

In Pursuit of Excellence for Cardiovascular Intervention at the Liverpool Heart and Chest Hospital

Operational Efficiency, Patient Safety, and Collaboration With the CareCube Platform

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Liverpool Heart and Chest Hospital, in Liverpool, United Kingdom (UK) is widely regarded as a beacon for innovation and excellence, not only in the UK, but in Europe and beyond. The hospital provides specialist cardiovascular services and procedures to a regional population of 2.8 million with additional specialist interventions performed on a national referral basis. For coronary intervention, minimally invasive valve replacement, electrophysiology, and pacing procedures, the hospital ranks among the highest volume centers across Europe.

The aim of this case study is to demonstrate how Liverpool Heart and Chest Hospital cardiac catheterization lab's willingness to improve by embracing change has provided the foundation for outstanding service delivery, operational efficiency, and patient experience. This review will focus on 5 key elements;

1. Communication and teamwork;
2. Patient experience;
3. Operational efficiency;
4. Patient safety;
5. Reporting performance and feedback.

Communication and Teamwork: Management by Consensus

Starting in 2006, the creation of regular meetings for all professional groups within the cath labs at Liverpool Heart and Chest Hospital provided a platform to share real-world issues with clinical and managerial leads. Prior to these meetings, problems affecting daily life within the department frequently grumbled along, creating discontent and division. The weekly cath lab user meeting created the space for the multidisciplinary team (MDT) to speak up, share concerns, and identify solutions. The same inclusive style was used in the creation of the 'Cath Lab Rules', an agreed-upon best practice approach to a range of factors affecting the culture and rhythm of departmental life. The 'Rules' addressed issues such as:

- Expected behavior of team members, including consultant staff;
- Start time and end time of all the labs, including the cut-off time for sending for the last case of the day;
- Rules and responsibilities for scheduling individual lists of cases;

- Responsibilities, authority, and scope for key roles; eg, cath lab coordinator and transfer staff.

Enhancing the Patient Experience

The motivation for much of the change at the Liverpool Heart and Chest Hospital has been driven by the desire to improve the patient experience from admission, to discharge and beyond, resulting from a Trust-wide initiative (UK Trusts are made up of 1-3 hospitals providing collaborative care). The goal was to transform the traditional, conservative approach of service delivery, revolving around the needs of the clinician, into the primary consideration of the needs of the patient. The patient (and their families), became the focus and drive for every aspect of service provision (Figure 1).

The Lounge Model of Care

The emphasis on the patient and family was at the heart of a landmark development, the Lounge Model of care at the Liverpool Heart and Chest Hospital. OLVG Hospital in Amsterdam, Netherlands, is the original architect of the Lounge Model of care, with the aim of ensuring the patient experiences a healing environment for the duration of their hospital stay. The choice of chairs, selection of fabrics, lighting, and facilities are all designed to create an environment more associated with a hotel than a hospital. Patients are free to roam within the area, and can access drinks and food as they wish. Most patients undergo procedures in their own clothes rather than a traditional hospital gown, improving levels of dignity. All consultations between the patient and the clinical team, such as observation records, wound checks, and discharge planning, take place in one of several purpose-equipped consultation rooms.

After a 2008 site visit to OLVG Hospital, Liverpool Heart and Chest Hospital established their own 'Day-Care Lounge' pilot project, offering a dynamic move away from the traditional method

Traditional Clinician Led Model

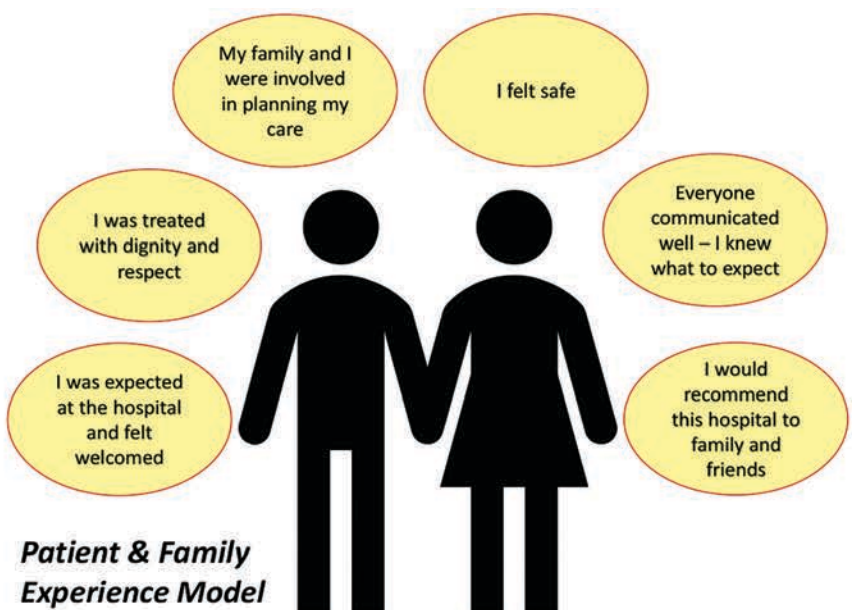
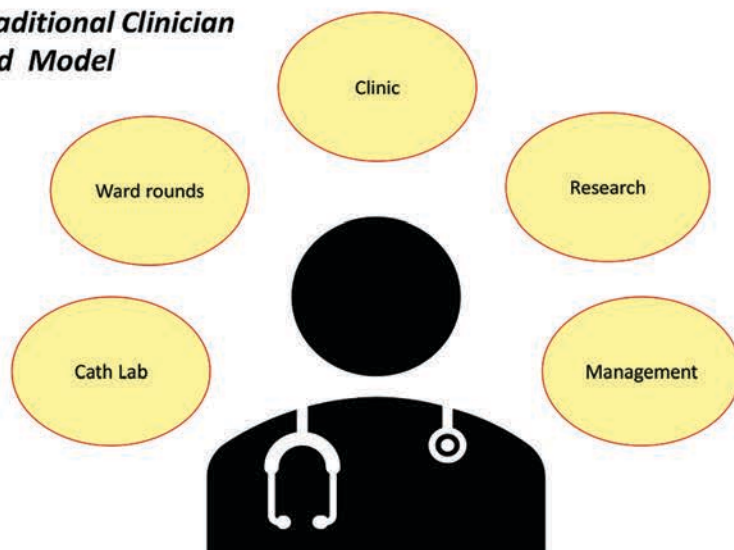


Figure 1. Contrast between clinician-led and patient experience models of service delivery.



Figure 2A-D. The Holly Suite at Liverpool Heart and Chest Hospital. (A) Patient Lounge. (B) Beverage Bay. (C) Chill zone, massage chairs, and mood lighting. (D) Computer hub for patients and their relatives.

of restricting patients to a single bed space, nil by mouth, and being wheeled to the cath lab, to the freedom and flexibility provided by the relaxed calm of a lounge environment. Patients were able to walk to the lab in their own clothes, removing the stigma of the hospital gown. The pilot project was a success not just in terms of clinical outcomes, with no adverse impact on infection or clinical incidents, but perhaps more importantly, it was a success for patients, who continue to enjoy this approach to care. The relaxed environment of lounge and lab almost eliminates the need for procedural sedation (used in about 7% of cases), maintaining patient ambulation, independence, and involvement!

Creating Holly Suite

The success of the day-care lounge pilot project led to the expansion of this same philosophy to all cardiac and thoracic patients who come to Liverpool Heart and Chest Hospital for a same-day discharge procedure. The new lounge facility, Holly Suite (Figure 2), is a much bigger patient care area with discrete zones. If a patient needs to rest post procedure, this takes place in a private area away from the lounge. Comfortable recliners provide an opportunity for patients to put their feet up. Massage chairs and soft lighting have been used to create a relaxation zone. The design was created with the deliberate intent of ensuring the materials used were of the highest specification, including feature walls, mood lighting, resin screens, open spaces, and artwork.

Some of our procedures cannot be performed in the patient's own clothes. This group of patients can enjoy the freedom and facilities of one of the two distinct lounge areas, designated for patients not in

their own clothes, but wearing a specially designed and tested lounge suit of trousers, top, and jacket. The suit pattern, created by the clinical team at Liverpool Heart and Chest Hospital, provides easy, Velcro-strip access for the various procedures we undertake, and ensures privacy and dignity for the patient at all times. This continuous drive for service improvement and enhanced patient experience has been reflected in an annual, confidential national survey of patient satisfaction (organized centrally by the National Health Service [NHS]). The hospital has been ranked number-one in England on 8 of the last 10 occasions.

The path to Holly Suite was the result of a 5-year journey, with key changes to practice including:

- **Radial Access PCI**

The move to establish the radial artery as the access point for angioplasty and stent procedures (PCI). The resulting improvements in comfort, early mobilization post procedure, and safety were dramatic and self-evident, and led to a wholesale change in practice.

- **Same-Day Discharge PCI**

The positive outcome of radial access PCI facilitated the next phase of development, moving from in-patient to same-day discharge PCI, offering the opportunity for patients to rest, relax, and recover at home; to sleep in their own beds rather than experience a night in the hospital and all that it represents, such as low levels of rest and sleep, and adjusting to ward routine, all of which can be an unnecessary inconvenience and the opposite of a 'healing environment'.

- **Pre-Admission Clinic**

Advanced nurse practitioners were recruited to

establish and organize the pre-admission clinics for same-day PCI patients. Obtaining the clinical history, performing the physical examination, and screening and consent of patients remains an essential, high quality element of the same-day discharge PCI service.

Operational Efficiencies

Flexible Working

As little as a decade ago, our cath labs were underutilized. On a consistent basis, as much as 20% of available clinical time during the normal working week was not even scheduled to be used due to staff shortages, poor scheduling, or other factors. The facilities stood idle. The established approach to cath lab allocation, with clinicians assigned to their regular set days and sessions across the week, was part of the dilemma. The advent of the primary PCI (PPCI) service in 2009 brought lab and operator availability sharply into focus. The fully implemented PPCI service added an additional 1200 cases per annum, an increase of 30% workload for the coronary cath labs. The PCI consultant medical staff agreed to move to annualized hours and flexible working. As a direct result, the additional emergency workload was able to be absorbed into the existing cath lab footprint and working hours.

Collaboration with CareCube

Throughout the last decade, Liverpool Heart and Chest Hospital has been aware of the need for quality information and information systems, not only to improve the efficiency of daily clinical practice, but also to provide aggregate data in order to better understand current performance and identify areas for future development. Practical experience gained with locally developed, standalone, 'pilot' digital systems provided helpful but limited support over the years. However, a collaboration with CareCube (CareCube Solutions) that began in 2017 provided an improved level of functionality to our existing digital systems for scheduling, patient tracking, and patient safety. Our local standalone systems were replaced with a single platform, providing a level of transparency and connectivity across all the clinical areas. The application provides a framework for clinical teams to support patient safety, reduce human error, and employ the best use of resources. The CareCube reporting module allows for the examination of every aspect of our activity in detail, in order to maintain our goal of continuous improvement.

The scheduling of clinical activity is performed by a variety of different individuals, focusing their attention on different time scales. For members of the hospital booking team, consultants, and their physician assistants (PAs), some scheduling is performed weeks in advance for planned elective activity. In contrast, every day, the hospital receives urgent transfers from other hospitals with advance notice ranging from 2 to 24 hours. We also provide one of the UK's largest emergency response services

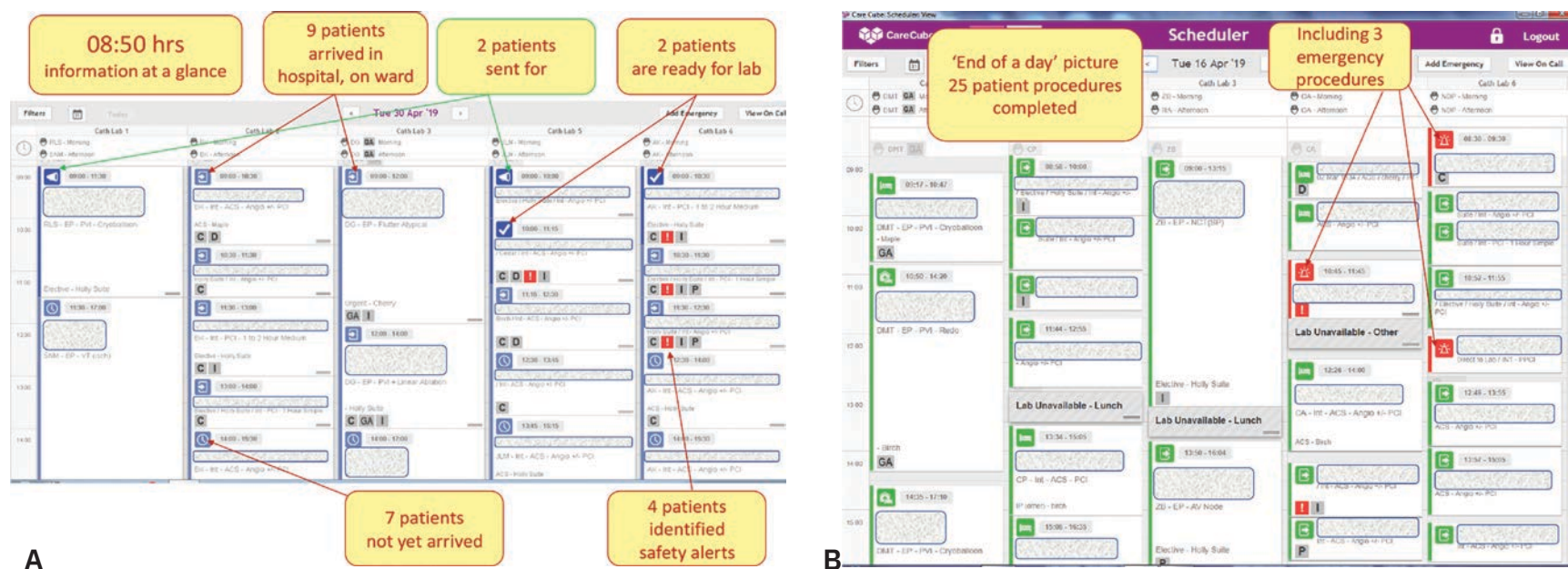


Figure 3. CareCube Schedule. A) Start of Day; B) End of Day. (For more images of the CareCube system, see the article online at www.cathlabdigest.com).

for the treatment of acute ST-elevation myocardial infarction (STEMI). The primary PCI service receives over 1400 activations every year, requiring a rapid and co-ordinated response, with the arrival of some of our sickest patients sometimes 5 times a day with only a few minutes notice.

CareCube's interface is displayed in a web browser and provides a medium through which staff in all clinical areas can seamlessly communicate with each other in 'real-time scheduling'. This eliminates the need for multiple individual communications, such as by pager or phone call, to communicate information about the progress in the clinical pathway of individual patients. Ward nurses will update the CareCube system with the click of a mouse to declare a patient has arrived, is later consented, and ready for the procedure. Cath lab coordinators announce that a patient has been sent for and arrived in the cath lab area with similar ease. Figure 3 shows the schedule at the start of the day, highlighting the symbols that aid communication, and then the schedule record for the end of the day, highlighting emergency cases fitted into the workload. Although we tend to quantify the benefits and efficiency savings with numerical parameters like cath lab turnaround time, the number of cases performed in a day, and other similar measures, there are, in reality, substantial savings in staff time, meaning that members of our clinical team can devote themselves more directly to the care of their patients.

Implementing a Patient Safety Checklist

The initial work on a patient safety checklist was performed in surgical theatres and followed the original model now often described as the World Health Organization checklist. With the support of the British Cardiovascular Society, Professor R.H. Stables led a working party to develop checklists specifically tailored to the cardiac environment. Staff at the Liverpool Heart and Chest Hospi-

tal have further extended this concept. The key aims have been to increase engagement with our patients during the checklist process (as active participants) and also to improve the team brief provided to staff.

The patient safety checklist and team briefing take place immediately before the procedure in the clinical area. It is conducted around a large touch-screen display monitor, mounted on the wall of the procedure room. The patient is completely involved in the process, can see their details on the screen, and confirm that their information is correct and clearly stated. Appendix Figure 4 (Appendix figures are online with the article at cathlabdigest.com) is a screenshot of the check-in process. The interactive screen also offers clinical staff the opportunity to review angiographic images, computed tomography (CT) scans, or sketch diagrams to assist with the case understanding and planning. Once the case has started, the electronic board display changes to a summary of the key clinical information. This is available for continual reference and also provides an excellent medium for the briefing of additional staff who may later be required to join the procedure. Appendix Figure 5 provides an image of the case display in practice. The check-out process takes place at the end of each procedure, before the patient leaves the lab. This action provides an opportunity for the team to check all important factors about the case are reviewed and discussed. Staff can also make observations or "flag" the case such that its potential for learning opportunities is identified at the time (Appendix Figure 6).

The CareCube reporting module allows the cath lab leadership team, on a regular basis, to review all flagged issues. The application provides the ability to launch immediate response key checklists for major clinical events (for example, cardiac arrest or mechanical ventilation). The checklist is specific to the nature of the procedure to be performed

(aided by artificial intelligence on initiation of the process) and wherever possible, the questions presented are adapted to individual details. For example, the system will autocomplete questions about pregnancy as not applicable in male patients. The system involves a password-guaranteed sign-off of both the team brief phase and eventual sign out of the patient. Information on the completeness of the checklist is stored and available for centralized audit of unit compliance. During the completion of an individual checklist, a traffic light system will alert users to the fact that key data fields are yet to be completed. Local Safety Standards for Interventional Procedures (LocSSIPs) have been incorporated into the CareCube modules and the data captured throughout the patients' journey meets all the recommendations required to comply with national safety standards (NatSSIPs). The Model Hospital and Care Quality Commission (CQC) demand a level of transparency for a number of key parameters to measure safety and quality, including:

- Lab allocation
- Touch time
- Start time
- Finish time
- Case numbers
- Turnaround time
- Deferral rate
- Cancellations

CareCube delivers reports on all these metrics and, in addition, provides valuable safety data on checklist completion and flagged issues. The emphasis is on high-quality report creation and the system will impose some restrictions — demanding, for example, a certain number of records to be present before the creation of summary statistics. Basic filters will include or exclude, for example, weekends and bank holidays, emergency cases, etc. Results are presented in a variety of forms.

Reporting Performance and Feedback

A review was undertaken of the CareCube performance over a 6-month period, from September 2018 to February 2019.

Cath Lab Allocation. Liverpool Heart and Chest Hospital has 5 cath labs and over a working week, this equates to 50 half-day clinical sessions (5 labs x 5 days x 2 sessions a day). The 2 weeks over Christmas and New Years have planned lab closures, providing maximum opportunity for annual leave for the whole team over what is traditionally a quiet period. Throughout the 6-month review period, there were 20 unallocated sessions, 16 (80%) in designated EP labs, and 4 (20%) in coronary labs (Appendix Figure 7). As a direct result of this new information, EP cardiologists have, starting in April 2019, moved to a model of flexible working to improve service utilization.

Lab Start Times. The aim is to have a patient on the table at 9:00 am across all 5 labs. The cath lab coordinator role is the main driver. The 6-month review of this metric showed a maximum delay time of 26 minutes (Appendix Figure 8). All labs started at 9:00 am 50% of the time, a 5-minute delay occurred 25% of the time, a 12-minute delay 10% of the time, and 15-minute delay 5% of the time. Monthly reports provide feedback and encouragement to the team. The late start data have triggered a review of working practices, including time needed to set up equipment in the EP labs, with the likelihood of changing shift times to accommodate realistic preparation time.

Touch Time. The definition of ‘touch time’ is the amount of time patients are in the cath lab with the clinical team, including preparation and set up, the procedure, and immediate post procedure activity. The UK standard for touch time is 85%. Over the course of this work, touch time at Liverpool Heart and Chest Hospital increased from an initial baseline of 48% to 87% in the 6-month period to date.

Turnaround Time. A second measurement reflecting best use of resources is ‘turnaround time’, the amount of time the lab is empty between cases.

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The minimum turnaround time was 0 minutes, maximum 60 minutes, and median 7 minutes. The interquartile range was 3-12 minutes.

Deferrals and Cancellations. Capturing and identifying reasons for deferring or cancelling patients is an important indicator of quality. During the 6-month period, a total of 3193 procedures were scheduled. Of those, 239 (7.5%) were deferred. Of the total numbers deferred, 175 (73%) patients were deferred due to lack of available lab time. The group of patients most affected were patients transferred from another hospital with acute coronary syndrome (ACS). The number of patients cancelled on the day of their procedure was 221 (6.9%).

Patient Safety – Checklist Quality. The gold standard for the 3-step in-lab patient safety checks is “every patient, every time.” The clinical team has achieved 99% completeness against the standard over the 6-month period (Appendix Figure 9). Of a total of 3193 cases, 40 (1%) were incomplete. Individual cases can be examined to identify patterns. Most involve emergency cases, some off-hours with minimal staffing. In September 2018, the checklist completion rate was 97%. This knowledge gave the team added motivation to improve. We have found rapid feedback is vital to support staff morale and provides encouragement for the team effort.

Flagged Events. Monitoring flagged events is important to identify trends or patterns of practice. These elements play an important role in enhancing the safety culture across the department. Summary data for ‘flagged events’ over the 6-month period can be seen online in Appendix Figure 10.

Estimating the Financial Gains Delivered by Change

In the cath lab, time is money. The overhead costs associated with cath lab operation are constant (and substantial), irrespective of facility use efficiency. Wasted time during routine working hours represents a missed opportunity to do more cases. Improved lab utilization has potentially generated the equivalent of an additional 18 (18.31) lab sessions each week, providing an additional income, based on the UK’s 2018-2019 tariff for PCI of £122,000 (USD \$168,712) per week, or over a 50-week horizon, an annual gain of over £6 million (USD, over \$8 million) (Appendix Table 1).

Conclusion

This case study demonstrates that change and the pursuit of excellence require a multifaceted approach. Digital systems alone are not a panacea, but they are a vital part of the solution. The effort and dedication to service at Liverpool Heart and Chest Hospital has been recognised by the Care Quality Commission (CQC), whose inspection in 2016 and 2019 awarded the Trust “Outstanding” status — one of only 5 Trusts to secure this grading

twice in succession. The philosophy of continual improvement at Liverpool Heart and Chest Hospital is clearly reflected in our current, ongoing projects:

- Build on the collaborative work with CareCube.
 - o Automate aspects of the patient journey to capture key metric data and release more staff time to spend with patients;
 - o Use intelligent technology to identify and track individual patients to deliver ‘VIP’ levels of privacy and dignity.
- Continue work on a £14,000,000 (USD \$19 million) redesign of the cath labs, providing 21st-century facilities to support world-class service. ■

This case study demonstrates that change and the pursuit of excellence require a multifaceted approach. Digital systems alone are not a panacea, but they are a vital part of the solution.

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Figure 4. CareCube In-Lab Patient Safety Check In.

Staff names, if the same for each case, can be repopulated on screen at the touch of a button

Data collected meets BCIS, WHO, NatSSIP standards

CareCube
Checklist Export ERC Wizard Save Close

Surname	Forename	Procedure	Hospital Number	Weight	Date of Birth	Age
<input type="text"/>	<input type="text"/>	Int - PCI - 1 to 2 Hour Medium	<input type="text"/>	95.5 kg	<input type="text"/>	67 years

Consultant	SpR	Nurse	Nurse	HCA	Technician	Radiographer	Other	Other
Khand, Aleem	Hussain, Rafaqat	Knight, Enya	Daquioag, Mark	Select ...	Crawley, Megan	Edwards, Roxanne	Enter name ...	Enter name ...

● Check In
 ● GA Checks
 ● Team Brief
 ● Case Display
 ● Check Out

Procedure

ID confirmed	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text"/>	
Clinical notes available	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>	
Patient understands procedure	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>	
Consent signed	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>	
IV access	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>	
LV function estimate	<input type="button" value="Good"/>	<input type="button" value="Moderate"/>	<input type="button" value="Poor"/>	<input type="button" value="N/K"/>	<input type="text" value="Notes"/>

Medical Conditions

Known allergies	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/K"/>	<input type="text" value="Notes"/>	
Previous contrast reaction	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/K"/>	<input type="text" value="Notes"/>	
Systemic anticoagulant	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/K"/>	<input type="text" value="Notes"/>	
Diabetic	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/K"/>	<input type="text" value="Notes"/>	
Pregnancy status	<input type="button" value="Yes"/>	<input type="button" value="No: Tested"/>	<input type="button" value="No: LMP Date"/>	<input type="button" value="N/A: Male or PA"/>	<input type="text" value="Notes"/>

Bloods

HB	Cr	eGFR	K	INR	BM	Plt
146	99	65	4.7			315

Results comments

General Checks

Dentures and crowns	<input type="button" value="Dentures"/>	<input type="button" value="Crowns"/>	<input type="button" value="Neither"/>	<input type="text" value="Notes"/>	
Glasses and lenses	<input type="button" value="Glasses"/>	<input type="button" value="Lenses"/>	<input type="button" value="Both"/>	<input type="button" value="Neither"/>	<input type="text" value="Notes"/>

Other Questions

Type question here	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>
Type question here	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>
Type question here	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>
Type question here	<input type="button" value="Yes"/>	<input type="button" value="No"/>	<input type="button" value="N/A"/>	<input type="text" value="Notes"/>

Figure 5. CareCube In-Lab Patient Safety Case Display.

Staff can 'Flag' a concern or an issue **during** the case at the touch of a button

Key data, relevant to the patient and case, is displayed throughout the procedure. This is an important visual aide for the team.

Plays a vital role in briefing staff arriving mid case in support of an emergency event.

Figure 6. CareCube In-Lab Patient Safety: Flagged Issues.

The screenshot displays the CareCube In-Lab Patient Safety Checklist interface. At the top, there is a header with the CareCube logo and navigation options: Export, ERC, Wizard, Save, and Close. Below the header, patient information is entered: Surname, Forename, Procedure (Int - PCI - 1 to 2 Hour Medium), Hospital Number, Weight (95.5 kg), Date of Birth, and Age (67 years). A red circle highlights the 'Issues' icon in the top right corner. The interface shows a list of staff roles and names: Consultant (Khand, Aleem), SpR (Hussain, Rafaqat), Nurse (Knight, Eriya, Daquiloag, Mark), HCA (Select ...), Technician (Crawley, Megan), Radiographer (Edwards, Roxanne), and Other (Enter name). Below this, there are buttons for 'Check In', 'GA Checks', 'Team Brief', 'Case Display', and 'Check Out'. The main area is divided into sections: 'Plan', 'Bloods', and 'Start Procedure'. The 'Plan' section has a table with columns for 'Yes', 'No', and 'Notes'. The 'Bloods' section has a table with columns for 'Moderate', 'Poor', 'N/K', and 'Notes'. The 'Start Procedure' button is visible. A 'Flagged Issues' dialog box is open, showing a list of potential adverse events with checkboxes. The 'Unexpected occlusion. Rota used' issue is selected. The dialog also includes a 'Post Comment' field, a 'Post' button, and 'Discard Changes' and 'Close' buttons.

Flagged Issues present as a drop down menu of potential 'adverse' events. Staff can 'tick' all that apply. Concerns collected in real time.

Flagged issues reviewed daily, reported monthly. Empowers clinical team to speak out safely

Figure 7. Cath Lab Allocation report from September 2018 to February 2019.

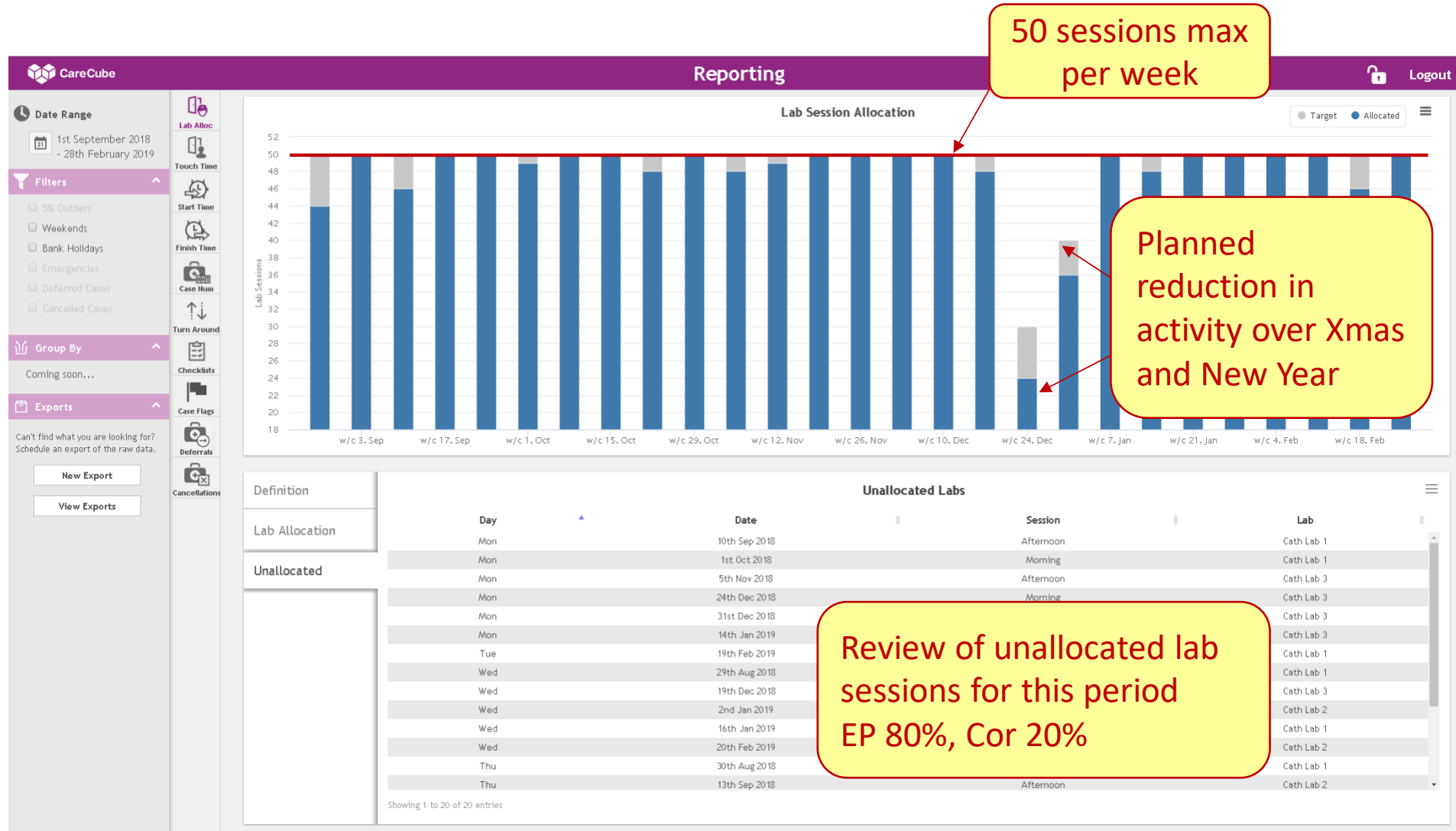


Figure 8. Cath Lab Start Times: Commitment to Goal Over Time, September 1, 2018 to February 28, 2019.

This level of engagement brings important rewards: pride and ownership of the process, crucial in the promotion and maintenance of patient safety.

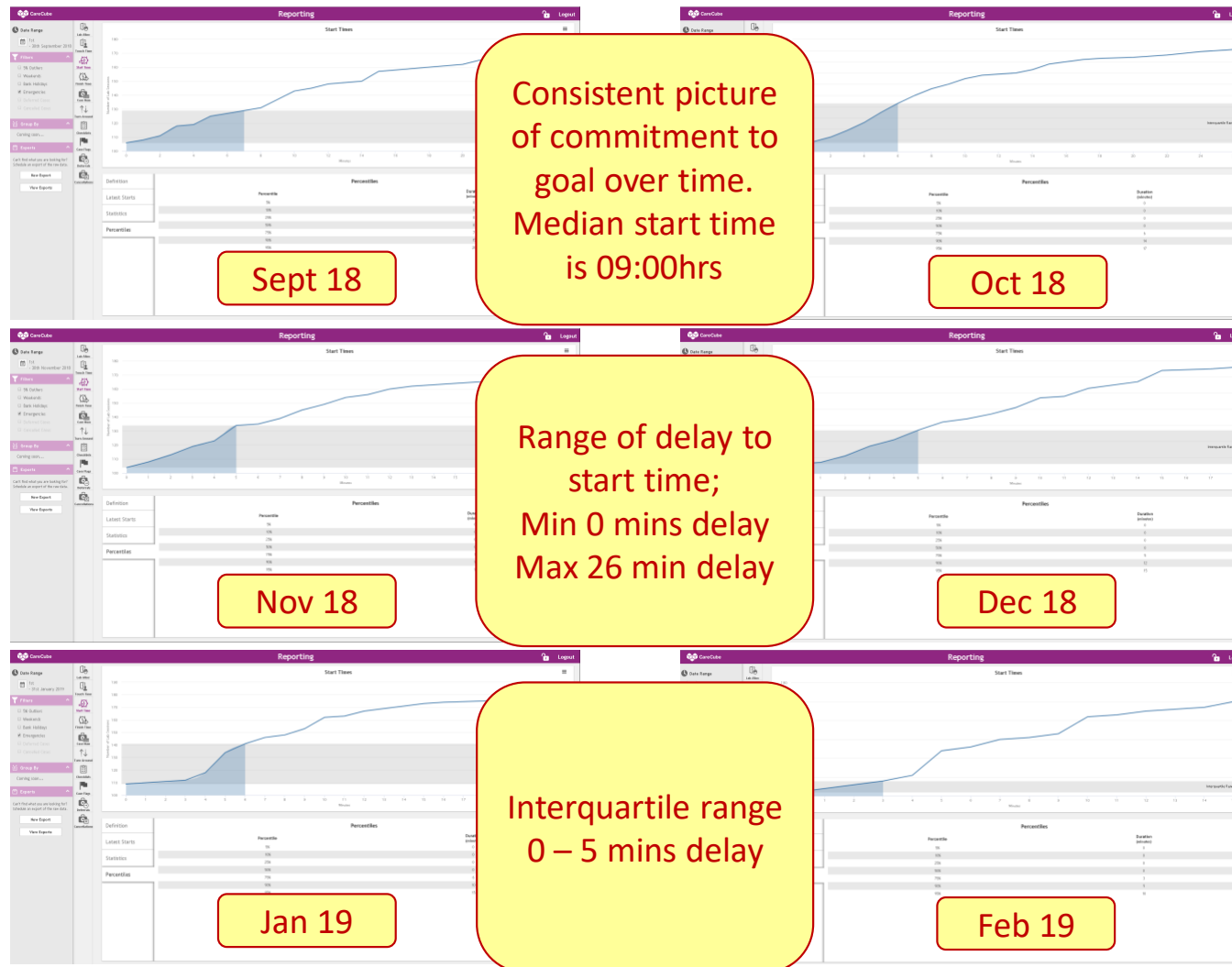


Figure 9. Patient Safety Checklist: 6-month summary, September 1, 2018 to February 28, 2019.

Monthly reports provide feedback and encouragement to the team. The late start data has triggered a review of working practices: time needed to set up equipment in the EP labs with the likelihood of changing shift times to accommodate realistic preparation time.

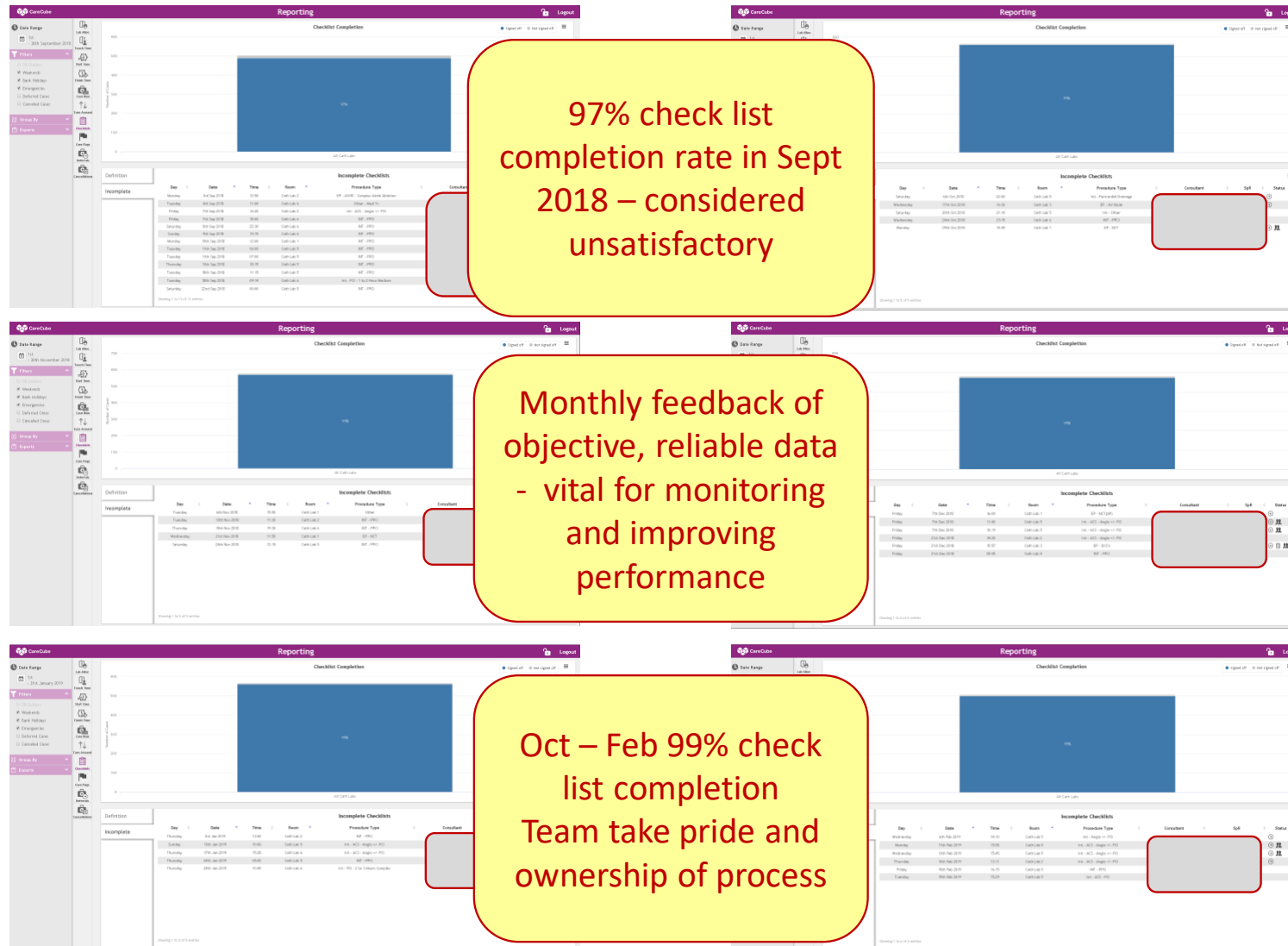


Figure 10. Flagged events: 6-month summary, September 1, 2018 to February 28, 2019.

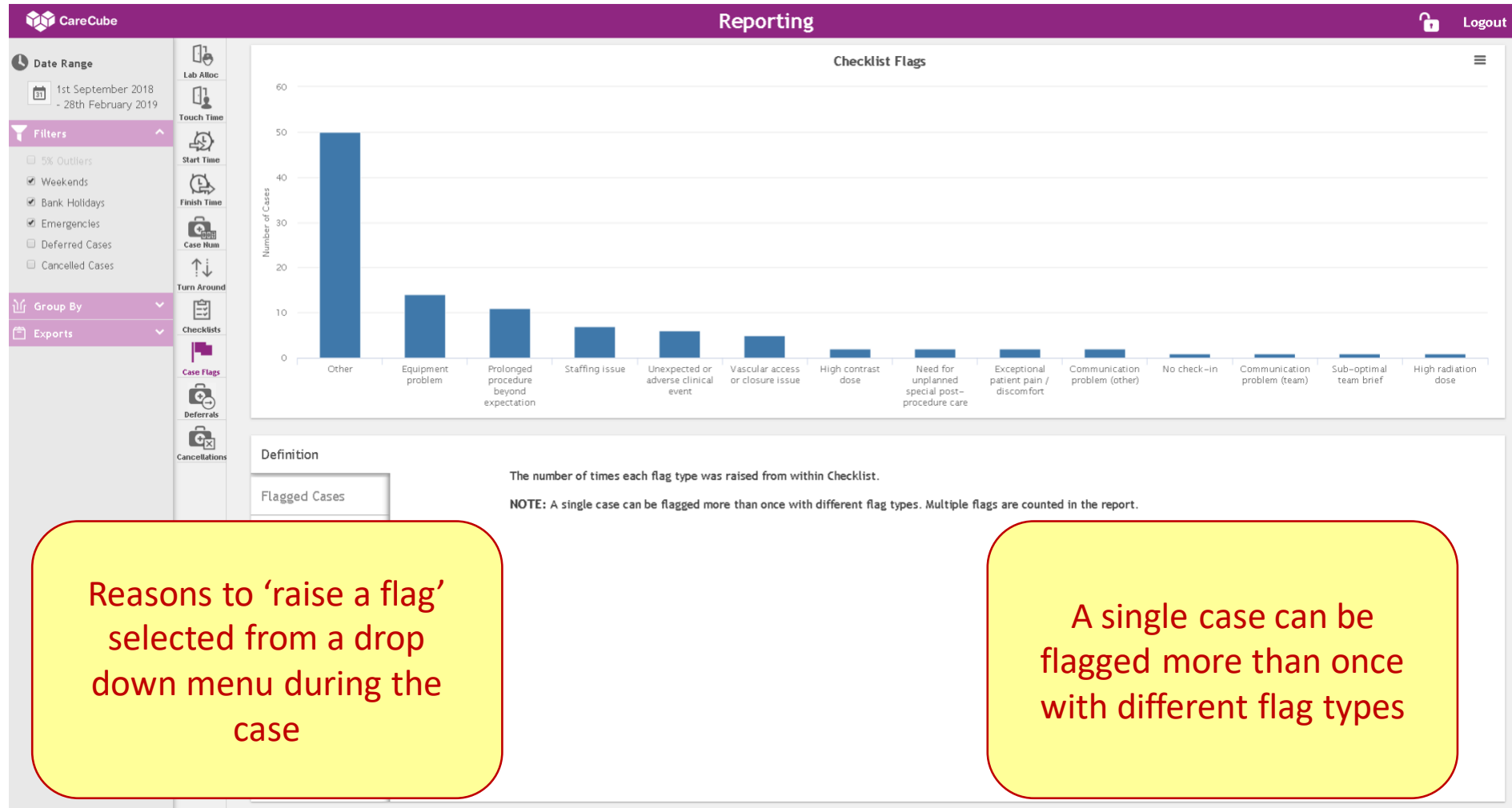


Table 1. Summary of Time Lost, Sessions Gained and Potential Additional Income Identified.

Figures Each Week	LHCH Past	LHCH Current
Sessions Available	50	50
Sessions Unallocated	10	1
Average Start Time Delay	15	2
Average End Day Lost Time	20	0
Average Turnaround Delay	20	9
Average In-Lab Delay	7	2
Touch-time Percentage	48.53%	85.15%
Total Sessions 'Unused'	25.73	7.42
Extra Sessions Gained	18.31	
Typical PCI Tariff Income per session	£13,365.00	USD \$18,638
Potential Maximum Extra Income per week	£244,698.30	USD \$341,236
Potential Mximum Extra Income per 50 weeks	£12,234,915.00	USD \$17,061,834
Proportion (%) that might be realised	50.00%	
Expected Extra Income (PCI) per week	£122,349.15	USD \$170,618
Expected Extra Income (PCI) per 50-week year	£6,117,457.50	USD \$8,530,611