Presenting patient data in the electronic care record: the role of timelines

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Summary

Objective To establish the current level of awareness and investigate the use of timelines within clinical computing systems as an organized display of the electronic patient record (EPR).

Design Multicentre survey conducted using questionnaires and interview.

Setting Seven UK hospitals and several general practice surgeries.

Participants A total of 120 healthcare professionals completed a questionnaire which directed structured interviews. Participants fell into two cohorts according to whether or not they had used clinical timelines, which gave 60 ‘timeline users’ and 60 ‘prospective timeline users’.

Main outcome measures To investigate the awareness of timelines, and the potential benefits of timelines within clinical computing systems.

Results Fifty-eight percent of participants had not heard of the specific term ‘timelines’ despite 75% of users utilizing a form of timeline on a daily basis. The potential benefits of future timelines were clinical audit (95%CI 77.6–91.6), increased time efficiency (95%CI 77.7–91.6%), reduced clinical error (95%CI 71.0–86.7) and improved patient safety (95%CI 70.0–85.9). One continuous timeline view between primary and secondary care was considered to be of great potential benefit in allowing communication via a unified patient record.

Conclusions The concept of timelines has enjoyed proven success in healthcare in the USA and in other sectors worldwide. Clinicians are supportive of timelines in healthcare. Formal input from clinicians should be sought when designing and implementing computer systems in healthcare. Timelines in healthcare support clinicians’ cognitive processes by improving the amount of data available and improving the way in which data are presented.
Introduction

The computerization of healthcare is expanding and the amount of data stored is growing at a phenomenal rate at a significant cost to the health service.\(^1\) However, the organized display of electronic patient records to present complex data in a simple and structured format has received little attention.\(^2,3\) Electronic patient records influence clinical decision-making, but current user interface design may not support the clinician’s cognitive processes.\(^4-6\) Clinicians must gain an accurate and complete picture from a catalogue of clinical events while identifying trends prior to making a decision. However, in many hospitals multiple clinical computer systems are used side by side, and they often operate independently from one another.\(^7\) This lack of data integration can have a negative impact and risk patient safety when working with patients with complex health conditions.

Timeline displays of data can provide a useful answer to these problems.\(^8-12\) Timelines are a temporal visualization tool which are already used with success in non-medical spheres to manage data. For example, the London Metropolitan Police Service utilize timelines software to display evidence against alleged criminal activity from various sources.\(^13\) The data are used to create a timeline which gives a single-screen overview with multiple facets displayed along the ‘y’ axis against time along the ‘x’ axis. The police then use the timeline to identify trends from large volumes of data, informing strategic planning to help solve the crime.\(^14\)

Traditionally, there have been many paper-based timelines such as the ward inpatient observation chart or the more complex ITU flow chart. Figure 1 shows an interactive timeline display of the observation chart.\(^15\)

Timelines were proposed by Powsner and Tufte\(^9\) to create a graphical temporal summary of...
medical records and have been trialled with success.\textsuperscript{2,6,8,12} Plaisant \textit{et al.} used the term ‘life-lines’ as opposed to timelines. They found that timelines facilitate the identification of trends and anomalies, and reduce the chances of clinicians overlooking information.\textsuperscript{2} Lindwarm \textit{et al.}\textsuperscript{12} found that timelines led to better recall of information when compared to a tabular representation of clinical information.

Plaisant \textit{et al.} designed a single-screen lifeline view of the electronic patient record which acts as a navigational tool (Figure 2).\textsuperscript{2} It displays a streamlined summary and gives direct access to patient data by double-clicking on any event with options to allow zooming where the data are crowded. As illustrated in Figure 2, multiple facets of the EPR are available for viewing simultaneously to help the clinician swiftly glean information about the patient. The clinician can easily navigate to a particular area of interest, such as diagnosis, allergies, medications or clinic appointments, to obtain more details. Information is displayed using text, icons or simply a line, and specific design features can be used to help illustrate relationships.

Figure 2 also illustrates a text search option at the bottom of the screen. This enables searches to be performed within the timeline view, which gives a timeline display of the result, as demonstrated in Figure 3. Shekelle \textit{et al.}\textsuperscript{16} found that performance improved when context-specific information was available which can empower clinicians in their work.

The launch of the British NHS Care Record Service (CRS)\textsuperscript{17} reinforces the need for electronic patient records. The use of a timeline view within future Summary Care Record solutions may be advantageous. The timeline can be structured for viewing in a way that answers clinicians’ needs.

The United Kingdom National Programme for Information Technology (NPfIT)\textsuperscript{18} aims to provide a uniform strategy for the ongoing computerisation of the National Health Service. As part of NPfIT, the Connecting for Health Common User Interface (CFH CUI) programme has produced guidance which can be used by independent software vendors (ISVs) to write timelines software to help ensure uniformity and patient safety. The guidance created is based on an iterative user-centred design process between clinicians, computer programmers and user interface designers. Some of the work used to inform the timelines guidance\textsuperscript{19} is presented within this paper. An example from Trochim and Donnelly is shown here as Figure 4.\textsuperscript{20}

The aim of this study was to establish the current level of timelines awareness among healthcare professionals, and to investigate the use of timelines within clinical computing systems as an organized display of the EPR.

**Methods**

**Design**

This was a multicentre face-to-face survey conducted over a geographically widespread area at
seven different UK hospitals within London, the Midlands and Hampshire and within various general practice (GP) surgeries. Institutions were chosen following a response to initial enquiries and a presentation on timelines was delivered. A questionnaire was distributed among healthcare professionals during medical meetings, on hospital wards and at GP surgeries. Respondents were then invited to complete a structured interview, leading to the recruitment of 120 participants, who fell into two cohorts according to whether or not they had used clinical timelines. There were 60 participants referred to as ‘timeline users’ and 60 participants referred to as ‘prospective timeline users’ because they had not used timelines in the past but would almost certainly become users of future timelines.

A pilot study was performed initially on a group of 25 participants to aid survey and questionnaire design. These participants were not included in the final sample population. The questionnaire was evaluated and modified by senior members of the CFH CUI CAPS team. The interview strategy was also refined through an iterative process with the team before conducting the main study. An introductory presentation about timelines, including a statement about the anonymity of response and voluntary nature of participation, was given to each participant. A number of both computerized examples and paper-based timelines were shown to the participants. Paper-based examples included large ITU charts, antenatal care records, partogram charts from maternity wards and complex drug regimes in oncology.

The questionnaires consisted of 16 questions for the timeline users and 11 questions for the prospective timeline users. Separate questionnaires had to be designed to obtain data relevant to each cohort’s awareness and experience of timelines. To obtain quantitative data, the questionnaire used a five-point Likert scale for participants to rate their answer to the statement in the question from 1 (strongly agree) to 5 (strongly disagree). Each question had space for the participant to expand on their answer or write their views to obtain valuable qualitative data.

Ethics committee approval was sought but turned out not to be required for this project, as it is categorized as service development rather than formal research.

Data analysis
The results were coded into a Microsoft Access™ database and statistical analysis was performed using GraphPad™ Software to calculate mean, median, percentages and confidence intervals. Participants responding ‘undecided/equivocal’ on the Likert scale were discounted during statistical analysis of certain data-sets to allow assessment as a binomial distribution.

Results
Demographics
The demographic characteristics of the participants are displayed in Table 1, divided into ‘timeline users’ and ‘prospective timeline users’.

More women (58%) than men (42%) were surveyed. The commonest age group was aged 26–35 years, which comprised 60% of timeline users. None of the timeline users were aged 56–65 years.

The largest occupation surveyed in total was GPs (34) followed by Specialist Registrars (SpRs and Specialty Trainees above ST3, 20), Core Trainees (CTs, previously known as senior house officers [SHOs], 15), then Foundation Year 2 (FY2) doctors (14). When grouped together, ‘junior
doctors’ formed the largest occupation (52%) followed by 22% from pharmacy, 17% senior doctors (consultants and GPs) and 10% from nursing.

Knowledge of timelines in healthcare
There was a general lack of awareness of the phrase ‘timelines’ with 58% of all participants not having heard of it prior to this study. Specifically, 45% of timeline users had not heard of timelines despite almost 75% of them using a form of timeline on a daily basis. This reflects a lack of a standardized definition and poor penetration of the term ‘timeline’ rather than a disinterest in the use of timeline software.

Computerized timelines were the commonest format of timeline used (80% of users). However, the precise nature of computerized timelines in current use varied widely, from a static display of a single data-set against time (e.g. haemoglobin levels over one week), to interactive multifaceted displays (e.g. inpatient admissions, outpatient clinics, imaging and pathology reports against time) which had zoom and filtering functions.

Ninety percent of users requested training in the use of the timelines available to them. However, only 57% received training prior to using the timelines, as illustrated in Figure 5.

Current use of timelines in healthcare
Timelines are used mostly in secondary care (88%). They are used on general hospital wards, acute care wards and outpatient clinics. Outside of secondary care, 6.5% of users utilize a timeline in GP clinics and 4.4% utilize a timeline in the community for home visits and other clinics.

Figure 4
An example of timeline presentation guidance. This shows how the clinical condition of the patient can be presented alongside the drug administration display. The patient data in the banner are imaginary.
The overwhelming opinion from both users and prospective users was that one continuous timeline between both primary and secondary healthcare professionals would be most useful. Most participants commented that a timeline view of clinical data within a clinical computer system would be advantageous provided the user interface could be manipulated and altered to suit the specific user and context. Some suggested that the timeline should display separate information depending upon the location (e.g., primary care or secondary care) but still have the facility to create one continuous timeline if required. Timelines should have the facility to display context sensitive information (e.g., all microbiology results for a particular patient, regardless of setting or location).

The commonest current use of timelines was for displaying results/investigations (38%). This is followed by 23% of users utilizing timelines for the display of observations and then jointly by medications and medical history (16%).

### Future use of timelines in healthcare

The vast majority of users commented that an interactive and multifaceted timeline would be most useful. For example, displaying pathology results, observations, medications and past medical history all on one timeline view was
considered to be most useful. All participants commented that having an interactive and dynamic timeline would be more beneficial than a static temporal display of information. Specific benefits included the ability for users to navigate their way to particular information (e.g. by zooming, searching or filtering), for the timeline to automatically update with information from other computer systems (e.g. display investigation reports and clinic letters either directly or indirectly via hyperlinks) and to view multiple facets concurrently within one timeline view (e.g. to display medical history, pathology results and medications at once). These three factors were considered ‘important’ or ‘essential’ if timelines were to have a practical clinical use.

**Potential impact of timelines in healthcare**

The highest percentage of participants, 86% (95% CI 77.7–91.6), strongly agreed or agreed that clinical audit could be improved with the use of timelines (Figure 6).

Electronic data entry and coding is already a great asset when conducting clinical audit. Timeline views of data could make it easier to identify relationships and potentially identify causality. Clinicians currently have to manually review patient notes to find key data for audit. Participants felt timelines would simplify this and increase efficiency and encourage more audits to be undertaken. However, the risk of assuming an event has a causal relationship when it is merely temporally coincidental must be recognized by the clinician. Furthermore timelines would only be as useful as the data entered, stored and displayed.

Time efficiency ranked second highest with 86% (95% CI 77.7–91.6) of participants strongly agreed or agreed that time efficiency could be improved with timelines. However, it was a concern to hear that 100% of participants felt this improvement relies strongly on the provision of more, and faster, computers. As a potential solution, several participants were in favour of introducing fast wireless networking and hand-held devices such as tablet PCs to the hospital or GP workplace. However, many participants were against the idea of bedside devices on the basis that they would need time away from the bedside to make decisions before returning to discuss them with the patient.

Reduced clinical error (80%, 95% CI 71.0–86.7), improved patient safety (79%, 95% CI 70.0–85.9) and improved quality of care (77%, 95% CI 67.8–84.2) were all perceived to be areas where timelines in healthcare would be beneficial. Participants felt this would be possible because concise and clear patient data would be available to the clinician upon which to base a clinical decision. They also felt that timelines would allow for
clinical guidelines to be followed more closely. For example, the annual reviews required for the management of a diabetic patient could be easily tracked on a timeline and flagged up if not being followed.

Improved handover was another potential benefit (82%, 95%CI 73.2–88.3). In particular, two junior doctors, who used a computerized timeline daily, commented that it helped them build up a mental picture in their mind of the patient’s ‘story’ which in turn helped them remember and relay information about the patient. On a wider scale, the use of one continuous timeline view between primary and secondary care was considered to be of great potential benefit in handover by allowing communication between them via one view and a unified patient record.

In contrast, 72% of participants (95%CI 62.5–80.0) strongly disagreed or disagreed that patient data protection would improve with timelines. Participants acknowledged that existing concerns around security and data protection would remain as with any other clinical computer system. This concern is one recognized by the British Government and the European Data Protection Working Party who acknowledge that electronic patient records carry security risks of their own, which are different from those associated with paper records.22

Discussion

Summary of main findings
Timelines in healthcare can provide a succinct and streamlined view of the EPR. The use of timelines care has had proven success in USA healthcare and other sectors worldwide.

Healthcare professionals are supportive of timelines in healthcare and recognize their potential benefits of improving clinical audit, time efficiency, patient safety and quality of care. Awareness of the phrase ‘timeline’ is limited. However, this has not impacted on the healthcare professionals’ ability to recognize a display as a timeline or their ability to use it.

As with any advance in medical informatics, not just the use of timelines, effective use of computer-based tools relies on future improvements in computer speeds, connectivity, and the provision of fast wireless networks within hospitals and primary care facilities.

Strengths and limitations of study
Selection bias is difficult to avoid in surveys and participants can be self-selecting. The use of a multicentre study design minimized bias towards the clinical practice or system within one specialty or Trust. It also allowed for feedback on various different types of current timelines views, which informed ideas for the future design of timelines in healthcare. Surveys have an inherent responder bias which can be difficult to account for and this may influence our findings.

The pilot questionnaire enabled amendments to be made to the questionnaire and increased its validity. The interview style allowed for direct interaction and one-to-one discussion with participants to establish an understanding of their views on current clinical computer systems and timelines in healthcare.

The small sample size and selection bias may have a consequent impact on whether the findings can be generalized. However, the sample consisted of a wide range of healthcare professionals, including pharmacists and nurses, from junior to senior levels. For example, junior doctors concerns were often practical and more focused on acute admissions, whereas consultants were more focussed on clinics and benefits to long-term outpatient follow-up. Therefore, this study incorporates a wide spectrum of opinion and viewpoints.

The five-point Likert scale used in the questionnaire may have resulted in participants selecting the middle value if there was uncertainty or disinterest in their mind. In future, a four-point or six-point Likert scale may be preferable to help avoid such bias.

Implications for future clinical practice
The findings from this study have implications at a local and national level. Locally, clinical computer systems should be adapted to allow data integration and communication between one another, and staff training is required before timelines are used. Nationally, this study highlights the known requirement for significant resource investment into IT provision and ensuring safer systems to
maintain patient data protection.22–25 The potential of using mobile devices such as tablet PCs may be one solution to increase computer accessibility and the use of wireless networking should be considered, however, specific research is required into these areas.

For timelines in healthcare to be of maximum benefit in patient management, one continuous timeline view across primary and secondary care should be considered. This would assist with maintaining a unified and up-to-date electronic patient record. Clinicians would then have access to full clinical information occurring in both primary and secondary care and assist with clinical decision-making. There is also potential economic benefit derived from reducing the number of duplicate investigations and referrals which currently arise from the loss of paper records.26

The majority of participants felt that timelines in healthcare have the capacity to become an integral view in any electronic patient record and would be an asset within any future Summary Care Record. The majority also agreed or strongly agreed that correctly designed and implemented, timelines in healthcare would be a powerful tool to allow a unified patient record, bring economic benefits and most importantly enhance safer patient care.

Conclusion

There is widespread support for timelines in healthcare from clinicians. They recognize that they can provide a succinct and streamlined view of the EPR which gives numerous potential benefits, particularly in patient safety and quality of care.

A user-centred design process with large-scale formal input from clinicians should be sought when designing and implementing computer systems in healthcare. This is advocated by international standards.27 Our findings support existing publications23–26 and should serve as an impetus to address such matters.

This study is the first to incorporate opinions from clinicians on the use of timelines in the presentation of healthcare data. Clinicians were appreciative and welcomed the opportunity to input. Clinicians were in favour of one timeline view within the EPR and felt it would support their cognitive processes better than current clinical computer systems.

Main messages

- Timelines in healthcare provide a visual graphical display of the electronic patient record, with existing success in the USA and other sectors.
- Healthcare professionals are supportive of timelines in healthcare and recognize the potential benefits of improving clinical audit, time efficiency, patient safety and quality of care.
- One continuous and interactive timeline view between primary and secondary care would maximize their benefit.
- Incorporate opinions from clinicians on the presentation of healthcare data.

Research questions

- Design and test prototypes of timelines in healthcare in order to test the impact of timelines on clinical performance.
- Investigate and address general improvements in IT resources in healthcare.

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