, Kiernan M et al (2013b) A benchmark too far: findings from a national survey of surgical site infection surveillance. J Hosp Infect, 83(2): 87–91. https://doi.org/10.1016/j.jhin.2012.11.010

Totty J, Harwood A, Wallace T et al (2018) Use of photograph-based telemedicine in postoperative wound assessment to diagnose or exclude surgical site infection. *J Wound Care* 27(3):128–35. https://doi.org/10.12968/jowc.2018.27.3.128

Walker J, Almond P. Interpreting Statistical Findings: A guide for health professionals and students, Maidenhead, Open University Press, 2010

Whitby M, Mclaws ML, Doidge S, Collopy B (2007) Post-discharge surgical site surveillance: does patient education improve reliability of diagnosis? *J Hosp Infect* 66(3):237–42. https://doi.org/10.1016/j.jhin.2007.04.014

Woelber E, Schrick EJ, Gessner BD, Evans HL (2016) Proportion of Surgical Site Infections Occurring after Hospital Discharge: A Systematic Review. *Surg Infect (Larchmt)* 17(5):510–9. https://doi.org/10.1089/sur.2015.241

World Health Organization (WHO) (2015) Global action plan on antimicrobial resistance. Geneva: WHO. https://tinyurl.com/yckzjkz5 (accessed 20 January 2022)

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