Going paperless at the emergency department: 
A socio-technical study of an information system 
for patient tracking

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A B S T R A C T
Purpose: The purpose of this study was to examine nurses’ attitudes and reflection on the transformation of their workpractices after the implementation of an Emergency Department Information System (EDIS).
Methods: A qualitative study using interviews, mainly with nurses, conducted four years after the implementation of an EDIS at the emergency department (ED) of a large university hospital in Midlands, UK.
Results: The introduction of waiting time targets for patients attending EDs and the spatial expansion of these clinical settings so as to support increasing numbers of attendances challenged the viability of paper records and whiteboards in the management of patient flows within the department. They also fostered the use of an information system for accumulating information and coordinating the activities of the multidisciplinary team. While whiteboards were abolished, paper still plays a role in nursing practice in response to issues of confidentiality, personal safety, ergonomics, computer literacy, interoperability, relationship with patients and overdependence on EDIS.
Conclusions: ED information systems can have a major impact on organisational practices particularly as new service models of care are gradually introduced in EDs. Considering their spatio-temporal implications while treating the technology as an artifact with transformative, rather than supportive or substitutive, power enhances our understanding of the implementation challenges that need to be addressed during the reshaping of the sociotechnical network.

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1. Introduction
Healthinformation systems, in general, have been around for the last four decades. Their specific aim is to contribute, from a patient-centred approach, to high-quality and efficient patient care [1], and thus to improve treatment, outcomes, and public health [2]. Their contribution is not solely to clini-
cal practice but also administrative and managerial tasks that support the delivery of care. They play a big part in decision-making while they facilitate research, evaluation, training and planning purposes [3]. They are also considered as reliable means of communication among health care professionals and institutions since they are capable of providing a platform for shared, multidisciplinary and continuous care [4]. The suc-
cessful management of the disease is achieved through the availability of ‘the right information at the right moment’ [5].

Advances in healthcare practice and health economics have led to multidisciplinary care as well as to redefinitions of occupational groups which often create ambiguities and conflicts over who is responsible and accountable for each task. Thus, the organisational flow of information needs to be mediated [6]. Nowadays, many different records for the same patient are scattered among different departments even within the same institution. More paperwork is necessary to store and chart observations, measures and data created by the numerous and increasingly complex monitoring devices, requiring valuable time from the clinicians’ work routine, often at the expense of care [7]. In addition, limitations on remote or multi-user access, poor and illegible handwriting, ambiguous or missing data and lack of active contribution to the decision making of clinicians are among the reasons supporting the need for an electronic form of this record [3,8].

The advocates of EPR advertise its benefits, especially in chronic conditions [9]. They claim that it can successfully coordinate care across multiple disciplines, medical specialties and a variety of agencies [10] required for the management of these conditions [11] with direct results in the reduction of hospital visits, adverse drug events, duplicate tests, contradictory clinical advices and generally of poor clinical outcomes [12]. Whether it is person to person, intra-organisational or across several healthcare organisations, continuity of care relies on shared and integrated information [13].

We report on a study in an emergency department (ED) investigating the implementation of a system designed to share and integrate patient information. The Emergency Department Information System (EDIS) was introduced in 2004 as a solution to the department’s growing needs for information sharing. The department had recently more than doubled its capacity for assessing and treating patients. A new national waiting time target was introduced which meant that reporting requirements were expected to increase as well. However, for the nursing staff the new system was anticipated as an efficient tool for replacing paper notes. The aim of our study was to explore nurses’ attitudes and understanding of patterns of use of this system 4 years after its implementation. We were also interested in examining whether the documentation part of their practice did, in fact, go paperless and whether this system was, in the end, able to replace the old way of tracking patients around the department using whiteboards and paper records.

2. Background

Hospitals are areas with unique characteristics in cooperative work. Vast amounts of high quality information are required by health professionals for the continuous planning, documenting and delivery of care, as well as the assessment of outcomes. Literature, particularly in Computer Supported Cooperative Work (CSCW), has examined collaborative technologies in these settings. Bossen [14] showed the complexities that characterise the development of Common Information Spaces (CIS) in hospital wards. In fact, these collaborative arenas, despite their limited physical space, can be more multiple and intensive in their communication requirements and practices than, for instance, a control room and, at the same time, as distributed in the performance of heterogeneous standardised procedures as a wastewater plant. Other scholars have shown the practical problems that information and communication technologies face when they attempt to replace paper-based practices without considering to a full extent their unique affordances and the way they have become an integral part of clinicians’ daily activities [15].

Examples of systems that were resisted due to the system’s penetration in work practices and routines include the COSTAR system at the Medical College of Ohio, a system at the University of Virginia Medical Centre, and an information system for mandatory order entry by physicians at Calgary’s Foothills Hospital [16]. Moreover, the implementation of an EPR system in one of the Kaiser Permanente’s (the largest non-profit healthcare system in the US) regions resulted in a ‘wild ride’ [17]. Key issues identified from the apparent failure of the system to convince the relevant parties included detachment of the system from the actual setting, technical inconsistencies and reductions in clinicians’ productivity. Studies from Australia and the US showed that where the system disrupted instead of facilitating work practices [18] and where it failed to meet staff expectations and instead attempted to realise solely organisational goals, it was withdrawn [19].

Several possible explanations can be given for these phenomena. Reasons for the low level of use have been suggested to be (a) access to computers in terms of availability of appropriate numbers of workstations, (b) computer literacy, (c) flexibility of paper records in terms of convenience (e.g. portability, writing habits) as well as (d) penetration in traditional work routines [20]. Others have cited (a) implementation costs for training, (b) change management, (c) loss of revenue, (d) operational control, (e) disruption to practice, (f) negative impact on clinician–patient relationship and (g) work pressure as substantial barriers to the computerisation of clinical tasks [21]. A lack of clarity on the potential advantages of EPR systems has also been identified [22]. The level of compliance for each user is determined, in this context, not only by the practical value that this system offers for professional competence, but also on how it alters the relations with other users and how it affects their professional culture. If the user cannot find any value or usefulness, either practical or professional, then the system is likely to be rejected. For example, several studies [23,24] have failed to prove the efficacy of a computer documentation system instead of a paper one in health outcomes.

Collaboration and coordination in ED settings present some characteristic challenges, the most important of which is increased multiplicity [25]. Multiple tasks need to be managed simultaneously and in parallel for many patients. However, this multiplicity of clinical work does not extend only to patients but also to space and several other providers outside the physical boundaries of the department. Patients move in and out to several other locations (e.g. radiology department, observation unit) and many other providers get involved in their trajectory and treatment process. In addition, there is always the issue of diagnostic coding. The nature of work in emergency department in terms of casemix is often extremely unpredictable. A patient that arrives in the department with a health related complaint will be assigned to a category after all
Lastly, the documentation of clinical activities becomes even more difficult to maintain at a satisfactory level that permits coordination of care. Given the fact that time pressures are always present, quality record keeping is a challenge, particularly when using paper-based artifacts. At the same time, other artifacts such as whiteboards offer a way of ‘managing the stack’ [25]. In fact, the affordances of whiteboards have been praised since they offer a channel for communication at a distance [26]. These artifacts serve as a space where asynchronous communication between a generator of information and a number of recipients can be maintained without the need for co-presence [27]. From a central storage point information can be easily accessed and disseminated across multiple users reducing the need for repetition, interruptions and the labour effort associated with synchronous modes of communication for managing activities and logistics in challenging clinical settings [28]. However, their usefulness is only temporary since they are only able to provide snapshots of current work without the ability to store information for retrospective analysis of bottlenecks.

3. Methods

The research reported in this paper is based on a larger study at an ED of a big university hospital (1800 beds) in the UK. It was devised as a case study [29] based on documentation analysis and semi-structured interviews in order to examine complexities and dynamics that characterise such settings in a unified and functioning manner [30].

3.1. Setting

The research site (located in Midlands) is one of the busiest emergency departments in the UK with around 400 patients attending it each day (~160,000/year) from a local population of 650,000. Around 60% of these patients are usually discharged directly, 25% admitted to the hospital and the rest are referred to other services as outpatients.

One year before the system went live (October 2004), the department had expanded its physical space to support the assessment and treatment of an increasing number of attendees. The resuscitation room now featured 9 bays compared to the previous 4, while the areas for minor and major illnesses or injuries featured 26 adult cubicles compared to the previous 12. Capacity has also expanded to support the activities of a larger Paediatrics area and the new role of Emergency Nurse Practitioner (ENP). In both the paediatrics and the adult area the cubicles are spread around a staff station. Around 14–18 nurses and 6–7 doctors of various grades and experience are on duty at any given time.

From January 2005 EDs across the NHS operated under a new national waiting times target which constituted a performance standard for the entire hospital. In particular, this standard expected the department to treat and then admit or discharge 98% of attendees within 4 h from arrival [31].

3.2. Information system

EDIS is an information and communication technology for patient registration and tracking by Hospital Administration Software Solutions Pty. Ltd. (now an iSoft company). At the time of the implementation this system was the only one available via the Local Service Provider scheme for the National Programme for Information Technology (NPfIT).

The system is interfaced to the hospital’s main Patient Administration System (PAS) which allows staff to register new patients or retrieve information from previous attendances for patients already registered with the system. Most of the daily activities of an emergency clinician can be tracked with this system. After registration at the reception desk by the Emergency Department Assistants (EDAs) clinicians, mainly nurses, can:

- enter triage details, observations, clinical notes, consultations, prescribed medicines, and investigations;
- view alerts;
- track patients around the department or in other departments (e.g. radiology) and waiting times;
- enter admission details;
- discharge patients;
- request a bed;
- produce letters for General Practitioners (GPs).

There is a computer terminal in each staff station with 3-wired desktop computers. Wired desktop computers are also in the reception desk, the sisters’ office and the doctors’ writing room while 13 wall-mounted workstations are installed in cubicles.

For maximum system availability, hardware requirements were benchmarked towards 100–150 concurrent users.

3.3. Data collection & analysis

Data were collected through semi-structured interviews (30 min long on average) from April to November 2008. During the interviews, nurses were asked to expand on their experiences of using EDIS 4 years after its implementation. They were asked to identify positive and negative outcomes from its use and to reflect on the ways the system has transformed their practice particularly in relation to patient tracking with existing (paper records) or abolished (whiteboards) ‘technologies’ for accumulating and sharing information in the context of the 4-h wait target. The interviews (15 h of taped recordings) were then transcribed and the transcripts were organised and analysed with the use of a qualitative data analysis software (QSR NVivo 8). All 28 transcripts were considered in the primary data analysis reported here. Using a grounded theory approach, the transcripts were carefully read and reread to identify prominent and recurrent emerging thematic categories. These categories have been made as inclusive as possible. Careful consideration was paid so as not to exclude activities, processes or accounts that offer limited explanatory value.

Documents such as implementation studies, user guides, technical reference manuals and paper forms for clinical notes taking were also collected and analysed as to retrieve more...
detailed background information about the system and its use, past and current workpractices, and to compensate for any phenomena of participant ‘memory decay’ [32].

The study was approved by the appropriate ethics and clinical governance committees. It was advertised by posters and emails with invitation letters attached. These were distributed by the Department’s secretarial staff. Participants were given an information sheet before the interview took place. They were assured of anonymity and confidentiality and written consent was obtained.

3.4. Participants

The purposive sample in this study comprised 28 participants (23 females and 5 males): 1 system administrator, 1 change manager, 2 EDAs, 1 operational services coordinator, 4 ENPs, 4 charge nurses (NICs), 15 nurses of various grades and experience. The decision to recruit mainly nurses was based on the fact that this professional group represents the biggest user group of this system which is also responsible for the coordination of activities in this setting.

All the participants were using EDIS at the time of the interviews and they had been working in the department for at least a year before the implementation of the system. This is because the research team was interested in recruiting nurses that could reflect on the changes that the information system has brought into their daily practice by comparing the two periods pre- and post-implementation.

4. Results

4.1. Before and after EDIS implementation

Prior to EDIS the tracking of patients was performed using a whiteboard placed at the centre of the department where many patients used to gather as they were waiting to be assessed and treated by the clinical staff. With the use of magnetic strips basic information about patients such as name, time of arrival and triage category could be displayed to everyone present around it. From this central point nurses (and doctors) could have access to an overview of the department in terms of patient numbers and flows with minimum physical effort. It also provided staff with an area in which they could interact and communicate around matters of concern for patient treatment progress.

However, nurses highlighted the fact that confidentiality issues were very problematic. In addition, illegible, handwritten posting of information caused misinterpretation errors. The very basic information that the whiteboard could handle did not facilitate adequate tracking of patients especially as rigid waiting time targets were gradually being introduced into their practice. The physical expansion of the department meant that more than 100 patients could be present at any time. As a result, nurses found it difficult to keep track of the number, location and the stage of the therapeutic progress for each patient during busy periods. For example, all the nurses in charge interviewed for this study expressed dissatisfaction with the whiteboard since they were struggling to calculate waiting times for each patient.

I suspect that if we had to go back to the whiteboard and relying on a nurse’s memory as to where a patient was at any given time, I think we would soon start to see a lot more four hour breaches. …actually being able to track times of patients to see how we are doing and where the weak points are maybe, that’s a big advantage. (ENP—Clinical Lead)

They were also unable to have information on the volume and casemix of patients who had been registered at the reception desk and were waiting for triage. One negative aspect of the use of whiteboards that arose from the interviews was the display of patient identifiable information. The affordances of this artifact particularly in terms of size and location mean that it can easily be processed not only by clinical staff but also by visitors. In the past, someone with criminal or violent intentions could easily locate a patient/target in a cubicle by checking the whiteboard.

… the white board we had in the old place was in the central area and everybody could see who was there. So with this [EDIS], it’s got better for patient confidentiality and the other thing is sometimes you would get people coming into the department because they wanted to beat somebody up and they could see their name on there and which cubicle they were in. (Nurse in Charge)

Given that the emergency care sector experiences a high number of incidents of aggression and violent behaviour such issues are important for clinicians [33,34]. Nurses have welcomed EDIS because, among other things, such information cannot now be retrieved without access to relevant wired desktop terminals. All the information is now securely locked in the software and away from misuse from non-clinical staff.

The most appreciated value of EDIS in terms of organising nursing practice is its real-time tracking feature. With this system they are able to manage their case load in an efficient way. In particular, the system allows them to have a clear view of patient flows in the department. While within a ward there is always a certain number of patients and in each bay there can be only one patient, in the emergency department they usually move around, in and out as various providers attempt to make sense of their trajectory and decide upon the best possible treatment.

It’s got a very good value, one of the good points is tracking for patients in the department whereas we never had that before, that is very good. We can turn round and say oh that patient is in X-ray or that patient is in Area 3, whereas before it was just guess work, you’d look to see what they came in with and then just use your knowledge to see what area they would be in. It’s very, very good for that, for tracking a patient. (EDA)

With EDIS nurses are able to track locations and waiting times. They are able to check the urgency of a particular case, where patients are at any given moment, whether they are in the department or they are waiting for an X-ray in the radiology department, what tests they have already done, what remains to be completed and which specific clinician is attending their case. Before, the whole process of tracking patients and managing flows was based on a paper-based system. A patient would come in and be booked in, given a set of...
paper notes and then go to the triage nurse. If the patients would be assigned to the adult treatment area for major and minor injuries their name would be appear on the whiteboard. Then the nurse would write their assessment and place the paper notes in a box in time order from front to back. The doctor would come, take one out, and see that patient.

Moreover, the amount of information now available to nurses about the location and the treatment progress of all the patients in the department also facilitates the real-time tracking of activities as well as the management of human resources. By being able to have an overview of the case load and case mix for each of the subsections of the department nurses in charge, area coordinators and consultants can redeploy staff to areas and activities of intense pressure.

With EDIS, I can look at all the different areas and say, there's more patients in Area 3, and I'll go to the doctors in resuscitation and say, you know, can you go to Area 3, so you can redeploy people from different areas to where your biggest workload is, so that's where EDIS is good, it comes into that. (ENP—Nurse in Charge)

As a result senior staff walking around or phoning up areas to receive updates in order to manage workload is now seen as an ‘archaic’ task. In addition, the ability to track patients has been appreciated by nurses because it has also saved them time when patients’ relatives enquire at the reception desk. With the new system any member of staff with appropriate access can provide relatives with the whereabouts of the patient, even over the phone, with a decrease in incidents of aggression towards staff.

4.2. EDIS at the point of care

In order to facilitate unobstructed access to clinical information a number of wall-mounted terminals were installed inside cubicles. It was expected that nurses would be able to use them and input clinical notes while they were assessing and triaging patients. It was also hoped that by keeping input to where clinical activity takes place, nurses would not have to leave the bays and walk to the staff station. The much smaller number of workstations would not have been able to support and accommodate production of information and coordination of work without delays and interruptions.

Although EDIS is designed to work on touch screens, nursing staff, after consultation, decided not to proceed with this kind of technology. The high cost of these screens and anticipated heavy use meant that there was an increased possibility of a high failure rate. Therefore the ED decided in favour of a small keyboard beneath the mounted screen. However, 4 years after the implementation they are not used widely by nurses.

The location of these terminals inside the cubicles was a major obstacle. At the beginning these were placed at the back of the cubicle so that nurses could maintain eye contact with patients during consultations. However, they soon realised that this position was not convenient as medical equipment that was moved into the cubicle physically obstructed its use. Staff decided then to move them closer to the entrance and away from the small dedicated area for this equipment, but this meant that nurses had to have their back facing slightly away from the patient. This became a reason for not using the system inside the cubicles, as nurses felt vulnerable to patients who exhibit hostile and aggressive behaviour towards them. Lastly, there were occasions where they would have liked to add notes and comments about patients’ conditions for which it was preferable not to let patients know at that point (e.g. domestic violence, mental health issues).

Data also revealed several other reasons for this apparent rejection which ranged from ergonomics to issues of computer literacy. In particular, some of the nurses, especially those of above or below average height, claimed that they could not adjust the height properly. They tended to use them for odd lines and tasks such as ‘the patient was given a cup of tea’, and writing full assessments on them rarely happened in practice. While at first they attempted to use them, they experienced backache and as a result they now prefer to go to the staff station where comfortable chairs can be found, even if they have to wait for their turn during periods of heavy workload.

We need either more computers because you do fight over some of them. There are plenty, don’t get me wrong, but a lot of them are in the cubicles and you are standing and your backs aching and you just want five minutes to sit down, especially if you’re here all day. Most of those are hanging off the wall now. (Adult Nurse 1)

Given the fact that staff in this busy department are constantly on the move, every opportunity for sitting down, even for a short while typing in data, is preferable to standing up.

Nurses, like other workers, require reflection on their activities before they are able to produce detailed reports of actions taken.

A lot of times you want to concentrate, although it’s really good because you can chat with a patient while you are typing, sometimes you don’t necessarily want to type in front of the patient because there may be things that you want to put on the notes that you don’t necessarily want the patient or their relatives to know. Not that you’re being defamatory or anything, but... sometimes it’s quite nice to just step back and...have that five minute thinking...so I don’t tend to use them. (Adult Nurse 2)

Given the complex nature of clinical work, they prefer to walk to the staff station and complete data input there so that while they are waiting for a terminal to become available they can reflect on the tasks they performed and the information they received from the patient. This is also due to the fact that after 4 years of daily use they still consider the patient or their relatives to know. Not that you’re being defamatory or anything, but... sometimes it’s quite nice to just step back and...have that five minute thinking...so I don’t tend to use them. (Adult Nurse 2)

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4.3. Overdependence

Despite the observable benefits of use in coordinating clinical activities nurses expressed some concerns about their high dependence on a computer system. Unplanned downtime of EDIS (or the ‘humbug of doom’ as they call it) is causing frustration and places additional work upon them even though the
system does not now go down as often it used to (particularly during its first year of operation). As one nurse frames it:

The entire place grinds to a halt because... you get so fixated on it, especially if you are coordinating, your entire little work world is that computer and of course when it's gone, it's just gone. At least with a white board... it's just there, nothing goes wrong with it... I mean the magnetic strips fall off onto the floor and we just pick them up and we put them back on the wall. (Adult Nurse 3)

Although these complications are usually attributed to the network infrastructure and rarely to the actual system, the process of tracking patients around the department and coordinating activities becomes very stressful for everyone involved including patients. When the system crashes or becomes very slow, nurses have to repeat many tasks to reach a stage where they have adequate information for an overview of the department. Following a very careful contingency plan they have to revert back to a paper-based system. Though a ‘downtime computer’ in the sisters’ office allows staff to print out the list of patients in the department before EDIS went down no other information is available. This paper list also needs to be populated with new arrivals. In effect, nurses have to relocate every patient in the department, confirm attendances and retake notes about their arrival time, presenting complaint and treatment progress. When the system is up again clerical staff collect the paper notes and begins inputting them into EDIS.

This reliance on the system leaves nurses very skeptical about computer systems in healthcare because, among other things, errors related to patient care can be devastating (although no such errors where reported during the conduct of this study). Nurses often mentioned the example of a clinician who has just taken blood from a patient for testing and ticked the relevant box in the system just before it went down. The next clinician who carries on from the previous one has no information about this task and will be trying to retake a blood sample unless the patient is in a physical condition that permits him to remind the clinician that this task has already been completed.

4.4 Persisting and added paper-based practices

Although nurses have praised the tracking features of EDIS for managing patient flows and organising their practice, the transition to paperless sharing of information remains the most valued motive for supporting the computerisation of their practice. When the system was about to be introduced, this ‘promise’ acted as a significant catalyst for accepting computers in the department in the first place. However, this has only been partially achieved.

The use of a computer system for data input and access to clinical notes has minimised paper-based record keeping. While previously a set of paper forms accompanied each patient from registration to admission or discharge, paper is still being used in cases where patients are being admitted to a ward or where referrals for appointments are needed. If a patient is being discharged directly from the ED, nurses do not have to print out and photocopy notes.

Paper is still being used by nurses for other clinical and administrative activities. For example, they still use paper forms for documenting observations such as temperature, blood pressure and fluids (and for prescription of medications by doctors). Apart from easiness and quickness, the use of these forms is perceived by nurses as a valuable opportunity to spend more time with patients since otherwise they would have to leave the patient, often in a deteriorating condition, alone in order to go and access a remote terminal for typing in the observations.

...for quickness, when you’re writing nursing observations down, blood pressures and things, you put them on a chart, we always have done and sometimes when you are with somebody really poorly you’ve not got a chance to pop to the computer and document every five minutes, so we log it on a chart so we can stay with the patient. If we had like hand-held computers each that would be fantastic... So paper does allow us to stay with our patients. (Adult Nurse 4)

Paper is also being used for requesting X-rays or laboratory analysis of samples. Before, nurses had paper labels where they used to write patients’ names on it and send them to the radiology department for the X-rays. The only difference with EDIS is that this label is now being printed off from EDIS while they still have to handwrite the name of the patient. The same process is followed for the labeling of samples to be sent to laboratories.

However, printing off labels instead of using the ones provided by reception as part of the patients’ set of paper forms has created frustration to the nurses. In particular, nurses expressed repeated dissatisfaction with their reliance on printers, due to the fact that the printers in the department are unable to handle the volume of paper that needs to be printed. Nurses often find themselves mending printers:

Because we have to print everything off so much...and we’ve all become printer technicians at the same time, because we don’t have suitable printers, it’s a printer that is only slightly better than you would have for a home printer and so it’s forever breaking and when that happens, it becomes a nightmare and someone has to sit and pull the printer apart all the time. (Paediatrics Nurse)

In addition, the ease of printing out clinical notes when the patient needs to be admitted to a ward can often increase the risk of duplicate notes being moved around. Before EDIS there was always some concern about losing the paper notes while patients were still in the department. Now the same anxiety exists for missing or duplicating notes as nurses print them out and prepare all the necessary paperwork for their colleagues in the other areas of the hospital where EDIS is not available. Duplicate notes can sometimes be circulated around the department, especially prescriptions. For instance, sometimes nurses (who are not usually professionally trained to prescribe drugs) will print the notes off for the doctors to prescribe the drugs since this activity cannot be completed from within EDIS. When the doctors actually assess the patient later on, they might print another copy of the notes even though nurses have already had one printed. Since the system does not, at the moment, have an alert signifying to the clinician
5. Discussion

Our study revealed that the particular information system (EDIS) has been accepted and appreciated by nurses. Its features for easy storage and retrieval of information, the tracking of patients and the digital display of calculated waiting times has proved to be invaluable in the coordination of their activities under specific time performance standards. On the other hand, this overreliance on the system has created some scepticism among nursing staff. At the same time, some of its physical aspects, particularly those that attempt to replace paper records during nurses’ encounters with patients, have not been welcomed and were gradually abandoned.

5.1. Temporality in emergency care

The introduction, by the central government, of the 4 h waiting target for 98% of patients attending an emergency department attempts control and regulation of the temporality of healthcare work, both individually and collectively. Members of the emergency care staff have to place their activities within a tight timeframe. For this, patients, irrespective of their condition’s urgency, arrive in the department with a well defined temporal trajectory. No matter what, the patient has to be treated and a decision to be admitted in the hospital or discharged has to be made within 4 h. This means that clinicians now have a very close and inflexible time horizon within which they need to perform their tasks [35]. Every delay in triaging, examining, lab testing and diagnosing could be detrimental for the patient’s trajectory and the operation of the department as a whole. A delay in admitting or discharging patients could mean that the department might soon find itself in a situation where breaches exceed the 2% exceptions margin with penalties imposed by the DH. Equally, the number and the casemix of current attendees mean that the ED could exceed its capacity to accept new attendees.

The tracking of patients now has to be achieved by accumulating information and coordinating activities under a new temporal rhythm [35]. All the actors involved align their work, knowledge and decisions collectively by being constantly aware about the waiting time target that they have to meet. However, in order to be able to adjust their activities individually and collectively, nursing staff have the need for punctual information not only about the patient’s condition but also about the overall situation in the department. This is because the unpredictability of emergency care requires a constant reevaluation and redefinition of the articulation work that needs to be temporally completed between the various heterogeneous entities [36,37].

The use of the old technology of the whiteboard and the reliance on paper-based records to track activities and calculate waiting times could not facilitate this process adequately. Apart from issues of misinterpretation, nurses had to calculate the number of attendees and how long each patient was waiting to be treated. The limited amount of handwritten information displayed on the whiteboard in a fixed place in the department also meant that nurses had to locate the records for more information elsewhere, and for this they often had to locate the clinician who was holding the paper record at that time. However, as the department gets busier such delays affect not only the patient’s temporal trajectory and thus the nurse’s time horizon but also the departmental temporal rhythm.

5.2. Spatiality in emergency care

From the above it becomes apparent that the articulation of work for efficient collaboration in emergency care is not just about time awareness. Space also has a valuable place in the analysis of the way a specific technology could transform the accumulating and coordinating activities of the clinicians. As the intertwined relationship of medical knowledge with technology effects the compartmentalisation of healthcare establishments, not only communication but movement increasingly becomes an important aspect of collaborative work, and the CSCW literature has been sensitive to the concept of mobility work as the spatial aspect of articulation of work in healthcare [38].

Bardram and Bossen have identified four aspects of mobility work in clinical settings [38] which, based on our findings, are applicable to those performed in the emergency departments. Three of these aspects (being in different physical spaces, accessing knowledge and contacting specific persons) are particularly meaningful in examining the acceptance and incorporation of such systems into the daily activities of nurses. The centralised storage and easy retrieval of the generated knowledge produced by the clinicians involved in a patient’s trajectory has reduced walking distances, as nurses no longer have to walk around searching for paper records or for colleagues who hold them at any given time. They do not have to contact physicians to interpret illegible handwritten notes. Also, the tracking of patients and getting access to updates of their conditions does not necessitate walking to appropriate slots where paper records were kept or contacting the clinician that is treating a particular patient. It also means that nurses do not have to walk around and locate patients each time certain tasks have been completed. In most cases the system provides information about the approximate location of the patients. This has proved valuable for nurses because, among other things, with EDIS they are now able to easily and quickly address relatives’ concerns regarding the location and the condition of the patient.

At this point, we would like to acknowledge the potential risks that these new practices might entail. Contacting a clinician for the interpretation of handwritten notes, asking for the paper record or receiving updates of a patient’s diagnosis and treatment progress may provide valuable occasions for supporting collaboration and inter-professional relationships. Such synchronous modes of communication (often through co-presence) may also offer opportunities for better contextual awareness of the information being conveyed [27,39]. However, our data suggests that nurses do not perceive these risks as existing. They still use synchronous communication channels when needed but they are now more capable of min-
imising ‘unnecessary’ interruptions, particularly under rigid time pressures.

As we have already discussed, before the introduction of EDIS much of the limited coordination work was achieved via the whiteboard. However, apart from the calculation of waiting times nurses had to return regularly to the area where it was kept to check which patient was to be treated next. At the same time, this artifact could not display adequate information about the overall position in the department. The area coordinator or the nurse in charge often had to walk to the other areas in order to check the workload or to phone up other nurses which meant that these nurses had to be or walk to where the phone was located. With EDIS they can access this overview (often remotely) and redeploy staff appropriately when the need is presented.

5.3. **Transformative artifacts**

EDIS has acquired a unique position among the nursing workpractices. This is because the system, as a new entity in the sociotechnical network of the department, has been activated – and its ‘fit’ produced – by IT professionals and nurses sufficiently enough to permit the transformation of the existing relationships into new possibilities of practicing nursing.

In particular, EDIS, as another reading and writing artifact, by reliably accumulating and computing the meticulous input of information allows with the coordination of activities across an increasingly complex spatial and temporal service model of care. Within 4 h nurses, doctors, receptionists, assistants, paper forms, labels, plastic containers, plasters, thermometers and a myriad of other artifacts as well as patients and their injury or illness itself need to be enrolled and aligned in a temporal network within a specific physical space, with specific starting and ending time points. Under a ticking clock, tracking of patients and waiting times for patients is not just about patients. It is about tracking this army of professionals and the information that they produce. It is about what has already been done, what is being done at each moment and what remains to be done. It is about tracking and counting the time each actor in this network has to take or has already taken to perform a specific activity, and how much time the rest of the actors have to wait before they make their contribution to the network’s performance collectively for each individual patient.

Before, patient tracking was achieved either with the whiteboard in conjunction with the paper clinical notes or with the whiteboard and nurses’ memory and knowledge of the patient’s approximate whereabouts. With EDIS these mediators have now been abandoned and the same activity has been transformed into a more accurate one. At the same time, it has allowed the incorporation of time awareness into the various individual activities across a continuously compartmentalised physical space. All this has been achieved without (a) altering the content of the data input (only its physical form—typing instead of writing) and (b) necessitating the cognitive reprocessing of information by the user in order to locate patients or calculate waiting times.

5.4. **Some socio-technical recommendations**

On the other hand, despite this transformative power EDIS has not been able to equally successfully ‘penetrate’ the nurse–patient relationship and replace certain paper forms during encounters [43]. While the standardisation of healthcare provision seems to facilitate the deployment of information technologies, since nurses are now better equipped to effectively align their activities under rigid protocols and well-defined frameworks of practice, and vice versa [42], the configuration of the system has been perceived to be limited in encompassing some of the unique caring aspects that nurses understand to be part of the essence of their practice culture and which the affordances of paper still support.

Although the wall-mounted terminals were installed in order to increase access to EDIS and move information input closer to the source, their fixed position increased the workpractice complexity. Apart from issues of inappropriate ergonomics, by having to turn their back nurses feel uncomfortable losing eye-contact with the patient. This is felt to affect not only their personal safety and patients’ (over-the-shoulder) access to their notes but, more importantly, their encounters with patients. The specific affordances of paper [15,44] provide the context for personalising and maintaining a close relationship [45] that is minimally ‘electronically intrusive’ and that, despite its decreasing temporality, is still probably the longest lasting in the ED. These issues should be considered especially when deploying clinical handheld devices.

Our findings in relation to other paper uses in the ED point to the need for interoperable information systems so that clinicians from other hospital areas can have access to the same information without the need to transpose it from a digital to a paper form [45]. For example, as we have seen in this study although EDIS has nearly removed the need for paper-based clinical records while patients are still in the ED, issues of duplicate records (prescriptions) still impose care risks and cause frustration to nursing staff who now have to print them out and double check them for consistency [46,47]. Careful consideration should also be given to the printing facilities in the department as nurses should not be expected to have or develop the technical skills for fixing them when they break down.

In addition, the deployment of reliable information systems, that are able to meet current and future demands of concurrent use, should be addressed and adequate back-up (e.g. paper-based) protocols and contingency plans should be established well in advance. Particularly during the first implementation, when nurses are still new to the use of electronic information media, system downtimes may severely affect their ‘trust’ in the new technology, a recurring issue in clinical information and communication technologies implementations which transforms ‘dependence’ from a desired outcome into an ‘unintended adverse consequence’ [48].

Lastly, in relation to issues of confidentiality in the ED, we would like to highlight the fact that the public display of patient-identifiable information on large mediums such whiteboards can often facilitate potentially criminal behaviour by patients or visitors. This should be taken into consideration when EDs are planning to deploy digital white-
boards particularly in the areas where non-hospital staff can be located or have easy access [49].

6. Conclusion

We have conducted a sociotechnical study to investigate how a particular information technology for patient registration and tracking has been perceived by its users to transform workpractices in an emergency department. Based on the analysis of interviews and supporting official documentation the aim was to understand this transformation by giving nurses – the biggest user group with the additional responsibility of coordinating patient flows – the opportunity to reflect on EDIS after four years of continuous use.

Our findings suggest that nurses have established a close relationship with EDIS as a way to adapt their workpractices in an increasingly standardised service model of healthcare provision. As the augmented volume and casemix of patient flows create the demand for timely accumulation of rich information and coordination of activities in compartmentalised physical spaces, information technology is gradually being considered a valuable ally.

However, this is not to suggest that paper has been or will eventually be completely abandoned. Nurses maintain a clear distinction between the managerial and the unique caring aspects of their practice [50–52], with the latter being promoted and supported by paper-based note-keeping as a way of preserving a close relationship with patients. Lastly, paper still plays a role in these settings, particularly in addressing the shortcomings of a technology that is not yet mature enough to respect the intricacies found in emergency departments. These issues were highlighted and the recommendations made could offer valuable information for future implementations of such systems in similar organisations.

Authors’ contributions

PV, ST and HW were responsible for the study conception and design. PV performed the data collection, data analysis, and drafting of the manuscript. ST and HW supervised the study. ST and HW made critical revisions to the paper for important intellectual content and approved the final version of the paper.

Conflict of interest statement

No conflict of interest has been declared by the authors.

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