Bed Management System Development

Flannagán Noonan[a], Juncal Nogales, Ciarán Doyle, Eilish Broderick and Joseph Walsh[b]
IMaR, Munster Technological University, Kerry Campus, Clash, Tralee, Kerry, Ireland
{*flannagan.noonan, juncal.nogales, ciaran.doyle, eilish.broderick, joseph.walsh*}*@mtu.ie*

Keywords: Bed Management, Hospital Administration, Patient Throughput.

Abstract: The costs of supporting hospitals are rising, bed numbers are falling and a growing population living longer will require more hospital visits over their lifetime. Thus there is a global focus on increasing the efficiency of patient throughput in a hospital. Bed management systems are still commonly paper-based and are effectively memory-less from the hospital point of view. The hospital information systems are typically billing and ordering systems with minimal information on patient movement along the patient pathway. The literature suggests that technology and shared information allow for shared views to model and predict usage to better manage finite resources. Paper-based systems work against this. This paper presents the design considerations for a bed management application developed in conjunction with a local private hospital. The application developed, provides a hospital-wide view of patient and bed status by recording and capturing touchpoints, that is patient-hospital interactions. Furthermore, it captures data electronically such that the data can be used for analysing patient presentation and bed moving with a view to improve bed management and patient throughput.

1 INTRODUCTION

The escalating costs, in the European Union (EU), for hospital funding is discussed in Schwierz, 2016. The paper also highlights that bed numbers are dropping, due to cost pressures and the changing healthcare model. EHealth it suggests "*may increase quality of service and create savings in hospital care*".

Paper based systems, still common in hospitals, are best effort systems and hence can increase stress on people delivering them, due to extra effort required at times due to unplanned events. Paper based systems create information silos that detracts from a common understanding across the organisation. Multi-disciplinary teams needs a common view of the information to make informed decisions and information silos detract from this.

Efficient management is key to delivering the maximum services to patients as quickly as possible, which is a good societal goal and delivers better value for taxpayer or health insurance funding.

This paper discusses the development of a bed management application in conjunction with a local hospital, one hospital in a hospital group providing private healthcare in Ireland. The proposed system provides a number of touchpoints, patient-hospital interactions, that can identify, in real time, where the patient is in the patient pathway. The goal is to answer the question "can data around patient interaction events (touchpoints) be gathered with a view to allow meaningful comparison of individual patient journeys?".

2 BED MANAGEMENT ISSUES

Bed management is a key area in addressing patient throughput in a hospital. Literature indicates issues with current bed management practices and suggests three areas of improvement: Communications; Process change; Modelling and Prediction. In all of these areas data is required for their implementation.

2.1 Admissions & Discharge

At a high level, the bed management process is, where a patient, either elective or emergency, is admitted to the hospital, placed in a bed and is treated. Following treatment, the patient is discharged, the bed occupied by the patient is renewed for the next patient and following renewal is made available to bed management for placement of another patient.

[a] https://orcid.org/0000-0001-9624-5181
[b] https://orcid.org/0000-0002-6756-3700

Noonan, F., Nogales, J., Doyle, C., Broderick, E. and Walsh, J.
Bed Management System Development.
DOI: 10.5220/0011690300003414
In *Proceedings of the 16th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2023) - Volume 5: HEALTHINF*, pages 376-383
ISBN: 978-989-758-631-6; ISSN: 2184-4305
Copyright © 2023 by SCITEPRESS – Science and Technology Publications, Lda. Under CC license (CC BY-NC-ND 4.0)

Admission and discharge are the areas that bed management can most influence and thus there is a large focus on both areas. Destino *et al*., 2019; Cho *et al*., 2017; Patel *et al*., 2017; Mustafa and Mahgoub, 2016, all cover initiatives to improve early discharge by focusing on process change and record the effects of these changes. However, James *et al*., 2019 and Rachoin *et al*., 2020, both suggest that the impact on Length of Stay (LOS) holds true for surgical patients but not for medical patients.

Given that a multidisciplinary team is responsible for discharge, shared information is key to managing and streamlining the process. This was highlighted in the studies above, where communication was a key factor contributing to the initiatives. Paper-based, mostly manual systems do not lend themselves to easy communications of status and create an overhead making the initiatives difficult to sustain.

2.2 Modelling

Bed management can be aided by modelling techniques. Modelling is very dependent on historic data to train and test the models and paper based systems do not lend themselves to easy extraction of the data, as input to models. Thus the capture of electronic data allows for shared information for management on a day by day basis. Additionally, these systems allow gathering of data over a period of time, which can be used to model and predict patient patterns to improve patient throughput.

2.3 Partner Hospital

The main computer based record system in the partner hospital is the Hospital Information System (HIS), primarily an ordering and billing system. The HIS is used to capture patient details when presenting for admission and updated sometime after patient discharge to show the bed available again. Until this happens, the bed is not available to other patients.

The current bed management system is paper-based and manual and to a large extent memory-less, in that each day a new paper model is populated from the HIS and the previous day's transactions forgotten. This does not lend itself to easy review of previous transactions to determine how the current method could be improved or made more efficient. The memory-less system limits discussion as the information and lessons learned rests with individuals and are not easily shared.

The HIS is not used by staff as a first point of call to get visibility of patients in the hospital relying instead on word of mouth or walking the wards. Requests for beds to be renewed are made directly to the Housekeeping staff on the ward. This contributes to the creation of information silos and a lack of real-time information. This lack of a shared view of the hospital occupancy, limits the visibility to a per ward basis, and inhibits administration of bed management on a whole hospital basis, creating inefficiency.

3 DEVELOPMENT OF A SYSTEM FOR BED MANAGEMENT

This section describes the development of the application. Being based in the hospital allowed access to clinical, administrative and housekeeping staff to gain a fundamental understanding of the hospital operation.

3.1 Requirements Gathering

An understanding of what was required was largely developed from documenting the high-level processes associated with the normal hospital operation, the patient pathways and supporting processes. Additionally, commercially available systems were examined. Most fell short of something that could be easily integrated into the hospital and the development of a bespoke system was undertaken.

Requirements gathering was primarily influenced by discussions with the Hospital Manager and the Bed Manager. In addition to the Bed Manager, the role was covered, outside of core hours, by the Assistant Director of Nursing (ADON) and their input was captured also. The Clinical Nurse Manager (CNM) for the Dayward covered bed allocations for that ward and contributed to the requirements. Interviews with staff, shadowing some roles and observing the hospital functioning all contributed to understanding the requirements for data capture. Review of the commercially available systems created a focus on developing a coherent system to manage the patient along the patient pathway while highlighting the bed renewal requirement and recording its completion.

Of note is that the bed renewal process involves both Housekeeping and Healthcare Assistant (HCA) staff. Bed renewal is complete when both roles complete their respective tasks.

A goal was to minimise any overhead a new system would impose, while providing benefit in terms of visibility. A series of screen mock-ups were created as a basis for discussion and feature definition with the Hospital Manager and Bed Manager. Subsequently a series of Hypertext Markup Language

(HTML) pages were produced to illustrate the User Interface (UI) concepts.

3.2 Requirements Recorded

Based on the above work, the requirements were defined at a high level as:

- Facility to allocate a bed to a patient
- Facility to move a patient between beds
- Facility to capture a patient details for later admission
- View wards and determine their occupancy
- View beds pending renewal
- Update beds to indicate renewal completed
- View bed availability
- View bed occupancy
- Filter bed criteria

The requirements definition included using barcodes as the means to identify staff, patients and beds. This reasoning was twofold. Firstly, as part of the Admissions process, the patient bracelet identifying patients contained a barcode representation of the data, thus being readily available. Secondly, a concurrent project was using barcode identifiers as the mechanism for identifying staff, patients and beds; and thus a commonality of techniques would serve for easier deployment of the application and training of, and acceptance by, the users.

4 SOFTWARE DEVELOPMENT

The following sections discuss the development of the various software elements that constitute the application.

4.1 Model Choice

A web based or browser based application was considered as the most suitable model for the application since it would be available across any device that could support a browser, including personal computers, tablets and phones regardless of the operating system installed on the device. Additionally, updates to the software could be pushed out by simply updating the software in a single location, rather than having to update individual clients.

A web browser, from a perspective of the Bed Manager and other administrative roles, functioned well, due to their ready access to a computer or device. From a perspective of other data entry roles such as HCA, Housekeeping and the Admissions staff, this was perceived as restrictive. Housekeeping particularly did not routinely access computers, thus it would be great change in work practice to adopt this. Similarly, for the HCA roles fulfilling the patient escort function, the mobility elements would make using a computer terminal counterproductive. Thus in addition to the web architecture a method to provide mobility with ease of access was required. Given the ubiquity of mobile devices and their general acceptance and use, a medical grade mobile phone as a means of data input was considered as central to a robust roll out. The addition of a web service element, to allow data entry from those functions that are mobile or entering very defined data, was viewed as a definite requirement.

A Model View Controller (MVC) pattern was chosen for the web application, since this would allow the main processing to be retained on the server, essentially requiring very basic computing power on the user device. This enhances the range of devices that could use the application. The MVC pattern is more supportive of changes to one of the layers whilst minimising impact on the other layers, than other patterns. A separate controller was built to accommodate additional mobile devices and operating the mobile views via a web service, extending the architecture. Fig. 1 represents the model as implemented.

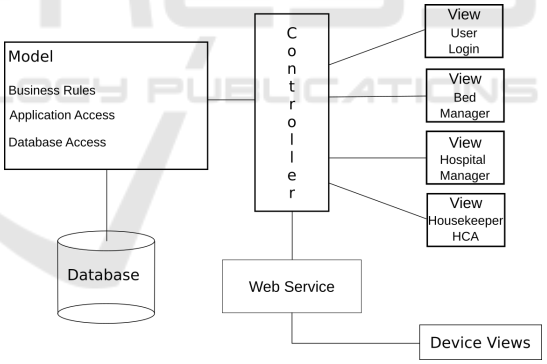

Figure 1: Design Model for Bed Management Application.

4.2 Database Elements

The database, conceptually, began with a bed needing to be associated to a patient for a period of time, from the patient being allocated a bed through to them using the bed and then being discharged.

An intermediary relationship is required to break down the bed / patient many-to-many relationship and a table called “StatusLog” was created to act as the link. This uniquely capture all transactions between all beds and all patients. Another requirement was to identify when a bed needed cleaning, and this could also be captured as a status.

Six bed statuses were defined: Allocated Pending; Allocated on site; Occupied; Out of Service Pending (represented as "OOS Pending"); OOS In Progress; Available. The status change transitions are recorded in table 1. Each bed cycles through these statuses as patients are treated. A "Status" table was created to capture these and referenced by a foreign key. The original bed status starts as "Indeterminate", which is where no "StatusLog" database entry exists for the bed. A bed with status "Indeterminate" can be allocated to a patient; the proviso being that the onus is on the person allocating to ensure that the bed is available to accept a patient. Once a bed has gone from the "Indeterminate" status, it will continually cycle through the defined statuses in the normal course of events.

Another mechanism to remove the "Indeterminate" status is via the bed renewal process. It was envisioned that, when the application was first deployed and all beds had "Indeterminate" associated with them, a situation would arise where Housekeeping and HCAs would be asked to renew a room with this status. Thus by scanning the barcode of a bed to indicate completion of bed renewal, the bed status would be changed from "Indeterminate" to "Available". Thereafter, it would cycle through statuses as shown in Table 1.

A key field in the StatusLog table was the timestamp associated with a status record, called "RecordTime". This timestamp allows the current status of a bed to be identified by searching on the latest timestamp associated with a bed. The use of a "where" clause allows searching within the "StatusLog" records as in

```
WHERE RecordTime = (SELECT MAX(RecordTime) FROM StatusLog
                    WHERE Bed_Fk = Bed_Pk)
                    AND Bed_Fk = Bed_Pk
```

The second repetition of Bed_Fk = Bed_Pk is to distinguish between multiple beds with the same timestamp, a common SQL technique.

Once that arrangement had been made, the other tables followed supporting the basic tables of "Bed" and "Patient". A room is a collection of one or more beds and a ward is a collection of rooms. The Room table was used as a grouping to enable gender changes on the bed collection associated with it. When a patient of a specific gender was admitted, or the last patient in a room was discharged, the gender of the room would change.

Table 1: Bed Status Transitions.

Status Steps	Status Change	Notes
Patient Allocated to Bed	Available → Allocated Pending	Bed Manager; ADON; Dayward CNM
Patient scanned at Admissions	Allocated Pending → Allocated On Site	Patient Details Captured
Patient Admitted via Bedside Scan	Allocated On Site → Occupied	HCA Patient Escort
Patient Treated	Occupied	No Data Collected
Patient Discharged	Occupied → OOS Pending	Captured at Ward or Reception
Bed Accepted for Cleaning Or Dressing	OOS Pending → OOS In Progress	HCA & Housekeeping Accept via Application
Bed Recorded Cleaned & Dressed	OOS In Progress → Available	HCA & Housekeeping Confirm via Scan

4.3 User Interface

The User Interface (UI) is divided across the Web Browser application and the Android application on the medical grade mobile phones. The mobile phone UIs are focused on data entry and are much more curtailed in terms of visibility of the status on the wards.

On the Web Browser, the concept of letting the user view each ward, as a floor plan, was formulated. It was felt that the user would be best able to relate to this view of the beds since they traversed the wards continuously, day in day out. Each ward would be represented by a single web page. Each bed would be colour coded to a gender, either male, female or non-gender. Single rooms and some wards are not segregated on a gender basis, such as the High Dependency Unit Ward and the Children's Ward. For multi bed rooms the bed gender is dictated by the gender of the person being first assigned to that room due to the hospital's single sex room policy.

4.3.1 Web Application UI

Each bed is represented by a rectangle and is filled with a colour denoting the associated gender; pink for female, blue for male and orange for gender neutral beds. To give a visual indication of whether a bed was available or not the concept of a diagonal strike through the bed was created. These two features combined allow a quick visual indication of the bed situation in a ward.

The graphic image of the ward is a Scalable Vector Graphic file and the bed rectangles have the background colour changed when the gender changes. The diagonal strike width setting is changed from 0 to a value when a bed is occupied. When a patient has been discharged on the system, the bed is automatically put out of service (OOS) and the diagonal strike and the border are changed to a yellow colour to provide visual indication that the bed is pending renewal.

In addition to the visual diagram, information regarding the bed population was also included in the text and as a pie chart at the top of the page, as a form of dashboard for the ward. A function was implemented to provide patient details for occupied beds

when the mouse hovered over the bed rectangle using a pop up canvas. This provided the patient name, Medical Record Number (MRN) and whether they were under isolation or not. This is illustrated in Fig. 2 by the large blue rectangle with the yellow band.

The yellow band with the red text gives a strong visual indicator that the bed has a second association with it. In the example given, the bed is OOS but the bed has been allocated to a patient for when the bed renewal is complete. There is also an indicator at the top right-hand side of the ward view, of beds that have been earmarked. Another potential scenario for using the earmarking feature, is when a patient is known to be imminently discharged then a second patient can be earmarked for that bed. This scenario can only be used for medical emergency patients, given their stochastic nature. Elective patients should be well defined and hence not added in this manner.

The ward layouts are fixed, taken from a floor plan and changing them would be a task for the developer. However, the number of beds in a hospital is a function of agreement with the hospital insurers and is not a simple change to vary the number of beds. Additionally there is a large reliance on routine, due to safety concerns. Thus there is a large inertia to overcome in changing the structure of the hospital. Hence, it is not something that would happen often and would require some planning. Changes to the display could be incorporated into that planning.

A visual reminder has been created of a patient waiting on a bed. Previously, this would have been done on a sheet of paper and this paper would have been archived at the end of the day. Now, a record is held, of each earmarked patient. These records can be reviewed and analysed to identify patterns of capacity constriction, potentially aiding efficient bed management.

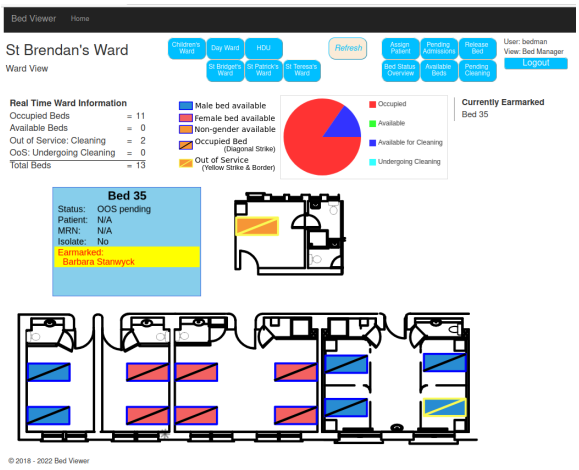

Figure 2: UI Ward View Test Application .

There is a screen for each of the seven wards, all similar to that represented in Figure 2 and accessible via the buttons above the dashboard. There are also other screens available both to the Bed Manager and other hospital roles. For the Bed Manager role, their buttons are similarly available at the top right of the ward screen.

The "Assign Patient" screen presents a collection of buttons, one per ward, that click through to the ward screens, where the underlying functionality is designed to allow a bed to be clicked and a patient assigned to that bed. Similarly, there is a screen that allows the Bed Manager to release a bed from a patient that is known to have been discharged. The scenario of usage might be that the Bed Manager is informed by Nursing that a patient has been discharged; and thus the Bed Manager can release the bed, to create an entry on the Housekeeping and HCA list of beds to be renewed.

The Bed Manager has access, via another screen, to the list of the beds currently out of service, detailing the bed status in relation to completion. Another screen allows the Bed Manger to capture details of patients being referred for admission by GPs. The patients are added to a "Pending Admissions" list. Each list item has an "admit" button that allows the Bed Manager to select a ward for a view of that ward, where the patient can be admitted. Generally, when taking calls from GPs with regard to accepting a patient from Admissions, it can not be done immediately as there are other factors to consider. This allows a patient's details to be recorded, and then the Bed Manger can come back to the list and admit patients when circumstances are aligned to allow admission.

Figure 3 shows a screen providing an overview of the bed status for the hospital as a whole. This screen is also available to the Hospital Manager's login and could be extended to other roles as required. This view provides a breakdown of the bed availability and status by ward. The default view shows the Available Beds in the blue buttons and below them a view grouped by bed type of bed statuses.

The filtering capability for Bed Category provides for availability of single beds or shared beds. Once a filter is selected, the per ward view updates to display the details, updating the text to reflect the filter. The grouping statuses update to reflect the filtered view also. Similarly for the Status By Ward filter, the text and figures, on the buttons, changes to reflect the view of cleaning by ward. The per ward view for cleaning status is deemed useful since it shows potential beds to be made available imminently. A separate page is available to the Bed Manager that focuses only on availability, essentially a subset of the overview view.

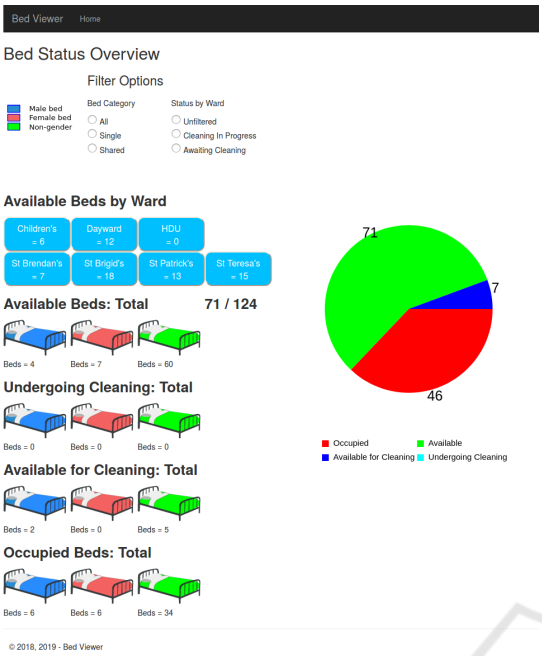

Figure 3: Hospital Bed Status Screen.

This page also provides pie charts giving a breakdown of available beds by gender, per adult ward.

The main focus, on functionality, was for the Bed Manager, with additional views for Housekeeping and HCA to trigger the start of a room being cleaned; deemed a supervisory function as the HCAs and Housekeepers would have limited access to computers. Additionally, a separate login exists for the Hospital Manager that provides, amongst other features, a screen to register users of the system.

4.3.2 Android Application UI

The purpose of the Android UI is to allow an easy mechanism to capture data. The devices used the inherent scanning functionality of this class of device to capture details via barcodes, both for patients and bed locations. This circumvented the need to manually enter information and thus reduce the possibility of error. The development focus was to reduce the number of button clicks required to capture the data.

The initial screen for the Android Application is a login screen. Login is achieved by scanning a barcode associated with a defined user on the database. If the user exists, then the server will return a JSON Web Token (JWT) to the device to allow it to continue communicating with the server. Without a current JWT, the server will return "Permission Denied". The JWT is set to expire after one hour but that is purely a nominal time, in the absence of any usage information. In addition to a hashed private secret key element for security, the JWT contains the user name and role used in the initial exchange and that dictates the screens available to the user. Table 2 lists the roles and the associated functionality.

A controller in a separate project is used as the Web Service for the mobile application, although it still uses the database access layer model in the main application to access data. The interaction between the mobile devices and the application is very defined with small data sets being passed up to the server. Confirmation messages or confirmation data is passed back to the mobile device. Given the use of barcode scanning to capture data and list selection as the only other data entry mechanism, the solution is robust to data entry errors.

One issue arose where, when a medical patient's details were entered, based on a GP referral, typographical errors crept into the data entry. Thus, when the actual patient details were scanned to admit the patient, the patient could not be admitted because their details did not match the details entered on the application.

This led to the development of an additional screen for Admissions to allow them to select a name from the list of patients pending admission and the patient database entry was subsequently updated such that where both existing and scanned patients have the same MRN, or the existing patient has no MRN and the scanned patient does not exist in the application database the scanned patient details and the MRN if

Table 2: Android Device Screens.

Role	Usage	Screens
All Users	Login	Main Screen
Admission	Scan the patient Set the Consultant	Admissions Screen 1
	Sets Finance Office Visit Required Sets Escort Requirement Sets Straight to Ward or Tests	Admission Screen 2
	Chooses the correct patient details if difference between scanned and application details	Admissions Screen 3
HCA Patient	Choose an Action, opens another screen	Patient Escort Screen 1
	Scan a Patient	Patient Escort Screen 2
	Scan a Bed	Patient Escort Screen 3
Escort	Select A Direct to Ward Patient	Patient Escort Screen 4
	Select a Patient for Test	Patient Escort Screen 5
	Record Transfer Complete	Patient Escort Screen 6
HCA & House-keeping	Record a Bed Renewal Complete	Bed Renewal Screen
Reception	Record a Patient Exit	Release Screen

applicable are applied to the database.

Alternatively, where the scanned patient MRN exists in the application database but is different to the MRN of the patient allocated, or the allocated patient has no associated MRN; then the "StatusLog" patient primary key reference will be changed to that of the scanned patient. Otherwise a new patient record, where the existing patient allocated to a bed, does not have an MRN and the scanned patient MRN does not exist in the database.

5 DEPLOYMENT & TESTING

The system was deployed in the hospital with the application running on a laptop acting as a server. The laptop was supplied with an IP address on an internal Virtual Local Area Network (VLAN) and mobile devices with IP addresses on this VLAN could communicate with the application and through to the application database. Fig. 4 was the planned deployment but due to the time to get the server deployed in the data centre, the testing was carried out using the laptop as the server. Thus the "Hospital Data Centre" role was implemented using the laptop, the laptop also functioned as a workstation for using the Web UI and the hospital VLAN provided the network transport from the mobile devices to the IIS and SQL servers.

The purpose of the testing was to provide the Hospital Manager with an understanding of the full capability of the system and to demonstrate the system and the functionality to other staff members, particularly the Bed Manager and the ADONs.

To test the application, the daily patient arrival, discharge and transfer data were entered onto the application, following the additional steps that would not normally be captured in the hospital, see Table 3 below. Although the timing data was not valid, due to the data being retrospectively added, it did allow the data to be captured, proving that this data could be collected. Over the course of the testing, from October 2019 through the beginning of March 2020, small coding anomalies arose and were addressed.

6 RESULTS

Four-hundred and sixty eight patients were processed on the application between October 2019 and March 2020. Testing was interrupted due to a staff member departing followed by a recruitment cycle. Based on hospital provided figures from 2016, some 50 discharges a day would be expected to occur. Thus the actual test quantity achieved is low but is sufficient to give an understanding of how the application performs.

The Hospital Manager, who carried out several days testing, did perform data entry over the entire patient pathway data recording and also the bed renewal recording. The Hospital Manager, required a short training session to grasp the functionality. Some features required elaboration which validates the need for training and discussion when introducing a new system. When considering that the application, designed for use by multiple roles, was being used end to end by people using the full functionality with less than an hour's training, this is illustrative that the ease of use criterion has been met.

Table 3 compares the features or data capture points, that currently exist between the Hospital Information System and paper based records kept locally and the application as implemented. This shows that significantly more detail is captured with the proposed system and can identify where a patient is along the patient pathways.

The feedback on the application, both the web browser and mobile device sections, from the Hospital Manager, supported the ease of use on the device. She felt the ease of use would lower the barrier to adoption. The use of the Receptionist role, to the release the bed and create an event highlighting the need for the bed to be renewed, was viewed as a critical feature. This allowed the highlighting of this task automatically, decoupling it from the Nursing role, where it could sometimes get overlooked due to Ward pressures. She thought that this feature, together with the bed automatically being made available following renewal, led to a big improvement in the efficiency of the hospital and bed allocation, for Medical Patients presenting stochastically.

The Bed Manager felt that the paper based mechanism she used adequately allowed her to manage the beds. She felt that the data entry required was onerous

Table 3: Event Capture Comparison.

Desired Feature	Existing HIS	System Local / Individual	New System Global View
Pre-Allocate Bed to Patient	No	Yes - Bed Manager	Yes
Record Admission	Yes	No	Yes
Record Arrival at bed	No	No	Yes
Capture Patient Egress From Hospital	No	No	Yes
Capture Bed Renewal Requirement	No	Yes - Nurse	Yes
Bed Available Notification After Renewal	No	Yes - Nursing / H'keeping	Yes
Graphical View of Patient Fill	No	No	Yes

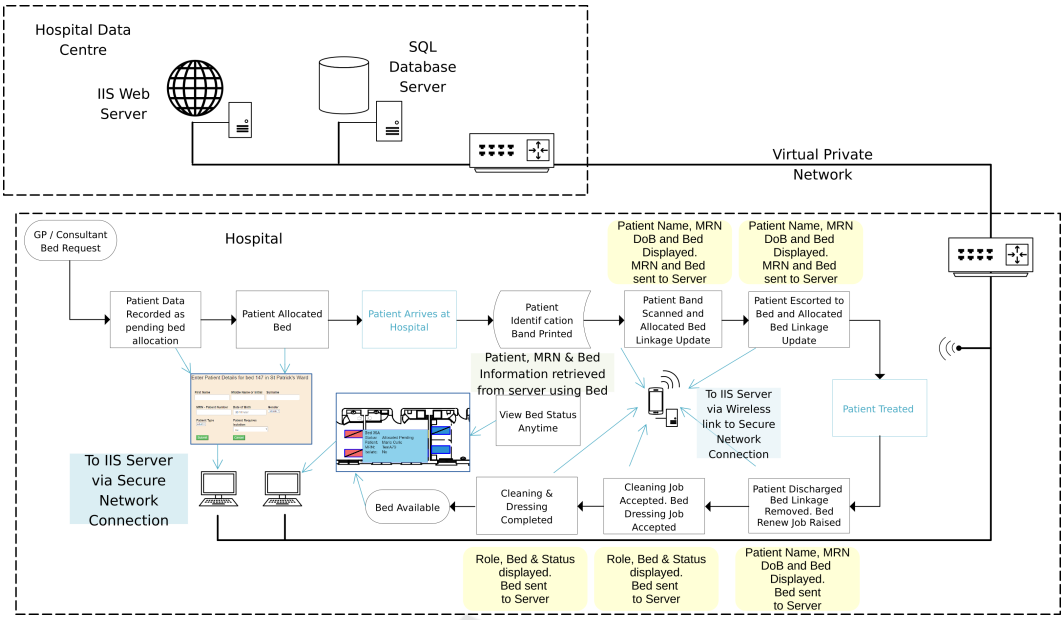

Figure 4: Planned Deployment and Data Capture Snapshot.

and was less efficient that her current system.

Some issues arose from this trial but were addressed. Some minor bugs were resolved in the software. The use of a defined naming with a fixed date of birth cause for patients caused an issue but was resolved simply by appending the day of test to the name.

Because data entry regarding patients was carried out retrospectively, no picture can be formed of patient movement, timing from admission to reaching the allocated bed and actual discharge times, but the fact that these have been recorded as events, even with artificial times, bodes well for data capture for use in a live environment, which is a further stage.

7 CONCLUSIONS

The literature reviewed suggests data sharing as a method for improvement of processes. This application allows data to be captured and presented graphically and textually to provide a common view of hospital status.

The system, as it exists, is a first step in being able to pull together different elements of the patient's journey along the care pathway. The next stage is to incorporate it into the overall information technology of a hospital to allow live data capture.

REFERENCES

Cho, H., Desai, N., Florendo, A., Marshall, C., Michalski, J., and amd A. Dunn, N. L. (2017). E-DIP: Early discharge Project: A model for throughput and early discharge for 1-day admissions. https://bmjopenquality.bmj.com/content/5/1/u210035.w4128. Accessed 07 October 2022.

Destino, L., Bennett, D., Wood, M., Acuna, C., Goodman, S., Asch, S. M., and Platchek, T. (2019). Improving patient flow: Analysis of an initiative to improve early discharge. *Journal of Hospital Medicine*, 14(1):22 – 27.

James, H., Steiner, M., Holmes, G., and J.R, S. (2019). The association of discharge before noon and length of stay in hospitalized pediatric patients. *Journal of Hospital Medicine*, 14(1):28 – 32.

Mustafa, A. and Mahgoub, S. (2016). Understanding and overcoming barriers to timely discharge from the pediatric units. https://bmjopenquality.bmj.com/content/5/1/u209098.w3772. Accessed 10 October 2022.

Patel, H., Morduchowicz, S., and Mourad, M. (2017). Using a systematic framework of interventions to improve early discharges. *The Joint Commission Journal on Quality and Patient Safety*, 43(4):189–196.

Rachoin, J., Aplin, K., Kupersmith, E., Gandhi, S., Travis, K., Stefaniak, M., and Cerceo, E. (2020). Discharge before noon: is the sun half up or half down? *American Journal of Managed Care*, 26(8):246–251.

Schwierz, C. (2016). Cost-containment policies in hospital expenditure in the european union. https://ec.europa.eu/info/sites/info/files/dp037_en.pdf. Accessed 11 October 2022.