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Rapid adaptation of a local healthcare digital system to COVID-19: The experience in Birmingham (UK)

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ABSTRACT

Background: The COVID-19 pandemic created unprecedented pressure on hospitals globally. Digital tools developed before the crisis provided novel aspects of management, and new digital tools were rapidly developed as the crisis progressed. In our institution, a digitally mature NHS Trust in England which builds software systems, development during the early months of the crisis allowed increased patient safety and care, efficient management of the hospital and publication of data. The aim of this paper is to present this experience as a case study, describing development and lessons learned applicable to wider electronic healthcare record development.
Methods: Request, triage, build and test processes for the digital systems were altered in response to the pandemic. Senior Responsible Officers appointed for the emergency triaged all changes and were supported by expert opinion and research active clinicians. Build and test cycles were compressed. New tools were built or existing ones modified in the central Electronic Healthcare Record, PICS (Prescribing, Information and Communication System), Clinical Dashboards and video platforms for remote consultation were developed.
Findings: 2236 patients were admitted to UHB with suspected COVID-19 between March and May 2020. Dashboards and visualisation tools enabled by efficient real-time data collection for all new patients, contributed to strategic, operational and clinical decision making.
Over 70 urgent changes were made to digital systems, including a screening proforma, improved infection control functions, help and order panels, data dashboards, and updated prescribing features. Novel uses were found for existing functions.
Interpretation: Digital tools contributed to a co-ordinated response to COVID-19 in an area with a high disease burden. Change management processes were modified during the pandemic and successfully delivered rapid software modifications and new tools. Principal benefits came from the ability to adapt systems to rapidly changing clinical situations. Lessons learned from this intense development period are widely applicable to EHR development.
Lay summary: Digital tools, which are well designed, can help clinicians and safeguard patients. Health crises such as the COVID pandemic drove rapid development of digital tools. This case study outlines accelerated development within a governance framework that successfully reused existing tools and built new ones. The lessons from this development are generalizable to digital developments in healthcare.

Introduction

SARS-CoV2 and the associated disease, COVID-19, was first recorded in the UK on 29th January 2020, a month after the first recorded cases in Wuhan [1]. The pandemic spread across Europe before reaching the UK, and the UK clinical community, in some instances, was able to prepare, to some extent, for the increased pressure on the National Health Service [2].

Implementation of digital systems in hospital trusts in England is increasing, although not yet ubiquitous. Electronic healthcare records

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(EHR), decision support tools, visualisation tools and real time dashboards are in various stages of adoption. The majority of English Trusts remain largely reliant on paper with some now deploying more extensive digital systems [3].

Digital system adoption in health care remains the single largest transformation programme of our time, and the implications of use of digital healthcare data are far reaching in terms of patient safety, restructuring of medical pathways for efficiency, resource use and convenience of access, and effective reduction of morbidity and mortality [4–8]. Well-designed EHR can help staff deliver timely care, prevent mistakes and ensure continuous collection of data at the point of care, which can later be used in research and analysis [9–12].

Building good EHR is therefore important to both staff and patients because it can aid in the delivery of excellent health care [13]. In the COVID-19 pandemic digital tools had immediate application. Data about who was being admitted to hospitals, severity of illness and underlying co-morbidity, immediately began to inform management [14]. In our institution rapid data collection for disease knowledge was required, both for treatment, research and hospital capacity issues. Screening tools were developed to guide care, panels for investigation ordering and rules built into systems to support clinical decision-making, such as prescribing. Digital tools gathered data from the EHR allowing for overall patient management, flow and capacity.

University Hospital Birmingham NHS trust Foundation (UHB) comprises four acute hospitals and community services [15]. The roll-out of the digital systems across the whole institution was under way with infrastructure and data consolidation onto a single Patient Administration System near complete. EHR roll out across the whole organisation, planned for early 2020, was delayed by the COVID-19 pandemic. This report focuses on the Queen Elizabeth Hospital for EHR developments and describes visualisation tools for the whole organisation.

Changes that were required in the digital systems were twofold: response to the disease itself requested by clinicians and policy makers, and in addition, changes to the hospital processes enforced by the pandemic. As part of the response to COVID-19, many frontline clinicians were deployed to different areas of the hospital and had to adapt to working outside their primary field of expertise. Surgeons, for example, were working on medical wards, and doctors from all specialties were redeployed to Intensive Care units. Footfall onto the hospital sites was reduced, visitors were not allowed and outpatient activity was converted almost entirely to remote review with very few patients seen face to face.

In this paper, we aim describe the changes made in the digital systems at UHB to support the clinical and operational response to the COVID-19 pandemic. Reporting of adaptation of EHR during the COVID-19 pandemic as a case study is important because it informs the wider community of the potential of EHR systems in managing crises, much of which is useful in the overall design and utility of EHR. The pandemic resulted in modification of systems, made at speed and in some case circumventing usual change process enabling rapid change and learning.

Methods

This is a case study of a local digital system and the changes that were made from March 2020 to July 2020 during the COVID-19 pandemic.

UHB is one of the largest NHS Trusts in England, providing direct acute services and specialist care to 2.2 million patients per year across four hospital sites, with 1802 acute care beds, including an expanded ITU capacity of 250 beds during the COVID-19 pandemic. UHB is a Global Digital Exemplar site, with the largest hospital (Queen Elizabeth Hospital Birmingham, QEH) having a full EHR developed in-house over the last 20 years: Prescribing Information and Communications System (PICS; Birmingham Systems) [15]. This EHR includes ePrescribing, observations and assessments, results display and complex clinical decision support rules as an inherent part of the application. In addition UHB builds visualisation tools and clinical dashboards which provide data back to the organisation and for national reporting. The digital programme is organised into two parts; the Digital Healthcare Department builds and deploys PICS, a Clinical Portal, a Patient Portal, outpatient management flow and booking systems and a suite of research applications. Developers, integration experts and application support staff are employed by the organisation, and are supported by a programme management office and information technicians. Secondly, the Informatics Department processes the organisation's clinical data and presents this in visualisation tools and dashboards for the organisation itself and for national reporting bodies and research.

The digital programme is overseen by the executive team and is clinically led with a Chief Clinical Information Officer accountable to the Chief Medical Officer (CMO). Requests for changes are reviewed and approved by the Digital Healthcare Group (DHG) chaired by the CMO. The DHG is advised by formal groups of doctors, nurses, pharmacists and allied health professionals who regularly meet to triage change requests, which are actively encouraged from all users of the systems. Business analysts scope requests and develop specification documents for recommendation to the DHG.

Digital Healthcare Programme – clinical leadership and methods of change/ adaptation during COVID-19 crisis

During the COVID-19 crisis there were a series of formal procedures put in place for requesting emergency changes to the digital systems as the usual process of discussion in expert groups with recommendation to the DHG was not possible. Senior responsible clinicians (SROs) were appointed to co-ordinate the hospitals' clinical response to the crisis. These clinicians were supported by a research group who co-ordinated and communicated all emerging evidence for clinical management of patients with COVID-19 and were overseen by the CMO. Requests for digital changes were received from clinical and operational staff members from the organisation itself, and also from national bodies. These were all directed back through the SROs who decided which changes should be implemented. The tertiary nature of the hospital means that there is considerable expert opinion with many active academic consultants in the Trust. Expert opinion is sought and considered for evaluation of clinical evidence for changes to the digital healthcare systems and this remained unchanged during the COVID-19 pandemic. Therefore, for example, changes to anti-coagulation protocols are overseen by the relevant clinical expert and this was continued throughout the crisis.

The digital healthcare team, clinically led by the Chief Clinical Information Officer received requests for digital change within the EHR including clinical decision support. Daily meetings were held with business change managers, programme managers, developers, integration experts and testers to design changes which then proceeded through compressed build and test cycles. Informatics changes and dashboards were led directly by the CMO. Dashboards and visualisation tools were built by a small team of experts and shared with the research team and the CMO. Release cycles were compressed from 4 monthly to weekly in order to deliver agreed functionality in short time scales. Evaluation of changes that were made during the pandemic are now being formally fed back through the DGH. The admission proformas that were built as a result of this process were mandated for every hospital admission.

Changing processes, reducing footfall

Although the hospital had been using electronic inpatient noting prior to the COVID-19 pandemic, new processes were created to improve communication between clinical teams and patients' relatives whilst they were unable to visit the hospital because of social isolation policies. No visitors were allowed in the hospital during the pandemic outbreak. Doctors responsible for patients were asked to ensure clear communication with relatives, with appropriate consent from patients, and undertook phone calls during or after ward rounds. In the Intensive Care

Unit (ICU), medical students were deployed to communicate each day with relatives of patients who were ventilated or otherwise unable to communicate. Clinical teams in high throughput areas (such as respiratory wards), and teams of support workers working remotely, used family liaison officers to relay information to relatives. These processes were dependent on the new digital tools allowing recording of all communications with relatives directly into EHR. Medical students were not allowed into ICU, but were able to work remotely, overseen by senior doctors (usually those shielding due to health problems and therefore unable to have direct patient care), Medical information, including up to date doctor and nursing noting, allowed remote review and communication with relatives.

Virtual consultations allowed vital outpatient medical review and treatment to continue - such as for organ transplant recipients, patients with cancer, and patients taking cytotoxic medications - whilst reducing the number of patients visiting the hospital site. Functionality was rapidly built to allow pharmacists to identify outpatients who needed medication to be delivered to their homes. The system was reconfigured to allow laboratory investigations to be ordered in advance, allowing patients to visit locations away from the hospital, to have bloods taken in safety by a remote phlebotomy service.

Data and dashboards

SARS-CoV2 positive laboratory results were fed directly into the EHR. The informatics infrastructure in the hospital and the ability to access near real-time EHR data enabled the development and rapid deployment of these results into dashboards. Having access to live inpatient data with key clinical and operational data allowed infection control officers, bed mangers and senior clinicians to visualise the distribution of positive, negative, and suspected cases around the hospital. Staffing rotas were revised and updated in conjunction with this data, allowing staff to be redeployed to areas where they were most needed. Additionally having one source of data for all our COVID-19 patients enabled the hospital to submit mandated returns efficiently.

Results

Evolution of COVID-19 cases and state of the hospital

The number of patients admitted with confirmed or suspected COVID-19, rose rapidly in the last week of March 2020 and continued for approximately two weeks, peaking on 6th April 2020 (96 admissions; 90% of emergency admissions) and falling overall thereafter, with several smaller, isolated spikes in admissions (Fig. 1).

The number of suspected cases of COVID-19 was substantially higher than the number of confirmed cases throughout this period. In total, between 25th March 2020 and 5th May 2020, 788 admitted patients had COVID-19 confirmed by a PCR swab for SARS-CoV2 and 1448 were suspected as having COVID-19 but did not receive a positive test result.

92 patients who were not suspected of having COVID-19 infection subsequently tested positive for the disease within 7 days of admission.

In intensive care, in the run-up to the COVID-19 admissions phase, the number of new admissions was higher than usual, peaking on 10th March 2020, with 34 new admissions (Fig. 2). These were predominantly short admissions, planned for post-operative recovery. ICU bed occupancy fell gradually throughout March 2020 as beds were cleared in preparation for the COVID-19 surge, falling to 47 at its lowest point on 30th March 2020. At the height of the pandemic in Birmingham, there were, on average, 12 COVID-related new admissions to our Intensive Care Unit each day. The average number of Intensive Care beds occupied at any given time was slightly below 80 (range 70-85 beds occupied). Bed occupancy was higher during the pandemic period with up to 115 bed occupied (Fig. 2).

The number of daily ICU admissions remained stable overall, showing only a small increase at the beginning of April 2020, peaking at 28 new admissions on 4th April 2020. The increased length of stay on ICU associated with COVID-19 caused bed occupancy to rise rapidly over the same time period, and it remained significantly above the normal bed occupancy for ICU for the whole month of April.

There was a large impact on the digital systems with 123 requests for changes to the EHR (Table 1S). 77 were completed within 4 weeks; 13 cancelled (e.g. configuration of beds at a private hospital which was subsequently not used during the pandemic), and 4 rejected (e.g. a request to combine all general surgical lists to facilitate ward rounds which on review were not operating in the way the requestor had

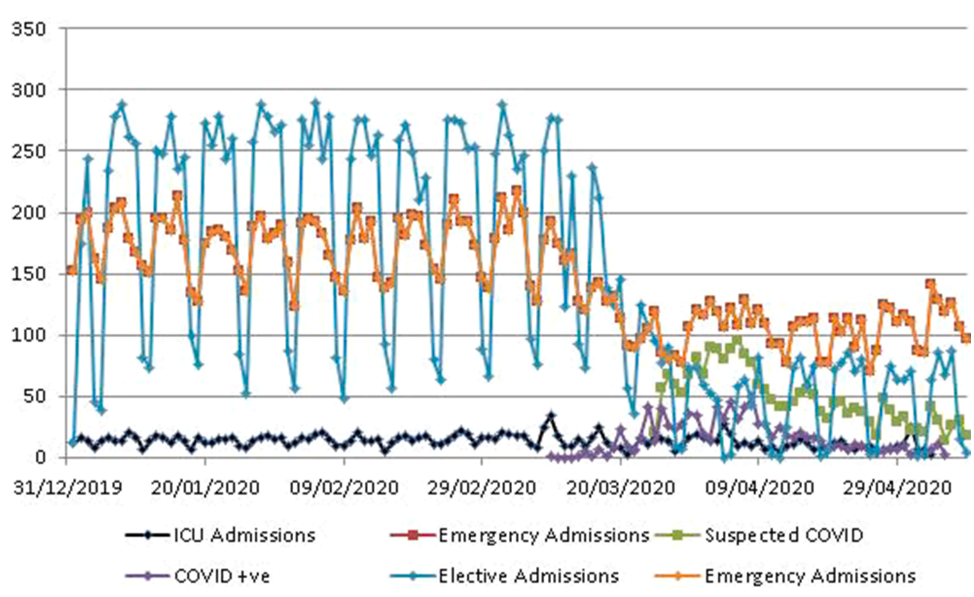

Fig. 1. Admissions to University Hospitals Birmingham; emergency admissions (orange), elective admissions (blue), admissions to intensive care (navy), suspected COVID-19 (green), and COVID-19 positive admission (purple). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

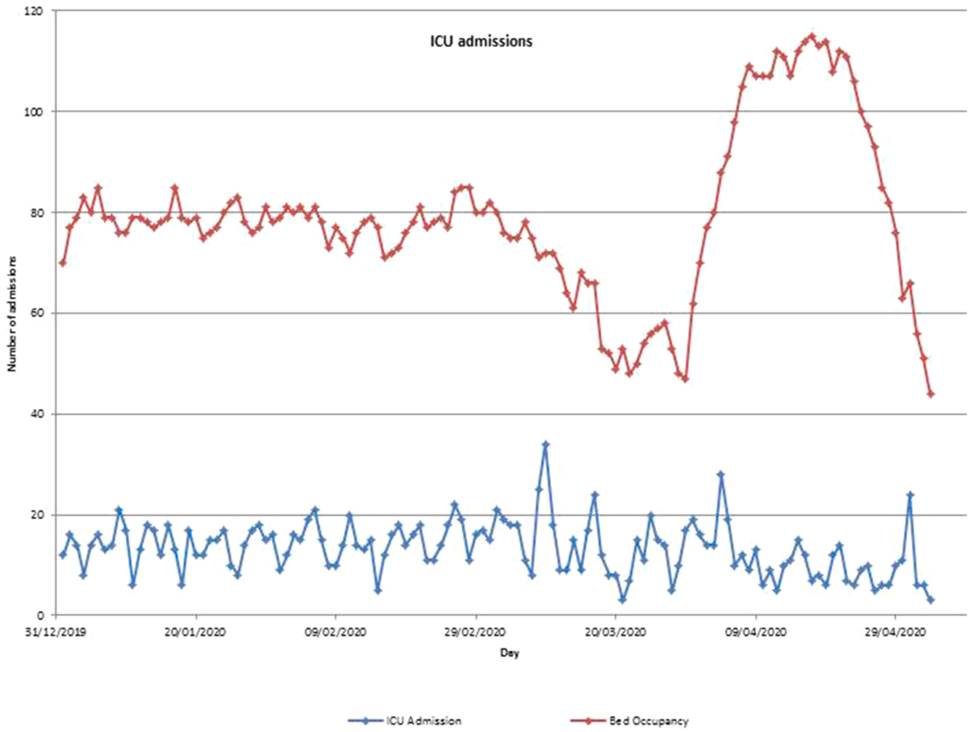

Fig. 2. Number of new admissions to ICU and overall ICU bed occupancy (the number of patients in ICU at 12:00 midnight each day).

envisaged). The rest are ongoing or part of larger projects. The programme of work for digital systems development was suspended at the beginning of the pandemic to allow teams to focus on COVID-19 specific build.

How existing digital tools helped

Existing digital tools were adapted or used as the hospital made rapid changes in response to the pandemic. The hospital presents information back to clinical and operational staff and existing via digital dashboards

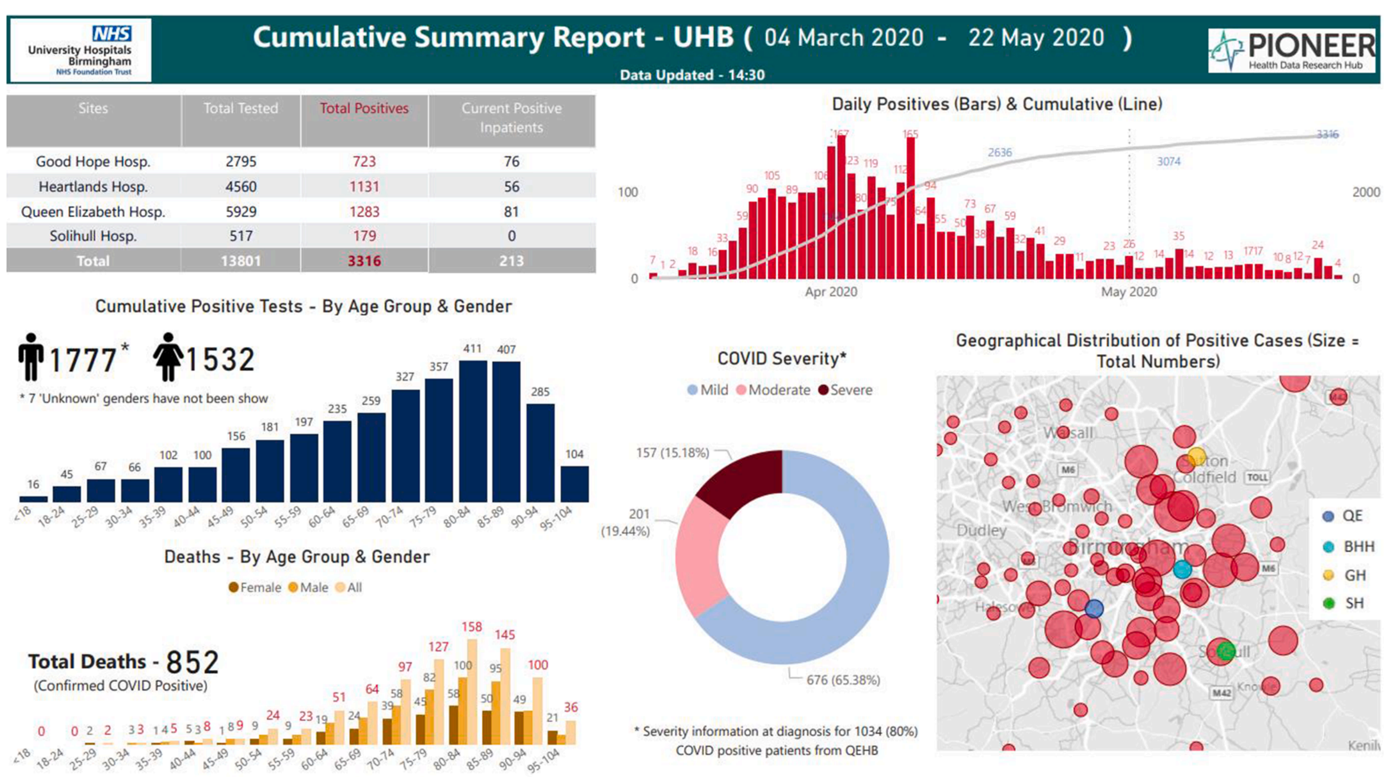

Fig. 3. Example of Dashboards built for COVID-19. Data represented for University Hospitals Birmingham (Queen Elizabeth Hospital, Heartlands Hospital, Good Hope Hospital and Solihull Hospital).

and visualisation tools for patient admissions and bed occupancy.

Prior to the COVID-19 admissions phase, new admissions to the hospital fell sharply overall as the hospital closed to all non-urgent activity. Representative dashboards were developed to present information back to the hospital and into the public domain (Fig. 3). These were important within the hospital as managers could cohort wards for patients who did not have COVID-19 to protect them from transmission, predict need, opening and closing wards and rapidly escalating ICU bed numbers as the crisis progressed. Outward facing data enabled the public and public authorities to understand the state of the hospital for planning and public communication.

Many wards were repurposed and some areas of the hospital were moved to new locations, these were rapidly built into the EHR. This included the opening of new Intensive Care wards and reconfiguring existing ICUs to include a greater number of beds. Ward clinicians, via the described process requested a number of updates to the digital systems, including adding a new device option for high flow nasal oxygen on the observation recording screen, which was previously only possible in Intensive Care (Annex 4).

Systems were reconfigured in the Emergency Department to reduce paper dependency, thus minimising the risk of transporting infection around the department and hospital on paper notes.

The EHR already utilised infection control icons and these were programmed to automatically update the patient record when COVID-19 positive results were confirmed in the laboratory information management system (LIMS). Results were therefore available to clinicians and managers as a warning icon on the patient record and on the patient list as soon as they were recorded in the LIMS (Annex 2). There were additions to infection control icons as the pandemic progressed; clinicians noted that although the automatic updating of these icons was helpful, when patients came from other institutions for example, a manual process was also required.

The high number of patients in Intensive Care led to a depletion in the number of syringe pumps available for the administration of intravenous vasopressors and these subsequently had to be prepared and administered in alternative forms. The digital system was modified to enhance the safety of this process by automatically generating the quantities of drug and diluent required to achieve a specific concentration, thus reducing drug errors by clinicians working in unfamiliar prescribing territory.

Digital inpatient noting was very well received in our organisation (feedback on-going) and because no visitors were allowed during the COVID-19 pandemic to reduce the potential for nosocomial infection, increased numbers of discussions with relatives took place remotely (by telephone or using video-conferencing) in place of the usual face to face meetings. These were documented in the inpatient record, making it much easier to understand who, when and how relatives had been updated (Fig. 4). Medical students and overseeing clinicians working remotely could review the entire medical record without entering ICU.

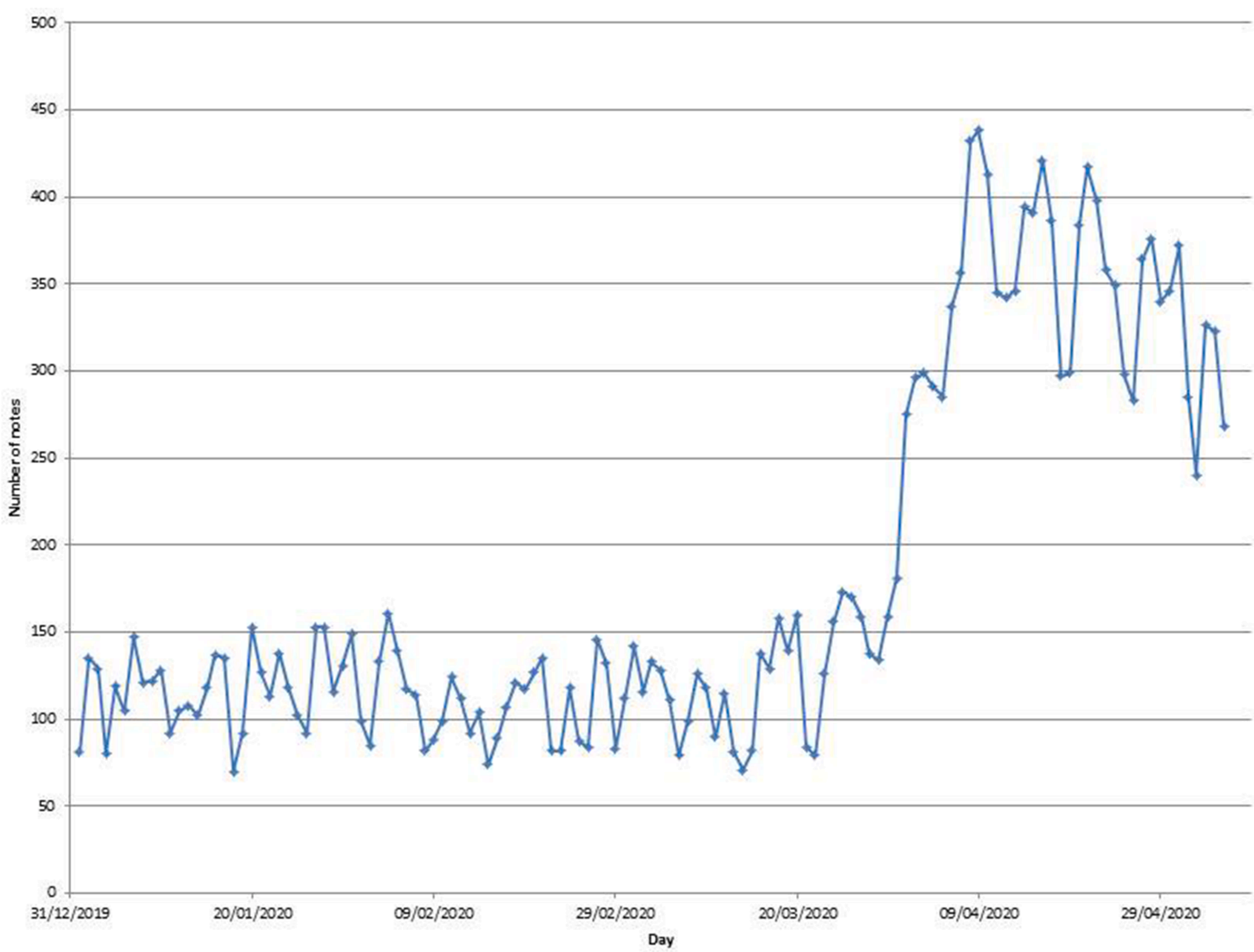

Fig. 4. Daily number of "Communication with relatives" inpatient noting.

How digital tools/systems were introduced or adapted to respond to the pandemic

A COVID-19 new screening proforma was designed by clinical staff and embedded in the admissions process. Its completion was mandatory for all new admissions. This assisted in identifying the likelihood of a COVID-19 diagnosis, guided clinical management including ceiling of care decisions, and facilitated the collation of relevant clinical information (Annex 1). The proforma included a checklist of emerging presenting symptoms based on the WHO checklist [16]. Help panels were included and were dynamically updated as new data emerged during the pandemic.

New SNOMED codes were added to the EHR to allow coding of COVID-19 and its related complications. These were automatically added to a patient's EHR problem list when a clinician recorded 'suspected COVID-19' on the screening proforma, and clinical decision rules were run from these diagnoses.

A new panel of blood tests was created for patients with suspected COVID-19. A rule was built which automatically requested this panel when a patient was logged as having 'suspected COVID-19' on the screening proforma. The set of investigations chosen was based on early data in the pandemic that identified potentially useful markers for diagnosing COVID-19 and identifying subsets of patients at risk of deterioration [17]. Clinicians could additionally request this laboratory order set at any point during the inpatient episode (Annex 3). This allowed clinical teams to monitor the trend of the acute phase response markers and markers of sepsis, and identify instances of acute kidney injury and disseminated intravascular coagulation, all of which affect the ongoing management of COVID-19 [18,19].

The panel of COVID-19 blood tests was used frequently in both the initial assessment and follow-up of hospital inpatients. It was requested for an average of 65% of patients with suspected or confirmed COVID-19 each day.

Decision support rules are extensive within the PICS application and prompt clinical decision making, for example around the prescribing of venous thromboembolism (VTE) prophylaxis. In light of evidence suggesting increased VTE rates in COVID-19, [20] rules were changed to advise prescribers that the use of low molecular weight heparin should be considered at lower thresholds than usual in patients with COVID-19.

The EHR usually warns prescribers of a contraindication to low molecular weight heparin in patients with a platelet count below 75×10^9/L. After discussion with haematologists, this threshold was lowered to 30×10^9/L in patients with COVID-19, based on evidence that COVID-19 can trigger a consumptive coagulopathy and in the absence of strong evidence of increased bleeding risk in patients with mild thrombocytopenia [20,21]. Use of decision support rules for VTE prophylaxis aimed to support clinicians in prescribing the correct doses of anti-coagulation and their implementation resulted in more patients being prescribed anticoagulation in accordance with our updated rules.

Updated structures for end of life (EOL) drug regimens were built to

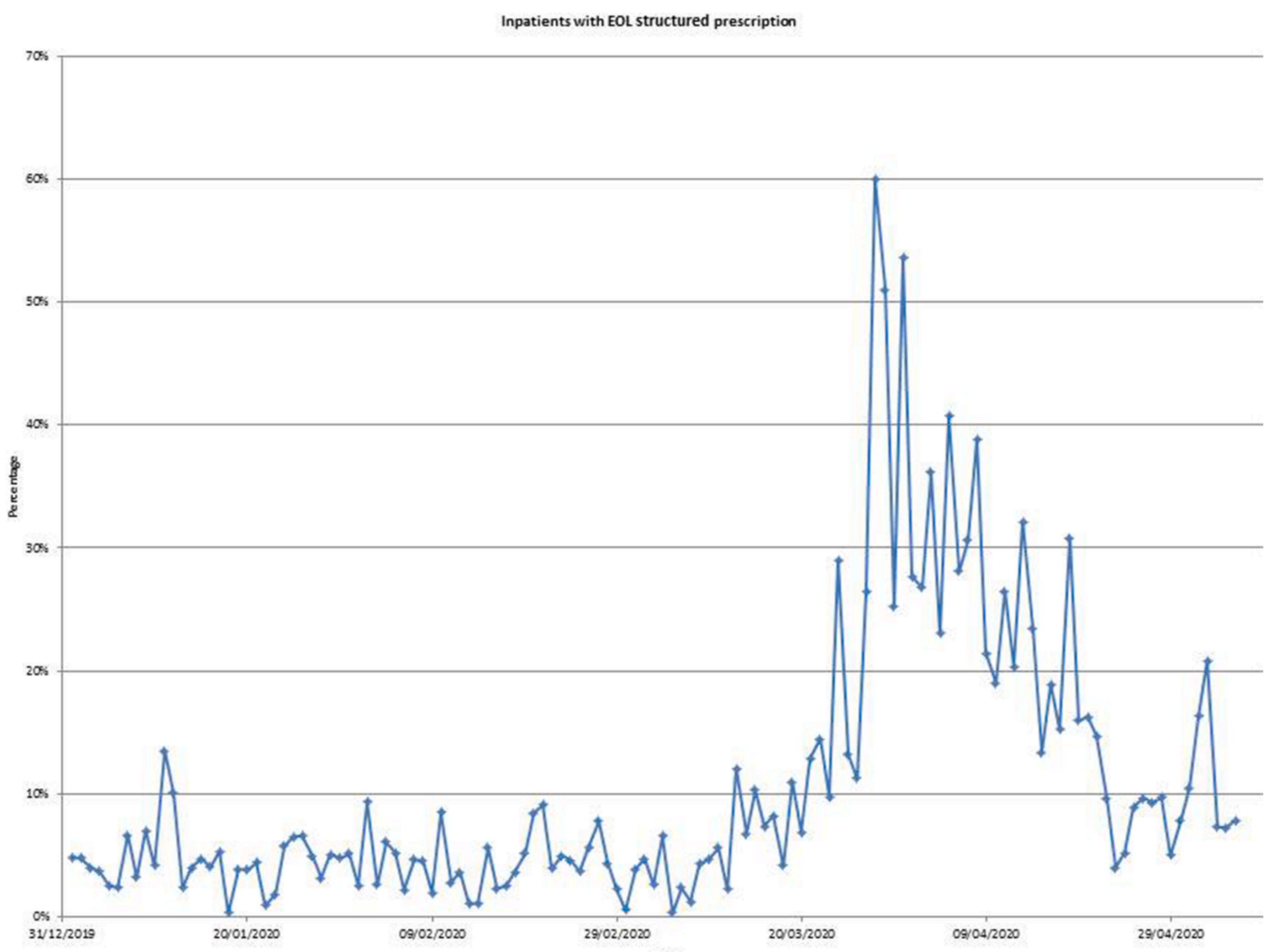

Fig. 5. Number of inpatients with an active structured prescription for EOL medications (as a percentage all hospital inpatients).

ensure that patients who were dying were not doing so in distress or pain. Structures had existed in a less detailed form prior to the pandemic. Selecting the EOL structured prescription bundle generated prescription proposals for four commonly-used medications in EOL care, which then required checking and authorisation individually by the prescriber. This mechanism balanced clinician convenience with patient safety, and maximised the likelihood that only appropriate drugs were prescribed, at safe doses.

Prior to the COVID-19 admissions phase, an average of 5% of hospital inpatients had an active prescription for EOL medications made using the structured prescribing function. This proportion rose substantially during the COVID-19 wave, averaging 23% in the period from 25th March to 30th April, peaking at 60% on 28th March (Fig. 5).

Lessons Learned

Collation of learning from the projects during the COVID-19 crisis concluded several important lessons and conclusions (Table 1).

Discussion

Electronic Medical Records, clinical decision support tools and clinical dashboards are all aspects of digital healthcare that can improve the efficiency, quality and effectiveness of healthcare provision [22] The ability to deploy and customise these capabilities rapidly in the COVID-19 pandemic situation proved valuable to our organisation and highlights the advantages of a digitally mature trust which has the capability to implement rapid changes to its electronic systems.

There are a small number of international reports that support similar rapid digital enhancements to health systems within the COVID-19 pandemic situation, concentrating on whole system approaches such as ours, or more specific elements such as automated laboratory testing and interactive dashboards [14,22,23]. Locally we found the principal benefits to come from the ability to adapt systems according to rapidly-changing situations. The ability for clinical teams and developers to work seamlessly alongside each other allowed agile transformation as the pandemic situation unfolded.

Table 1
Organisational functions relevant to adapt a digital programme to a crisis; lessons learned and generalization.

Organisational Function	Characteristics from this experience and generalisation
Clinical leadership	In a crisis many conflicting ideas and requests arise. Requests must be triaged for clinical relevance and evidence of benefit to patients
Executive oversight	Clear leadership is required; conflicting requirements, lack of sight of the overall picture and relative importance of each request for change will undermine effective delivery without authority
Responsive digital provider able to respond rapidly to clinical need	In crises changes must be timely but well thought out and evidenced
Intuitive build with clinically useful functions	Digital systems must be helpful and easy to use. There must be effective data flows to prevent siloed information and careful attendance to logic. Data must be easy to enter and be relevant. Presentation of data must be easy to interpret
Avoidance of support alert and data entry fatigue	Multiple alerts will result in important information being missed. Overall impact of combined functionality must be considered; alerts must be clinically important and only used if evidenced patient advantage.
Provide relevant information to clinicians in the right place at the right time	Alerts shown to the wrong user will cause alert fatigue. Disruption of work processes will lead to error.
Require data collection only if it is clinically relevant (and it must be brief)	Overburdening clinicians with data entry that does not result in immediate patient benefit will lead to disengagement.
Encourage and listen to feedback	Clinicians will help build EHR that they are engaged in especially if changes are immediately apparent. This leads to useful EHR and increased engagement

The evolution of the pandemic in our institution was well understood due to the ability to collect data. The Trust is digitally mature and had several tools already enabling staff to easily record and review clinical information in real time, and not requiring staff to necessarily be in the same location as the patient. The Trust was also able to introduce new tools, or rapidly adapt existing ones to respond to the pandemic.

Building effective electronic interventions

The digital healthcare team in our institution is well-established and has a clear project methodology. Decisions about what to build are directed by clinicians with executive oversight from the CMO and Chief Executive of the trust, allowing the whole organisation to contribute to digital systems build. During the COVID-19 pandemic requesting, triage, build and test processes were necessarily changed. Requests for change were generated for management of the disease itself, or by changes in the logistics of the hospital to cope with the pandemic. All requests for clinical changes to the digital systems were triaged by research-active clinicians. The result was an evidence-based build that could contribute to patient safety, clinical management and organisational response.

At the beginning of the pandemic, all programming, management, integration and testing resources were redirected to the emergency response to COVID-19. This created an extremely efficient pathway for rapid software delivery. As a result, there was very little ‘redundant build’, although there was some redundant scoping where, after consideration, some suggestions were not helpful in practice.

Supporting frontline clinicians

Help panels and clinical decision support functions within the EHR provided prompts, reminders, and warnings to support clinical decision making, which were expanded as the COVID-19 evidence base grew. Reconfiguration of wards was updated quickly within the EHR. Although the digital teams were able to do this very quickly, some lead time was required and very good communication between the digital and operational teams was necessary. The high availability of the EHR, on a client based platform means that there was no issue with accessibility to the tools. This is evidenced by no unplanned outage during the COVID pandemic and 82 minutes of unplanned outage for the PICS system in the last 3 years.

Data gathering

The client-based, ubiquitous use of the EHR throughout the institution enabled rapid data collection from all patients admitted with COVID-19. Initially, these data allowed managers to separate patients based on their infection status and minimise hospital-acquired infection. Other data collected is currently being used to support a number of research endeavours and aggregated data is available to Public Health England and the UK Government to support the national response to the pandemic. Dashboards provided real-time information to managers about new admissions, hospital capacity, and staffing levels per area, which were used to formulate patient pathways around the hospital (for example wards were closed to admissions without COVID-19 or kept ‘clean’), to cohort patients based on their infection status, and guide distribution of Personal Protective Equipment (PPE) for staff (for example in areas of aerosol generating treatments where patients with COVID-19 were looked after full PPE was required before entering the ward).

Shared Learning

There are several critical learning points from our experience that have wider, long-term utility (Table 1). Digital tools are known to help safeguard care and improve efficiency [22], whilst collecting vital data simultaneously. We suggest this is also the case during the COVID-19 pandemic.

Our digital healthcare team received a high volume of requests for changes to the EHR as the COVID-19 situation developed. A clear referral process facilitated efficient triage of, and response to, these requests. Close communication between clinicians and the digital healthcare team enabled effective software to be built and delivered in extremely short timelines.

There are some limitations to our digital solutions. Data relating to nature, duration and severity of presenting symptoms was only collected for patients in whom COVID-19 was suspected on completion of the screening proforma, thus data capture opportunity is lost in patients with atypical presentations. Conversely, we are likely to have included within our data some patients subsequently found not to have COVID-19. Additionally, in any digital system build it is possible for clinical staff to bypass certain screens, and in this case a clinician could bypass the COVID-19 screening proforma by selecting the 'COVID-19 not suspected' option. We designed mandatory data fields to be as efficient and intuitive as possible, aiming to avoid data entry fatigue. There has been no formal evaluation of the changes implemented in the digital systems to date. Future studies could include evaluation of these changes and inclusion of feasibility/satisfaction checklists.

Conclusion

Digital tools helped to facilitate a rapid and co-ordinated local response to the global challenge of COVID-19 and enabled safe and timely care of patients in our institution. Integration between the EHR and laboratory systems provided up-to-date information that allowed clinicians and managers to rapidly identify patients with COVID-19, put appropriate isolation measures in place quickly, and reduce the risk of in-hospital transmission. Patient numbers and demand for resources could be monitored in real-time, allowing staff to be redeployed throughout the hospital in line with changing clinical demand. The same systems helped to negate some of the risks and challenges associated with the movement of staff to unfamiliar working environments. We employed decision support alerts and structured prescribing mechanisms that were bespoke to the situation in our institution, and updated these rapidly as new challenges emerged. Ensuring that new updates were evidence-led and intuitive prompted high rates of staff buy-in. With the support of digital tools, the hospital was calmly and efficiently run and data gathered through our systems is now being pooled with other NHS organisations and being used to advance our understanding of the disease. Clinically directed, well led digital systems are effective in managing healthcare crises and lessons learned during this rapid development are applicable to EHR build in calmer times.

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Ethical approval

Not required.

Patient consent

Not required.

Declaration of Competing Interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.hlpt.2021.100568.

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