

Development and Evaluation of Web-based Software to Efficiently Run Enhanced Recovery Surgery

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Abstract

Enhanced recovery surgery (ERS) has revolutionised patient outcomes. It involves a standardised peri-operative patient management regiment, leading to a reduction of length of stay, morbidity and mortality. ERS requires extensive peri operative assessment accompanied by numerous investigations and data collection within restricted time. For this reason, several units have allowed such services to be specialist nurse-led. The purpose of this study was to develop and evaluate web-based intranet software in assisting the ERS service of our institution.

The use of an ERS software in conjunction with a nurse-led service is effective and important for the success of implementing an ERS scheme. The improvement in practice resulted in a significant reduction of the length of hospital stay. In the long term, with the availability of these software-generated data, clinicians will be provided to further evaluate and improve their practice. Such specialised software tailored according to the needs of specific departments should be fully supported by the hospital management and the IT departments. This approach provides information to allow evidence-based comparisons within different institutions and this open source software can act as a template to achieve this.

Keywords: Enhanced Recovery; Surgery; Software; Complications

1 Introduction

Enhanced Recovery Surgery (ERS) (also known as Fast Track Surgery) was introduced as an approach to reduce the physiological dysfunction and morbidity associated with traditional peri-operative care. This involves a multi-modal approach to minimise post-operative pain, immobility and gut dysfunction. It was pioneered in colorectal surgery, [1] but such principles have been applied to other surgical subspecialties. Several traditional peri-operative practices, many regarded as unchallenged dogmas, have been shown to offer no benefit or even be harmful to patients. Such practises include bowel preparation, excessive starvation prior and after surgery and prolonged use of nasogastric tubes (NGT) in the post-

operative period. ERS typically involves attention to peri-operative nutrition [2], avoidance of premedication, epidural anaesthesia, early drain and NGT removal, avoidance of excessive fluid and sodium loading [3], and early mobilisation. The ultimate goal is to reduce morbidity and hence, length of stay (LOS) along with costs.

A recent meta-analysis, comparing ERS with standard care in colorectal surgery, of 4 randomised controlled trials (RCTs) and 7 controlled clinical trials (CCT), including 1,021 patients showed that primary LOS (weighted mean difference -2.35 days, 95% confidence interval (CI) -3.24 to -1.46 days, $P <$

0.00001)) and total (primary and re-admission) LOS (weighted mean difference -2.46 days, 95% CI -3.43 to -1.48 days, $P < 0.00001$) were significantly lower for the ERS programs. Morbidity was also lower in the ERS groups. Authors concluded that such protocols show high-level evidence on reducing primary and total hospital stay without compromising patients' safety and offering lower morbidity [19].

Several pre-assessment tools exist for general and colorectal surgery to further aid in risk prediction in order to apply preventive measures. The Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) requires 12 physiological and six operative parameters for its risk assessment [4]. It can be also used in the pre-assessment clinic to give an estimate of risk. Other scoring systems are used by anaesthetists, such as "ASA" for general risk prediction and "APACHE" for critically ill patients in the intensive care unit (ICU). ERS requires extensive pre-operative assessment accompanied by numerous investigations and data collection within restricted time. For this reason, several units have allowed such services to be specialist nurse-led [5]. To our knowledge, this is the first time such specialised software is being evaluated along with an ERS service.

The purpose of this study was to develop and evaluate novel web-based intranet software that would aid in running smoothly the enhanced recovery service of our unit. This would be achieved by assessing the impact of the software on the patient and information management as well as by further evaluating the unit's performance

2 Methods

During November 2006 and December 2006 we assessed the performance of the colorectal unit of our institution. ERS was planned to be introduced aiming to reduce the patient morbidity, LOS and associated costs. There were two key strategies associated with the ERS service. Namely, changing the traditional surgical care to a more scientific and evidence based one and modifying the "surgical stress response".

Prior to the implementation of the ERS software, patient pre-assessment was performed (and often poorly) by surgeons in the form of questions regarding patients' past medical and social history. Research fellows were involved in different projects as the colorectal department had no available prospectively collected data to analyse (apart from the basic demographics). Clinicians involved in investiga-

tions requests had to follow them up during their limited time and in a rather non-systematic manner. There were occasions that the patients were ready for their operation, the surgeons were not fully aware of the pre-operative results and had to search for them in a limited time (e.g. some results were not available in the hospital Electronic Patient Records (EPR) system). The colorectal department had to adapt to the new ERS scheme by employing two specialist nurses, developing the ERS software and converting the physician-led patient pre-assessment to a specialist nurse-led one

2.1 Development of the Software

In consultation with healthcare professionals (two Consultant Surgeons, two Registrars, two Junior Doctors, two Specialist Nurses, four Research Fellows, one Clinical Fellow, two secretaries, two administration desk employees, two technicians), of our hospital, as well as those from other hospitals (two Consultant Surgeons) with an established ERS program and the clinical risk management committee (three members), we determined the fields and functions for the web-based software. A user-driven design process was used and functionality reflected the core work of the clinician and the newly appointed specialist nurses of the department. The software was developed on a Microsoft 2000 SQL Server database (stored at the University College London Hospitals main server) using Windows Internet Explorer version 6 (IE6) as the software interface. This contained "html elements" and "SQL queries" for data entry, query, update and delete, schema creation and modification, and data access control. The software design is available as open-access and can be requested for free from the authors (D.A.R.) for implementation in any national health system worldwide. The developer (D.A.R.) is a surgeon with a particular interest in healthcare informatics and there was no significant input in its development by the IT department of the hospital.

In summary, fields included in the software were the following: Basic demographics and patient characteristics (Figure 1), pre-operative assessment and investigations (Figure 2), post-operative and recovery information (Figure 3). The tabs at the top of the screen on the menu bar represent the basic operating features of the software (Figures 1-3). We decided to include all major validated patient assessment risk scores (POSSUM, ASA, APACHE (Figure 2)) in order to create risk-adjusted preventive management measures. Furthermore, we also included the cardiopulmonary exercise test (CPEX) (Figure 1) [4], a novel investigation that measures

the anaerobic threshold (AT) of the patients, reflecting their lung and heart function. This facility was available at another local institution with direct access to the software. It was also decided that all pre-operative assessments would be organised fully by our ERS specialist nurse. Main responsibilities are shown in Figure 1:

Parameters	Comments
Information	Explain to the patients about ERS. Provide leaflets. Daily milestones.
Pre-operative plan	Organise all investigations including CPEX, bloods, further imaging. Nutritional assessment and high energy drinks.
Medical assessment	Medical history Risk prediction
Social assessment	Smoking, alcohol. Home conditions
Expected discharge plan	Identify factors that may delay discharge

Figure 1: Pre-assessment performed by the specialist ERS nurse

Figure 2 is the first page regarding the patient data entry. Basic patient demographics are mandatory to continue within the software to ensure adequate data collection. DOB stands for “Date of Birth” and Hosp. No. for “Hospital Number”. The presenting complaint could be either “asymptomatic” or predominantly the change in bowel habit, loose stools, diarrhoea, blood per rectum, abdominal pain, bloating and other. FH stands for family history (for cancer) and PSH stands for “Past Surgical History”, an important factor associated with the complexity of surgery and outcomes in surgical patients. In the pre-operative, discharge and outpatients sections, data such as height, weight, BMI (Body Mass Index), MAC (muscular circumference), TST (Triceps Skin fold Thickness), MAMC (Mid-arm Muscle Circumference) are entered in order to evaluate the fitness of the patients pre- and post-operatively and further correlate those factors with the surgical outcomes. The PMH (Past Medical History) as well as the SH (Social History) are also very important to be included in order to engage preventive medical measures, include them in the statistical analysis and correlate them with the outcomes. All patients must receive pre-operative CXR (Chest X-Rays) and an ECG (electrocardiogram) as well as other Ix (Investigations) to further aid the risk assessment. Observations such as SBP (Systolic Blood pressure), DBP (Diastolic blood pressure) and the HR (heart rate) should be also entered. Bloods (Haematology laboratory findings), U&E (Urea and electrolytes), LFTs (Liver function tests), Clotting data are also entered in order to evaluate whether the patients’ are safe to have surgery, their post-operative progress and correlate them with the outcomes. As previous-

ly mentioned, feeding (i.e. Clinutren, a high energy drink) is very important to surgical stress and recovery. Bowel prep (preparation in the form of cathartics), the use of NG (Nasogastric Tubes) and TPN (Total Parenteral Nutrition) are generally avoided in ERS as they are known to provide no benefit to the patients and slow their recovery. It is also important to plan the post-operative course of the patients and informing them with the predicted D/C (DisCharge) date. The Cardiopulmonary Exercise Test (CPEX) is an integral part of the data collection process as this test has been shown (see below) to be an independent predicting factor of complications. This test allows preventive medical measures such as post-operative admission to the intensive care unit (ICU).

UCLH Enhanced Recovery

BioStatIT Web Developments

Figure 2: Demographics and pre-assessment section

Figure 3 is the peri-operative section key data are collected such as the use of blood transfusions, adrenergic drugs (e.g. adrenaline), whether an unplanned splenectomy was performed, whether bleeding and abdominal faecal contamination was encountered. All these are well known to complicate the post-operative course of the patients; all doctors must be aware of them (which had not always been the case) and are important in comparing laparoscopic with open surgery and their outcomes. The use of drains, cath (catheters) and epidural analgesia are also important to be documented so that all doctors are aware of their use and avoid unnecessary prolonged use. Parameters of the anaesthesia induction and at the end of surgery are also collected for comparison purposes and risk assessment. The Colorectal POSSUM and ASA risk predicting scores are also included here along with the consultant and the primary surgeon’s grade.

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Figure 3: Peri-operative information section

2.2 Evaluation

2.2.1 Choosing the Main Areas of the Software Evaluation

During the first phase of the software design (January 2007), all participants met together to agree on the main areas of the future software evaluation. This was based on their concerns, needs and personal ideas. Using a qualitative study design [6], the following were found to be the main areas for the software evaluation: a) Functionality b) Usability, and b) Independency. These were derived from the participants' answers to open-ended questions of semi-structured interviews concerning their attitudes and opinions regarding the areas of improvement of their work. This is a validated method for creating the main areas for evaluation as described elsewhere [25] Figure 4 illustrates the study flow.

2.2.2 Evaluation of the Software during its Design and Development

The purpose of the evaluation was to measure the effectiveness of the software in meeting the users needs and solving their problems identified in the first phase of the design. This was also performed using the same qualitative method described above. Functionality assessed the ability to improve the workflow of the healthcare professionals. Usability was assessed with regards to its user friendliness. Independency was defined as the ability of the software to cover all information needs of the ERS service without having to necessarily access other EPR systems of the hospital. Semi-structured interviews [6] investigated these criteria and observation notes were collected while using the software in real time (May 2007 – June 2007) (Figure 4).

2.3 Implementation

An electronic manual was available on the start menu of the software and support was provided by the developer (D.A.R.) of the software involved in the project by email, telephone and the hospital bleep system for immediate help when needed. A shortcut icon was placed to all relevant computer terminals of the hospital. These included the following areas: The outpatients' clinics, the wards, the CPEX facility, the operating theatres, the medical secretaries and the clinical fellows' room. A training session was held for the specialist nurse and the research fellows involved in the project. Login names and passwords were provided. This was divided into 2 sessions. The first was performed prior to the implementation to ensure an adequate efficacy of the software as well as to avoid any errors in data entry. The second session was performed 1 month after the implementation to improve the software by taking under consideration further suggestions, minor changes and correcting minor errors.

2.4 Ethical and Legal Issues

All efforts were taken to ensure compliance with the Data Protection Act and good clinical practice guidelines for research. The database was password protected and only accessible via the hospital intranet. Only the design team had access to database records and all users of the Trust involved.

2.5 Statistical Analysis of the Quantitative Data

The software was designed to export automatically all data in a Microsoft Excell™ format and then were imported to SPSS 16 for further statistical analysis. Continuous variables were compared using either the two-sample t test or the Wilcoxon rank sum test depending on the normality of the distribution. Categorical data were compared using the Fisher's exact test. A p value of ≤ 0.05 was considered statistically significant. Binary and linear multivariate regression model was used to calculate independent predicting factors of complications and length of stay respectively. Statistical analysis was performed on SPSS 16® for Mac.

3 Results

3.1 Assessment of the ERS Software

The ERS software provided a novel approach in the

way that ERS patients were managed. Based on the controlled, semi-structured interviews of the healthcare professionals involved, the following were noted regarding the impact of the ERS software to the Colorectal Department.

3.1.1 Impact on Nursing

The specialist ERS nurses noticed that the software was a useful tool to aid in the patient management. This was mainly due to the ability to have all patient information in a single location, not having to access patient data through different hospital EPR systems that were not compatible with each other. Also, the CPEX test scores (that was performed in a separate institution) initially had to be requested by email and then faxed to the medical secretaries that were situated in a different hospital building. With the implementation of the software, the CPEX results were readily available in all computer terminals of the hospital including the outpatient's clinic and the wards. The specialist ERS nurses concluded that this software was beneficial in significantly reducing the time needed for data entry as well as searching patient information in different sites. Furthermore, they felt that it improved the patient information management by having it centralised.

3.1.2 Impact on Surgeons

Prior to the ERS software implementation, numerous investigations and pre-assessment evaluations created chaos to the physicians that were already busy with their clinical activities, not having enough time for administration and investigation arrangements. With the ERS software, the surgeons had immediate and updated access to patient information, important dates and the current patient status. The senior surgeons appreciated the efficiency of the software in creating monthly morbidity and mortality audit data automatically. The software also had the ability to create data lists of patients compatible with other different ERS services, allowing comparable results to be analysed among other centres and in meta-analyses [19]. These improvements resulted in reducing the time and effort in searching patient information, ensured that all important data were available for the patient assessment as well as provided the ability to evaluate their service continuously.

3.1.3 Impact on Anaesthetists

Anaesthetists were pleased that all pre-assessment data were available in a single site. This made them

aware of the patients' risk assessment prior to their admission for surgery (in this hospital admission occurs at the day of the operation rather than the day before). They were also able to assess the efficacy of the epidural anaesthesia (technically very advanced) and audit their own practice with prospectively collected and less biased data (initially the success rate of epidural anaesthesia was 55%, surprisingly low when compared to the published data). Anaesthetists were also relieved by the fact that they did not have to "negotiate" for the limited intensive care beds for their post-operative patients as this was already organised by the specialists nursed and aided by the ERS software. Thus, such improvements resulted in a better-run and organised anaesthetic service.

3.1.4 Impact on Research Fellows

Clinical research fellows were pleased to have the ability of access these standardised collected automatically generated by the ERS software data. With the software function of being able to export data in various file formats, they found it extremely helpful to be able to perform their statistical analyses in SPSS and/or Stata statistical packages, the most important aspect for their research interests. They were also surprised with the absence of missing data, especially when compared to their previous experience of retrospective data collection from paper-based or custom made excel sheets. The benefits included the availability of ready for analysis accurate databases, a significant reduction in the data collection time, thus allowing the research fellows to use their limited time for more deserving tasks, such as data analyses, manuscript preparation and literature searching.

3.1.5 Impact on Patients

During the controlled, semi-structured interviews, all healthcare professionals agreed that with the implementation of the ERS software, the major "winner" was the patient. In the short term, a clear management plan was created and the patients were aware of it. For example, high-risk patients received an ICU bed post-operatively, intermediate-risk patients a high dependency unit (HDU) bed and the low-risk patients a bed straight to the surgical ward after surgery. Most importantly, this decision-making was performed by the specialist ERS nurse, the clinicians involved and in conjunction with the suggested automated planning created by the software. Standardised electronic discharge letters that included also ERS information (not present in the

current hospital electronic patient records (EPR)) were available to the patient and the General Practitioner (GP) immediately. We argue that these improvements provided direct benefits to the patients, by improving communication, patient awareness and the potential reduction in the risks involved when not all information is available immediately when needed.

3.1.6 Overall Benefits

As mentioned above, this software had a significant impact on clinicians, nurses and patients. The overall benefits lie on the fact that it improved the time and information management in all fields of nursing and medicine by ensuring that all needs are satisfied in a multi-perspective way. We are hoping that a better-run service will ultimately benefit the patient experience and outcomes.

3.2 Assessment of the ERS Scheme

Analysis of data of 294 patients prospectively collected data with the use of the ERS software, between February 2007 and December 2008 (Figure 5), revealed important findings. The patients were divided into 3 groups. 1) Those that had an incomplete or were unable to complete the CPEX AT test, 2) those that had a score result of more than 11 (low-risk group), and 3) those that scored < 11 (high-risk group). The LOS, reflecting morbidity, was significantly higher in those with an incomplete test and in those in the high-risk group when compared to the low-risk group (Figure 5). Multivariate regression analysis performed for the identification of predictors of morbidity as well as of prolonged length of stay, revealed that the operation type ($p=0.046$), the surgeon's grade ($p=0.019$) and the CPEX AT groups ($p=0.043$) were significant.

When comparing the current results of ERS LOS with historical data of the colorectal unit of this institution, it was found that there was a decrease in the median LOS by 6 days [14 (2-102) vs 8 (2-84) $p<0.001$]

The post-operative course of the patients is documented on the page in Figure 4. This includes data regarding pain (efficacy of the epidural anaesthesia and to evaluate our service), the time the patient was mobilised (also known factor of recovery and healing), their bowel function, fluid management, psychological status, nutrition, whether their kidneys are functioning and the tissue viability (associated with skin breakdowns and infections). Important blood tests are also collected.

UCLH Enhanced Recovery

The screenshot displays the 'UCLH Enhanced Recovery' software interface, categorized under 'BioStatIT Web Developments'. The navigation bar includes links for Home, Demographics, Pre-op, Operation, Questionnaire, and Search. The main content area is divided into several clinical assessment sections, each with checkboxes and input fields:

- Patient details:** Fields for HN, name, and date.
- Pain:** Checkboxes for Epidural effective and Epidural removed; a text field for Linear pain score at 18:00.
- Mobility:** Checkboxes for Not recorded, S/B Physio, No of H out of bed, and Walk 1 through Walk 4.
- GI status:** Checkboxes for Not recorded, Nausea, Vomiting, Flatus, and Bowel motion.
- Fluid balance:** Checkboxes for IV fluids, Oral, Central line removed, and Arterial line removed.
- Psychological:** Checkboxes for Drowsy, Psych status as usual, and Oriented in time and place.
- Nutrition:** Checkboxes for Not recorded, High protein drink (any time), Oral fluids ml, Breakfast, Lunch, Supper, and Snacks.
- Urine output:** Checkboxes for >1/3 ml/kg/hour and Catheter removed.
- Stoma:** Checkboxes for Stoma present and Stoma healthy.
- Tissue Viability:** A checkbox for Watertight score.
- Bloods:** Input fields for various tests including hb, hcv, wcc, plt, neut, na, k, urea, cr, po4, alb, bili, alp, ast, gamma, ca, irr, and aptt.

Figure 4: Post-operative and recovery information section

4 Discussion

New approaches in pain control, introduction of techniques that reduce the surgical stress response and the more frequent use of minimal invasive surgery have been introduced over the past decade [7]. ESR is gaining popularity by reducing morbidity and hence LOS. It is currently applied predominantly to routine elective surgery. A recent meta-analysis comparing ERS with standard care in colorectal surgery supports these findings [19]. Similarly, in our study, it was found that there was a significant decrease in the patient median LOS by 6 days. The additional risk assessment and CPEX patient stratifications may allow the extension of ERS to more complex surgery (i.e. liver and pancreas surgery). The proliferation of nurse-led initiatives arising from the rise in nurse specialist/practitioners and latterly consultant nurse posts, in primary and secondary care, is leading to a quiet revolution throughout the healthcare system in terms of not only service delivery, but also the nature and profile of the nursing profession [8]. Other ERS services have allowed the service to be nurse led with great success [5]. Similarly, this service was nurse led and was further evaluated to be very successful and mandatory for its smooth-running and patient safety.

To our knowledge, in the medical/healthcare informatics literature, there is no such software previously described in aiming to aid in the smooth running of an ERS scheme as well as further identifying independent predicting factors of patient outcomes. However, there are many published examples of cases highlighting poor communication between healthcare professionals having serious consequences for patient outcome [20,21]. For this reason, it is well recognised that accurate electronic documentation of clinical information is of great importance to patients' safety [22]. The ERS software provided a novel approach in the way that ERS patients were managed. Based on the controlled, semi-structured

interviews of the healthcare professionals, we found that it had a great impact on those involved. The specialist ERS nurses noticed that the software was a useful tool to aid in the patient management by localising all patient relevant patient information in a single site, not having to access patient data through different hospital EPR systems that are not compatible with each other. The surgeons noticed that they had immediate and updated access to patient information and important dates thus significantly improving their time efficiency. The Senior surgeons appreciated the efficiency of the software in creating monthly morbidity and mortality audit data as well as allowing comparable results to be analysed among other centres in meta-analyses [19]. Anaesthetists were also able to assess the efficacy of the epidural anaesthesia service and audit their own practice in a less biased manner. Clinical research fellows were pleased to have the ability of access these standardised prospectively collected and automatically generated by the ERS software data and analyse them in statistical programs.

It is well known that most of surgical research is still produced from retrospectively collected data [24]. This ERS software has significantly improved the research design, data collection and statistical analysis methodology. Software tailored according to the specific clinical needs and research interests have shown to improve the accuracy of documentation and information sharing. There is good evidence that data collected electronically using such computer systems are more accurate and contain fewer errors than data captured manually with traditional “pen and paper techniques” [9-11]. Similarly, this software allowed accurate and standardised data collection that provided both an evaluation of the unit’s performance as well as independent predictors of patient outcomes related to these specific settings.

In an EPR system, structured data are preferable to free text, because most benefits rely on structured or coded data [12]. Structured data entry (SDE) applications can prompt for completeness, provide better ordering for searching and retrieval and permit validity checks for data quality, research and especially decision support, [13-15]. In this software, data entry was predominantly in the SDE form. It was well designed not requiring additional free text data to be entered that later would have to be grouped subjectively for statistical analysis. During the controlled semi-structured interviews of our healthcare professionals we also found that SDEs also reduce that time of data entry.

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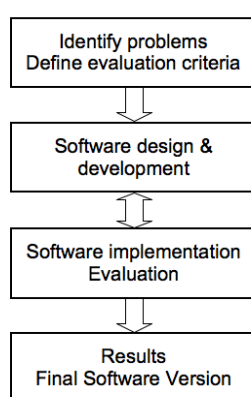


Figure 5: Study flow

We first identified the problems that could be encountered, the needs as well as the evaluation criteria. After having designed the software, during the implementation phase, it was evaluated and continuously re-designed according to the remarks of the

users. This was also performed in case-by-case bases. Finally, the result was the final version of the software, which all participants had contributed significantly in its development.

Figure 6 illustrates the summary of the findings generated by this software. It is important to note that without such a systematic prospective data collection process, there would have been no available data to generate these findings. A total of 294 patients were included in the ERS scheme, 47 were unable to complete the CPEX (Cardiopulmonary Exercise Test), 178 were able to complete it, 26 did not attend (DNA) their appointment and in 43 patients the test was not requested as they were young and fit for surgery. For those that completed the test, 134 had an AT (Anaerobic Threshold) of more than 11 (good heart and lung function) and 44 had a reading of less than 11. When comparing these 2 groups, the mortality rate and the median length of stay was significantly lower (10 (2-84) vs 7 (2-75) days, $p=0.006$) in the group with an AT of more than 11. The patients that were unable to complete the test were associated with a longer length of stay when compared to those that completed the test and had a reading of more than 11 (11 (2-72) vs 7 (2-75) days, $p=0.006$).

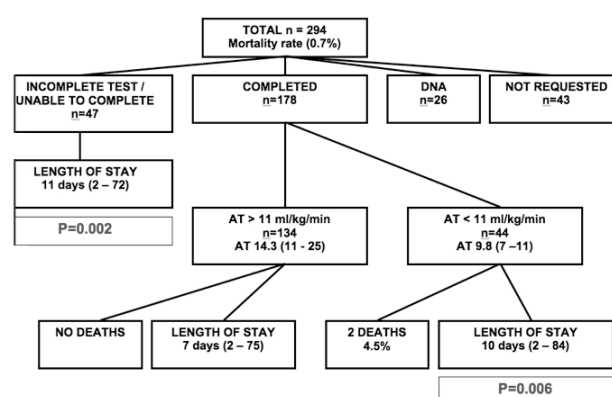


Figure 6: Important findings generated by the use of this software

This software allows the creation of up-to-date lists of patients waiting for a clinical appointment, investigation and admission for treatment. Having the facility to produce automated sheets avoided errors and saved time by not having to duplicate information several times. A prospective, randomised trial demonstrated that a computer system improved workflow by reducing the amount of time spent re-copying data, by decreasing the amount of time needed to complete activities and by helping clinicians finish their work sooner [16]. Similarly, the users of this software were pleased to be able to have all the important patient information immedi-

ately at a single site, rather than having to search different hospital EPR programs not compatible to each other (such as the haematology, the imaging and the clinic letters databases of our institution).

Sarkar et al. [17] described the development of a problem-based patient-tracking tool called Synop-SIS. This software was not a stand-alone system but an integrated part of the Electronic Patient Record. Central to their design process was to map patient data available in the electronic medical record to each of the main functions of the software and this was part of its success [17]. Other systems have integrated other existing hospital information systems already in place to automate data gathering tasks to enhance workflow efficiency [18]. During the design process we were intending to fully integrate this software with the main hospital EPR system and automatically transfer patient demographic and other investigation results to this software. However, this was not possible due to the lack of the IT department's interest and support.

Thus, it is important to emphasise the need of the hospital management and IT support to such specialised software tailored according to the specific clinical needs of certain departments. We feel that an ERS scheme cannot be officially assessed and improved without such specialised software and one of the reasons is the large amount of data that need to be prospectively collected. For example, we found with the use of this software that independent predictors of morbidity as well as of prolonged length of stay, to be the operation type, the surgeon's grade and the CPEX AT group to be significant. Multivariant regression analysis requires the collection of large amount of data to be able to produce patient characteristics adjusted outcomes.

Certainly, our future aim is to manage to integrate this novel ERS software with the current hospital EPR system as well as to continue analysing additional data to further identify independent predictors of patient outcomes by adding any potentially new risk-predicted scores. Furthermore, we need to assess the patient experience from their point of view as well as to assess the benefits of such a service and software reported directly by patients with the use of a validated questionnaire. Another field that needs to be improved in the near future is the classification and grading of the surgical complications. Traditionally, surgeons have selected and assessed their own outcomes, mainly focusing on short-term clinical measures of technical success. Such outcomes are not standardised and reproducible, impeding their evaluation. One proposed strategy is to use a validated "therapy-oriented" complication

classification system, which ranks negative events by severity and avoiding confusing terms [23]. This would allow this ERS open source software to be a validated template for all ERS services.

5 Conclusion

The findings of this study suggest that the use of an ERS software in conjunction with a nurse-led service is effective and important for its success. We have also demonstrated that the improvement in practice resulted in a significant reduction of the length of hospital stay. In the long term, with the availability of these software-generated data, clinicians will be provided with further independent predicting factors of surgical outcomes, allowing them to improve their practice and the patient management. Such specialised software tailored according to the needs of specific departments should be fully supported by the hospital management and the IT departments. Finally, this approach provides information to allow evidence-based comparisons within different institutions and this open source software can act as a template to achieve this.

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