Service design: a database approach to the management of digital images of wounds in the hospital setting

Background: Comprehensive wound assessments demonstrate better patient outcomes. Digital photography is a useful adjunct, aiding assessment and reducing the risk of over-treatment. **Aim:** This study compared the quality of digital photographs uploaded directly to the electronic patient record (EPR) with those uploaded via a database by non-specialist nurses as part of the development of a standard operating procedure in two cardiothoracic centres. **Methods:** Two specialist surveillance nurses retrospectively audited 1,837 wound photographs: 1,713 uploaded to the EPR via a database and 124 uploaded directly to the EPR. Image quality was determined by: 1) function, including clarity and documentation of appropriate clinical details alongside the image; and 2) format, including size, rotation and focus. Both function and format needed to be satisfactory to meet quality criteria. **Results:** Only 52% (65/124) of photos uploaded directly to the EPR were of sufficient quality versus 99% (1,702/1,713) of photos uploaded via a database. There was a significant difference in the quality of images managed using the two methods ($p<0.0001$). **Conclusion:** Findings suggest that, in practice, a database should be recommended to ensure quality control as it reduces the risk of error and facilitates reporting on wound types, care and resources.

Surgical site infection (SSI) is a costly and morbid healthcare-associated infection. Mediastinitis is one of the more severe classifications of coronary artery bypass graft infection and is associated with a mortality risk of 33% (Margereson and Riley, 2003). Moreover, SSI following coronary artery bypass graft results in a longer stay in the intensive care unit, longer overall hospital stay and trebles hospital costs (Broex et al, 2009; Graf et al, 2010). Furthermore, SSI places the individual at increased risk of sepsis (National Institute for Health and Clinical Excellence [NICE], 2013). Thus, SSI in cardiac surgery patients places a considerable burden on both patient recovery and hospital resources.

Studies demonstrate that the addition of colour photograph(s) assists clinicians and healthcare professionals in decision-making, monitoring healing and assessing the impact of therapy (Wirthlin et al, 1998; Swann, 2000; Engel et al, 2011; Wiseman et al, 2015; 2016; Sanger et al, 2016). Alongside proactive and appropriate treatment, documentation and serial wound assessment are essential in managing SSI (Johnson, 2015). Traditionally, surgical ward nurses use hard copy paper-based wound charts to record wound appearance by sketching a representative outline with key features and a care plan. In cardiothoracic centres, ward nurses routinely request medical illustrators and/or specialist tissue viability nurses to take images (Cardiac SSI Network, 2017), although these services may not cover weekends or evenings.

Our experience is relatively unique in that our hospitals have implemented the Photo-at-Discharge (PaD) scheme (NICE, 2017). For the PaD scheme, surgical nurses routinely take photos of post-operative wounds, negating the need for medical illustrator or tissue viability nurse involvement. Our surgical wards delivering PaD use small digital cameras, stored in a locked cupboard when not in use, to take images and a personal computer upload the images to the electronic patient record (EPR). The small digital cameras are reported by Hayes and Dodds (2003) to be suitable for the purpose of PaD. Ward nurses have received

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Table 1. Ways in which digital images can be added to the electronic patient record (EPR).	
Direct upload	**Upload via database**
• Photos of the wound(s) are attached to the EPR • Photos may be inserted into a Word document prior to upload or uploaded directly to the EPR • Word documents increase the risk of error, including spelling mistakes, cut-and-paste errors and manually-entered patient demographics (if supplied) • It is not easy to mine/audit this information, as it is only provided in free text format	• Photo(s) of the wounds are inserted into an electronic form created automatically by the database and attached to the EPR • Data fields are easy to complete • Reports for surveillance, resources, wound types, etc, are easy to produce because of the defined data fields

Table 2. Quality of wound photos added to the electronic patient record.		
Method of addition to the electronic patient record	**Satisfactory**	**Unsatisfactory**
Direct upload	52% (65/124)	48% (59.125)
Upload via the database	99% (1,702/1,713)	1% (11/1713)

training on how to take wound photos, in line with published evidence (Bradshaw et al, 2011; Hampton 2015; Swann, 2000; Hayes and Dodds, 2003). In practice, we identified that nurses would attach digital images to the EPR either by direct upload or using a database approach developed for PaD (*Table 1*). From an organisational perspective, the different methods could create a variance in outcomes.

METHOD

We reviewed the practice of wound photography at two cardiothoracic centres. The impact on wound healing rates was not assessed in this audit. This project was registered on the Trust's audit register (CIRIS Project ID: 002100) and RBHT Innovations database. Research ethics approval was not required.

Wound photos were identified and split into two groups, see *Table 1*. Wound photos obtained by specialist colleagues (tissue viability nurses or advanced nurse practitioners) were excluded from the audit. Two nurses trained in SSI surveillance retrospectively audited the colour wound photos taken by non-specialist nurses. All photos were reviewed on the EPR system to replicate the process used by multidisciplinary team members reviewing patient records.

The photos were assessed in terms of usability, as determined by image focus, the clarity of what is being viewed and whether appropriate clinical details have been provided. Photos were then assessed for image format (size, rotation and focus). In instances where disagreement occurred, the opinion of an infection control matron was sought to determine whether the image met quality criteria. The decision of the matron was final.

A high- or moderate-quality image was defined as a photo sufficient to determine the wound's appearance and its location, either from the image or its associated description of wound type or location (i.e. a photo inserted into a Word document). 'Limited utility' was defined as an image that was not clear and/or whose location was not identifiable as a standalone resource (i.e. if the healthcare worker would not know the type or location of the wound after reviewing the photo (*Figure 1b* and *1c*) and/or if a photo was uploaded that required re-sizing by the viewer (*Figure 1a*). Formats needing re-sizing were deemed low utility because many staff did not know how to adjust settings to view the photo — 17% (seven out of 42) of medics and specialist and ward nurses had asked how to do this in the unpublished June 2017 audit. The difference between the two approaches was examined using chi-squared test and a significance of $p<0.05$ was set.

As part of the assurance and quality process, the authors collaborated on a standard operating procedure for the management of digital images (*Box 1*).

RESULTS

There were 124 photos directly uploaded or inserted into a Word document and then uploaded to the EPR (direct upload group). These photographs were obtained from an IT department search using the term 'Wound Photograph'. There were 1,713 photos added to the database in electronic form and uploaded to the EPR (upload via database group). These photos were captured by a report facility in the PATS/Dendrite database by the surveillance nurse. The results of the nurses' assessment of photo quality are given in *Table 2*.

Both nurses agreed on image quality for all but five photos. The infection control matron's opinion was sought for these images. Agreement between the two raters was near perfect (inter-rater reliability 99.7%).

A comparison of proportions for type I and type II errors (using chi-squared test) was used to calculate the required sample size. The total number of cases per group as well as the total sample size

Figure 1. Wound photos directly uploaded to electronic patient records: (a) an outsized image; (b) the location of the wound cannot be determined and there was no accompanying information or documentation; and (c) poor focus and indeterminate wound location.

were satisfactory. There was a significant difference in the proportions of high or moderate quality images between the two groups ($p<0.0001$).

DISCUSSION

The majority (96% 1,767/1,837) of digital wound photos taken in hospital are of good quality in terms of function and format. This suggests that hospital ward nurses are at ease with the aims of wound photography, the procedure and equipment needed, which is well-established from guidance by the Institute of Medical Illustrators or works such as Bradshaw et al (2011). Our audit suggests that the database approach to managing digital wound images in a cardiothoracic hospital is superior to direct upload to the EPR (within a Word document or as a photo only). This finding reinforces experience in telemedicine demonstrating that nurses can use secure and efficient electronic systems for routine clinical practice in any setting (Hayes and Dodds, 2003). One of the key issues with photos uploaded directly to the EPR (or system within intensive care) is that there is not always appropriate accompanying documentation, reducing its usability by colleagues. The photo should support written documentation rather than replace it (Benbow, 2016).

Despite broad experiences with digital photography in wound care, particularly in the community setting, to our knowledge this is the largest study in the tertiary sector in the UK. Findings from this audit provide overview of the fundamental requirements for managing digital wound images from an organisational perspective (*Figure 2*). A central database for photos offers a number of benefits, including improved accuracy and efficiency of data, availability of data for reporting on wound types, reports on resources (dressings used, including negative pressure therapy, etc) as well as quality control. However, there are two main governance issues to be considered. First, although a digital photograph for clinical purposes is considered part of the treatment plan, legal opinion is that explicit consent be obtained (Institute of Medical Illustrators, 2007), ideally using a specific clinical photography consent form. This ensures the patient is fully informed of the reason for and use of the photograph. Second, secure image storage is paramount and must be in line with local policies and the Data Protection Act 1998 (Institute of Medical Illustrators, 2007). Direct upload into the database reduces the risk of errors and, as the photo is entered into the EPR, it can only be accessed by authorised personnel for clinical treatment purposes, thus complying with governance requirements (data protection, secure image storage and access). Using a database is therefore better than undertaking reviews of multiple care plans or wound charts (Pieper et al, 1999).

One of the findings from the audit was that some photos uploaded directly to the EPR had patient stickers adjacent to the vulnerable (unhealed) wound bed, going against the basic principle of asepsis (Association for Perioperative Practice, 2016). Placing potentially contaminated items, such as stickers or medical notes, immediately adjacent to the aseptically-managed wound increases the risk of transferring microbes to the exposed wound bed and should be avoided (Alothman et al, 2003; Hamza et al, 2007; Teng et al, 2009). No stickers were observed in the upload via database

Box 1. Standard operating procedure for in-hospital use of digital images (photographs) of wound.

Standard:

- Matters of privacy, dignity, safeguarding and consent should be in accordance with the Trust's standards and those of professional governing bodies (e.g. Nursing and Midwifery Council, Royal College of Nursing, Royal College of Surgeons). These principles must be applied to practices of wound photography
- The offer of a chaperone should be documented
- Exposure of skin should be kept to a minimum
- Digital images/photos of a wound (any type) must be usable:
  - Fill the frame area with the wound. This can be achieved by holding the camera perpendicular to and at a reasonable distance from the wound. Once the picture is taken, review the image on the camera to ensure the picture is sharp, in focus and well lit. There should be no areas of shadow, nor should the picture be blurry. Take additional picture(s) as required, for example a close-up of a particular area of concern
  - Good resolution (usable file size) and quality depends on the equipment used. Use Trust-provided equipment, e.g. camera or device (tablet). Equipment should be stored in locked cupboard, along with the recharge cable
  - Wherever possible, take the photo in a treatment room because the overhead lighting produces a better picture. Where this is not possible, use the flash on the camera (leave flash as auto default setting)
- Poor quality photos must be discarded and a new photo(s) taken
- No other identifying information or other patients should be in the photo
- Once taken, the photo(s) may be edited to ensure patient privacy /dignity (i.e. cropped so that the image of the chest incision is available) or rotated for correct angle of display. A privacy screen is advised for ward computer screens so that images may be reviewed and edited by staff
- Photos should be immediately uploaded, deleted from the camera or device and shared drive once this is completed. IT may be able to set up automatic deletion on the cameras and shared drive for each computer
- The same camera or device should be used for serial photos, ideally in same environment and patient position
- There should be referral to the tissue viability service and team responsible, as appropriate
- A scaling tool is advised as appropriate, with a recommendation to seek tissue viability nurse input for complex wounds and/or comprehensive measurement technologies and methods

Infection control:

- Wounds should be managed in line with tissue viability guidelines and infection control policy for aseptic non-touch technique. No patient labels, stickers, packaging or paper should be placed adjacent to, near or over open, healing or vulnerable wounds
- The camera should not come into contact with the patient or patient's surroundings
- Hand decontamination should be performed as appropriate
- The glass camera lens should be decontaminated with an alcohol wipe and the camera wiped with detergent-containing wipe
- Clinical judgment should be used before using camera equipment in the management of an infected patient/cohort
- Seek infection control team advice as necessary

Database management of wound photographs:

- All photo(s) taken of any type of wound should be uploaded to the electronic patient record using a Trust-agreed, secure database. On creation of the form and photo upload, the patient's details (name, medical number, date of birth and NHS number, if available) must be confirmed to ensure the correct photo(s) is uploaded to the correct patient's record
- It is the responsibility of the individual uploading the photo to enter details of informed consent (verbal, witnessed verbal, signed consent, parental or guardian), wound type, wound location and the name of the person who took the photo
- Additional details on wound description, care given, resources used and planning can be added via selection of radio buttons, drop-down lists and/or completing free text field(s)
- Photo(s) and forms do not need to be printed out in hospitals implementing a paper-light system. If a print-out is requested, this should be printed in colour and placed with the patient's medical record

Photo at discharge:

Details of wound appearance on the day of discharge should be completed for all consenting adult cardiac surgical patients up to and including Day 20 (later if the wound is not completely healed). Photo at Discharge also applies to hospital transfers from the surgical ward. Only the incision should be exposed at the time of the photograph (i.e. for female patients do not remove the bra, only unhook the front fastens). A hard copy of the form (photo and infection prevention advice) must be given to the patient /carer(s) and an electronic copy saved to the electronic patient record

Box 1. Standard operating procedure for in-hospital use of digital images (photographs) of wound (continued).

Contingency:
- If the electronic system is unavailable, staff should revert to traditional hand-drawn wound charts or record the photo with patient and wound details on a Word document temporarily. If the latter is used, the staff member taking the picture is responsible for uploading the picture and completing documentation.
- Staff noticing issues with the database should report these immediately to the database manager or the IT department
- For records requiring removal (deletion) from the system, this should be done via IT

Training and monitoring:
- Staff using the system should receive training on digital wound images (including editing) and the database system. They must have their own user account, password and PIN (if applicable)
- The responsibility to deliver training can be locally assigned
- Pictures of the wound(s) taken on the patient's own phone/device are NOT covered by this standard operating procedure
- Quality control and reporting of digital images will be monitored on a regular basis using the database system

group, presumably because the nurse providing the care immediately uploaded the photo, which automatically inserted patient demographics. A flow diagram of the process is provided in *Figure 3*.

We modified an existing database system (PATS/ Dendrite) with site-wide licences, although a simple Microsoft Access database could provide similar functions if it has EPR connectivity. Any system specification is a factor of multiple things, like purpose (e.g. database, images, transactional, computation), number of users, data volume, connectivity bandwidth, backup, uptime, speed, etc. Nurses need to ensure their input into the
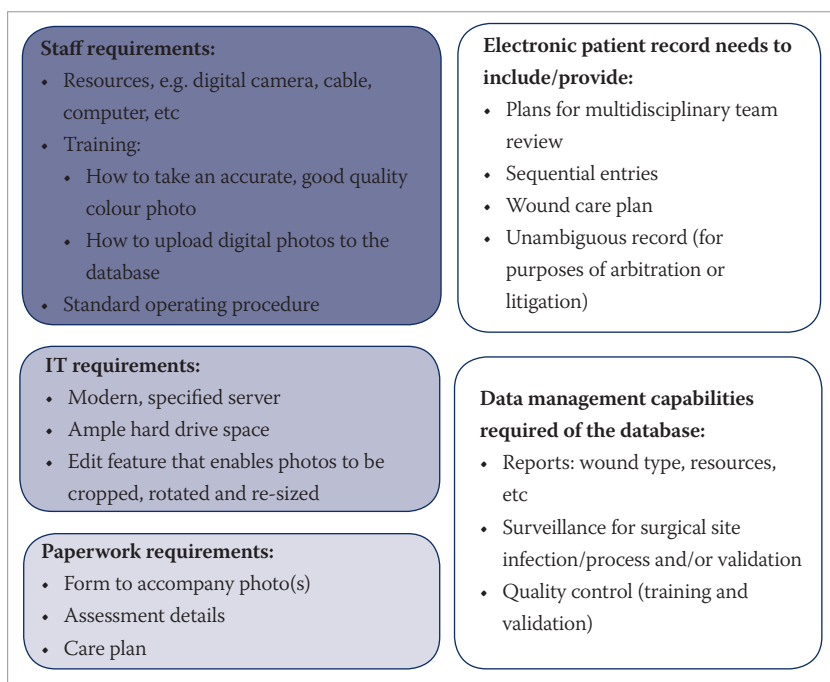
creation or modification of database systems includes wound descriptors, sepsis risk assessment (as applicable), wound care environment, resources used and additional actions/advice given. The quality improvement approach using Plan–Study– Do–Act cycles to develop our database is described in Rochon et al (2016).

Currently our centres use a standard digital camera because trials with a number of different tablet devices have not been successful. The database approach may in future include a mobile application or 'app'; however due to security considerations, until an appropriate assessment tool is available, healthcare apps are not endorsed by the Royal College of Nursing (2016).

CONCLUSION

The use of digital photography for wound care, particularly in the context of PaD, is increasing rapidly at our hospital sites. This increase relies on nursing staff as opposed to medical illustrators (Swann, 2000) and, importantly, a mechanism for quality control. Our aim was to develop a framework for non-specialist nurse use of digital photography in a tertiary referral cardiac setting to ensure the usability of photographs in patient care and establish a standard approach for quality control.

Our audit suggests that database management of digital photos reduces the risk of unidentifiable images and increases the ease of reporting at an organisational level. From this a standard operating procedure was developed. The key recommendation from our study is that a database approach improves the process of digital image management and reporting at an organisational level. **WUK**

Staff requirements:
- Resources, e.g. digital camera, cable, computer, etc
- Training:
  - How to take an accurate, good quality colour photo
  - How to upload digital photos to the database
- Standard operating procedure

Electronic patient record needs to include/provide:
- Plans for multidisciplinary team review
- Sequential entries
- Wound care plan
- Unambiguous record (for purposes of arbitration or litigation)

IT requirements:
- Modern, specified server
- Ample hard drive space
- Edit feature that enables photos to be cropped, rotated and re-sized

Data management capabilities required of the database:
- Reports: wound type, resources, etc
- Surveillance for surgical site infection/process and/or validation
- Quality control (training and validation)

Paperwork requirements:
- Form to accompany photo(s)
- Assessment details
- Care plan

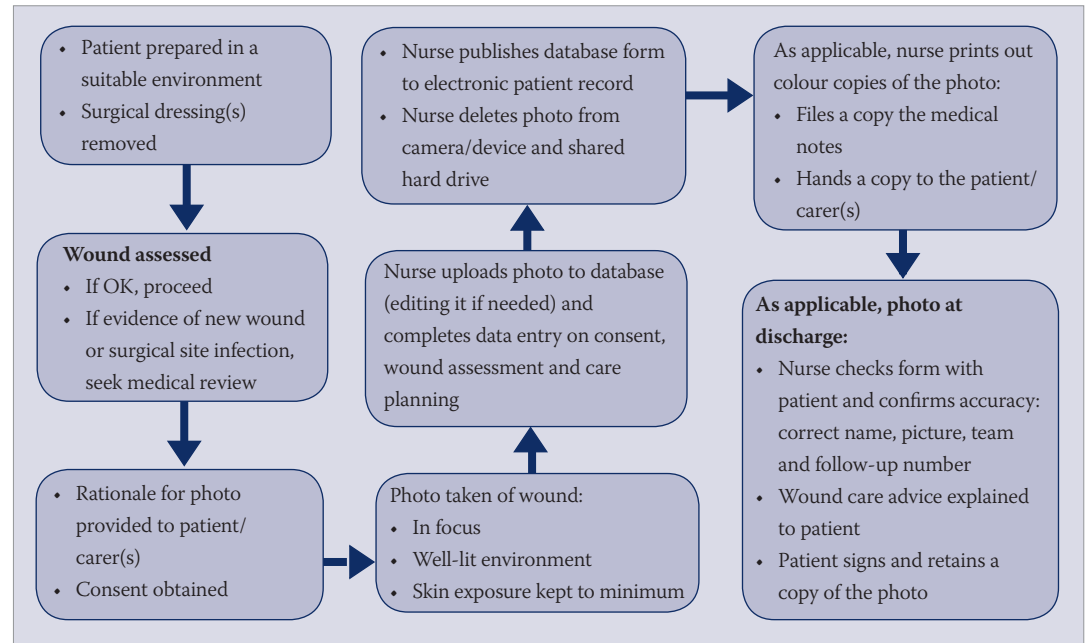**Figure 2. Fundamental system requirements to manage digital wound images.**

Figure 3. Flow diagram of the process involved in obtaining and processing wound photos.

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