Enhancing patient safety in a large HIV out-patient service: evaluation of an electronic results checking system

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Objective: To establish whether an automated electronic tracker system for reporting of blood results would expedite clinician review of abnormal results in HIV positive out-patients and to pilot the use of this system in routine clinical practice

Setting: An out-patient service in central London providing specialist HIV related care to 3900 HIV positive patients

Design: A comparison of the time taken from sampling to identification and clinician review of abnormal blood results for biochemical tests between the original paper-based checking system and an automated electronic system during a three week pilot

Results: Of 513 patients undergoing one or more blood tests, 296 (57.7%) had one or more biochemical abnormalities identified by the electronic checking system. 307/371 (83%) biochemical abnormalities were identified simultaneously by the paper-based system. Of the 307, 33 (10.7 %) were classified as urgent, 130 (42.3%) non-urgent and 144 (47%) as not clinically significant. The median interval between sampling to i) receipt of results was 1 (IQ range 1-2) vs 4 days (IQR 3-5), $p<0.0001$; ii) clinician review 3 (IQR 1-4) vs 3 days (IQR 3-6), $p<0.037$; and iii) review of non-urgent abnormalities by the regular clinician 2 (IQR 1-4) vs 10 days (IQR 9-12), $P=0.136$, for electronic and paper-based systems respectively. 7 (11%) of the missing paper-based system results were classified as urgent. The electronic system missed three abnormalities due to a software processing error which was subsequently corrected.

Conclusions: The electronic tracker system allows faster identification of biochemical abnormalities and allowed faster review of these results by clinicians. The pilot study allowed for a software error to be identified and corrected prior to full implementation. The system has since been integrated successfully into routine clinical practice.

Introduction

The numbers of individuals living with HIV in the United Kingdom continues to increase as a result of the benefits of antiretroviral therapy and continued high incident infection rates. It is estimated that the number of individuals living with HIV in the UK will exceed 100,000 by the end of 2012.[1]

HIV can now be considered a chronic condition and patients can expect near normal life expectancies as a result of antiretroviral therapy.[2] Many chronic conditions including HIV require frequent monitoring. The British HIV Association guidelines for the routine investigation and monitoring of HIV-1-infected adults (2011) outline which tests are required to assess the newly diagnosed individual and to monitor those on and off antiretroviral therapy.[3] HIV services face the challenge of regularly monitoring growing cohorts of patients and ensuring that clinically significant abnormalities are identified and acted upon promptly.

Our service provides out-patient HIV related specialist care to 3900 HIV positive patients, all of whom require regular blood test monitoring. Until the introduction of the electronic results checker we relied upon a manual paper-based system to identify and flag abnormalities to clinicians. On receipt of blood results at the clinic reception, these were sorted into normal and abnormal results by reception staff. Abnormal results were reviewed by nursing staff to identify clinically significant abnormalities for review by the on-call doctor. The on-call doctor would then judge whether these abnormalities required urgent action or would pass on results to the patient's regular clinic doctor for non-urgent review.

Several concerns about the paper-based system were identified including missing results, delayed delivery, clinician error and lack of an audit trail. These put patients at risk of serious clinical events such as drug toxicity and new infections. A recent systematic review identified failure to follow up test results in acute hospital settings as a substantial problem and a critical safety issue.[4] Automatic alerting systems have been shown to improve efficiency and timely management of abnormal results in other heath care settings.[5]

The importance of continuous quality improvement has become firmly embedded in NHS governance structure and organisational strategy[6]. There is increasing recognition that all individuals with responsibility for healthcare delivery have a professional obligation to strive to improve the safety, clinical effectiveness and patients' experience of their service[7]. On identifying an aspect of local practice for which there is scope to improve performance for the benefit of patient care, the undertaking of a Quality Improvement Project affords a systematic approach to achieve tangible, practical and sustainable improvements in outcomes for patients.

Having identified the shortcomings of our paper-based results reporting, we identified an electronic system (TA Monitor™) with the potential to overcome these issues. TA Monitor™ classifies results as normal, non-urgent and urgent

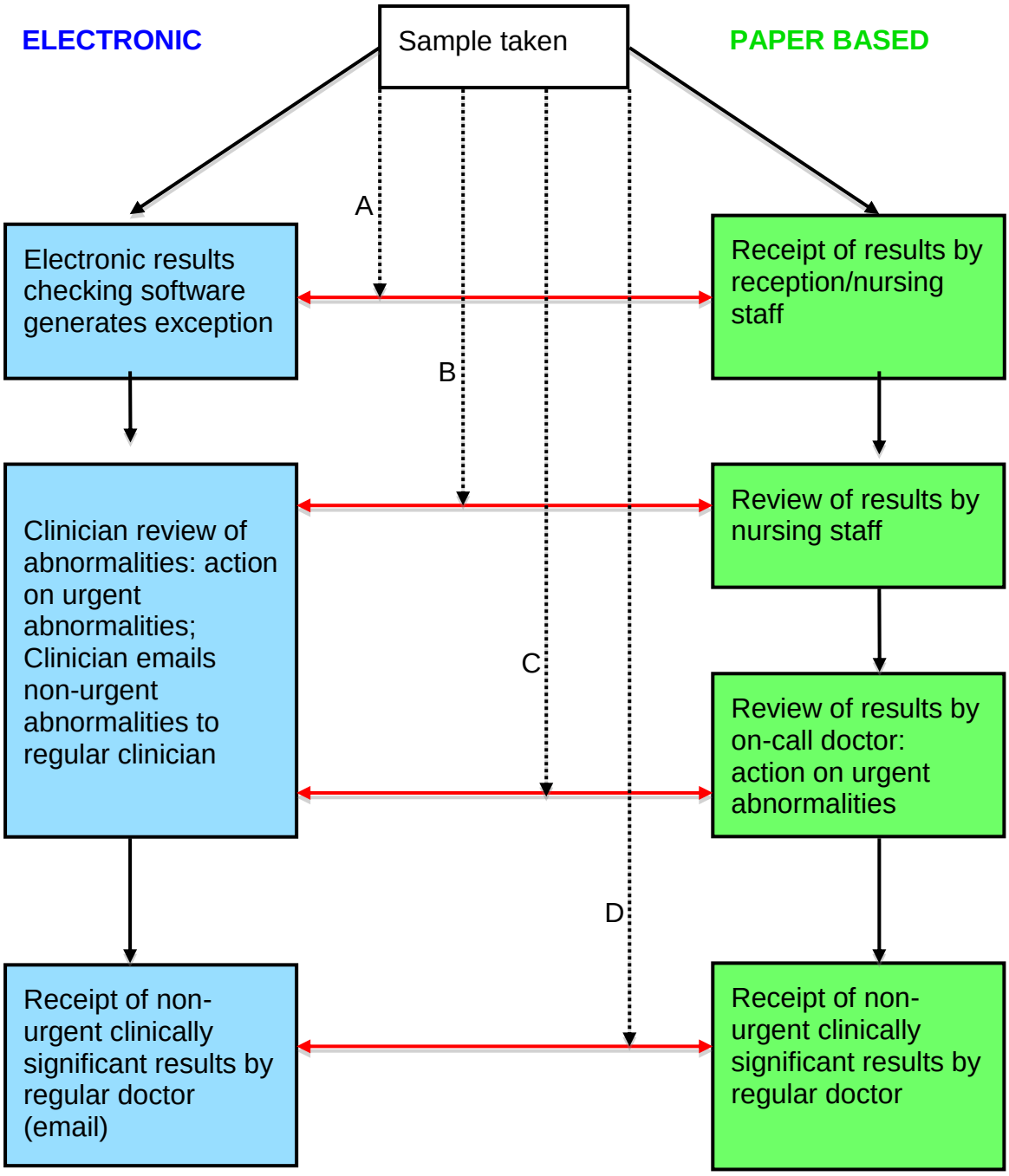
according to pre-defined thresholds. On logging into the checking system, the clinician is alerted to newly received laboratory abnormalities to dismiss, act upon or forward via email to the patient's regular doctor. We undertook our intervention within the QIPP (Quality, Innovation, Productivity and Prevention) framework[8] with the intended quality improvement aim to identify and act upon abnormal results more promptly.

Methods

We conducted a study to compare the performance of the paper and electronic systems in identifying abnormalities. The study also served to pilot the electronic system prior to implementation in routine clinical practice.

For a three week period in July 2011 the electronic and paper systems were run in parallel to allow direct comparison of the time intervals from sampling to equivalent time-points for each system, namely: A) receipt of results, B) clinician (nursing staff) review of abnormalities, C) clinician (on-call doctor) review of abnormalities and D) review of non-urgent abnormalities by the regular clinician for both systems as shown in Figure 1 below. Owing to the large volumes of paper data generated, we restricted our pilot to a subset of common biochemical tests. Abnormalities were reviewed daily by clinicians using the standard paper-based system, but in addition these were classified as 1) urgent, 2) non-urgent or 3) clinically non-significant according to pre-defined thresholds and graded 0-4 according to the Division of AIDS table for the grading of severity of adult and paediatric adverse events[9]. Clinic staff were asked to date and time stamp the paper results they reviewed to enable recording of the time period between blood sampling and review of results. During the same three week period, abnormalities generated by the electronic system were reviewed daily by a designated clinician. On logging into the system, the clinician is presented with those abnormal results which have been received since the previous login. The clinician could then dismiss or act upon the abnormality, or forward the result to the regular clinician as appropriate. The time-points for the receipt of results and clinician review were recorded automatically by TA Monitor™ thus allowing comparison of equivalent time intervals with the paper-based system. Urgent results were acted upon as soon as they were identified by either system. Data was analysed using STATA V11.0. Mann Whitney U tests were used to compare the intervals using both systems.

Figure 1: Comparison of receipt and review of abnormal results between the paper and electronic systems



Results

Of 513 patients undergoing one or more blood tests, 296 (57.7%) had biochemical abnormalities identified by the electronic system as shown in Table 1.

Table 1: Number of biochemical abnormalities

Test	Number	Test	Number
Urea/Creatinine	24	Bilirubin	45
Sodium	23	Alanine transaminase	23
Potassium	12	Alkaline phosphatase	32
Calcium	42	Lipids	172
Phosphate	92	Urinary Protein Creatinine ratio	14
Glucose	14	Other	47

307/371 (83%) biochemical abnormalities were identified simultaneously by the paper based system. Of the 307, 33 (10.7 %) were classified as urgent, 130 (42.3%) non-urgent and 144 (47%) as not clinically significant. (Table 2) Of the 155 results classified by the Division of Aids grading table, 60 (39%) were grade 1, 64 (41%) grade 2, 30 (19%) grade 3 and 1 (0.6%) grade 4 abnormalities.

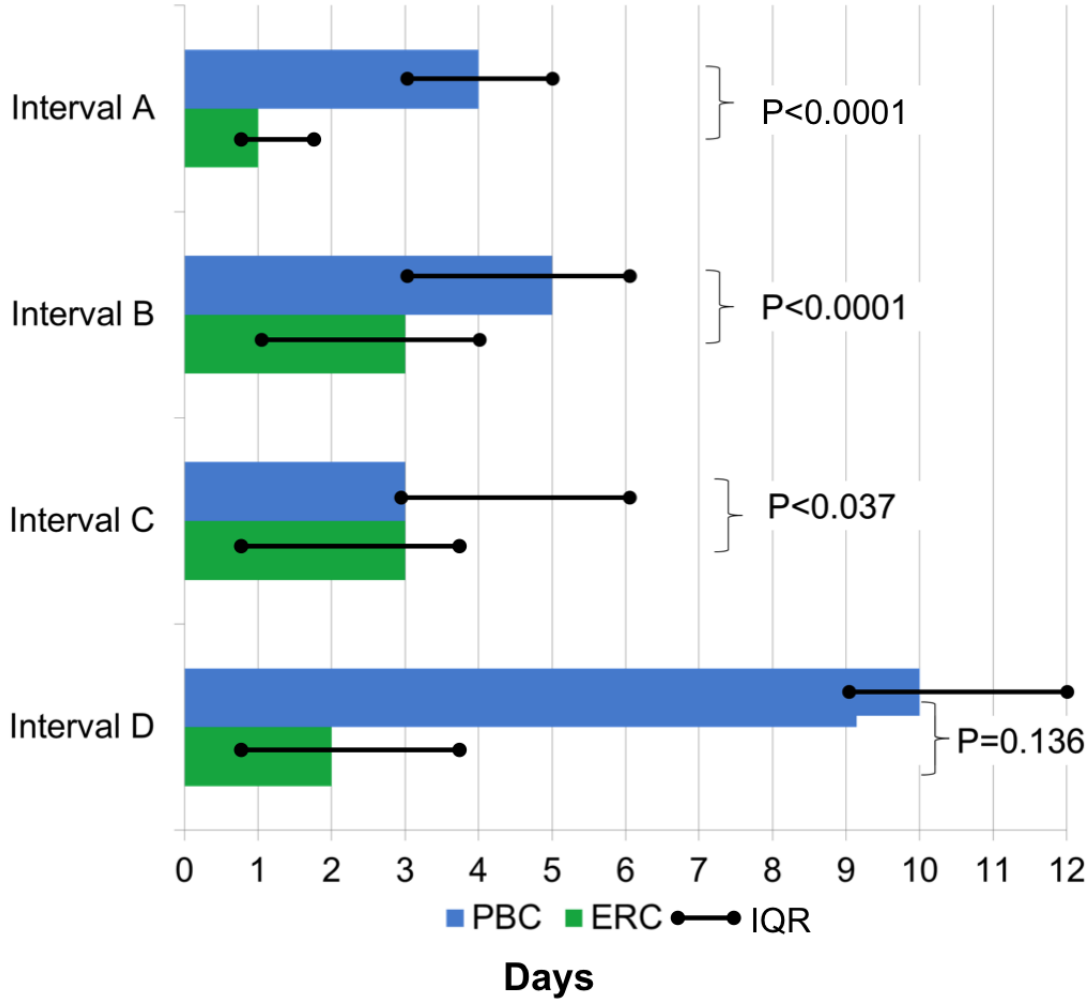
Table 2: Number of biochemical abnormalities and time to receipt and review of results according to time interval and clinical significance for the electronic and paper systems

Interval	**Significance**	**Electronic**	**Median days (IQR)**	**Paper**	**Median days (IQR)**
A	Urgent	33	1 (1-4)	33	4 (3-6)
	Non urgent	130	1 (1-2)	130	4 (3-5)
	Non significant	144	1 (1-2)	143	4 (3-5)
B	Urgent	30	3 (1-4)	24	5 (4-6)
	Non urgent	123	3 (2-5)	66	5 (4-6)
	Non significant	143	2 (1-3)	39	4 (3-5)

C	Urgent	30	3 (1-4)	18	4.5 (3-6)
	Non urgent	123	3 (2-4)	56	5 (3-6)
	Non significant	143	2 (1-3)	27	3 (2-3)
D	Urgent	9	1 (1-7)	5	9 (9-11)
	Non urgent	19	2 (1-4)	15	11 (10-14)
	Non significant	4	2 (1-3)	6	10.5 (10-11)

7/64 (11%) of the missing paper results were classified urgent. The electronic system missed three abnormalities highlighting a software error which has now been corrected. All results requiring action were acted upon as soon as they became available through either system. The median interval between sampling to each time point (A-D) is shown in graph 1.

Graph 1: The median number of days and interquartile range for intervals A-D following sampling for the electronic results checker (ERC) and paper-based checker (PBC)



Discussion

Delays in the receipt of abnormal test results are a common source of frustration in clinical practice: one survey found that 83% of physicians reported reviewing at least one test result within the last two months that "they wished they had known about earlier"[10] whilst an international survey of patients found that 8% in the UK had experienced delays in being notified about abnormal results.[11] Failure to follow up on abnormal test results in a timely fashion may have critical safety implications for patients[4,12] alongside potential medico-legal consequences and a negative impact on patients' experience of the service. The adoption of the QIPP methodology provided us with a structured approach to address the shortcomings in our system by undertaking an intervention to improve the safety and experience of our patients.

Biochemical abnormalities are common among our HIV cohort. Compared to the paper based checking system, the electronic system was significantly faster in identifying laboratory abnormalities, facilitating timely management. Given the

high volume of tests performed, we anticipate that the electronic system will avoid delay/non-identification of a significant number of abnormal results within our service.

The impact of faster clinician identification of laboratory abnormalities on our patients' health outcomes is difficult to quantify and would require a larger cohort and prolonged follow-up which is beyond the scope of this pilot study. Nonetheless, the electronic system offers the additional benefit of a clear audit trail whereby in the event of an adverse clinical event, a written record is retained of when any laboratory abnormality was identified and by whom.

Although our evaluation is limited by having examined biochemistry results alone we would anticipate similar reductions in reporting times for haematology and microbiology results. The number of abnormalities missed by the paper based system should be interpreted with caution as the failure for a result to be returned for audit does not always imply failure in receipt of the result and appropriate management. The effectiveness of the paper based system may thus have been underestimated.

The pilot showed that a high proportion (47%) of results identified as abnormal by the electronic system during the pilot were judged not to be clinically significant. These included minor abnormalities in lipid profile and below-normal levels of urea and creatinine requiring no action. This finding prompted us to refine the thresholds for abnormalities identified by the tracker to reduce the quantity of unnecessary reviews by the attending clinician. The checker software also allows refinement of thresholds at an individual patient level. For example in a patient known to have chronic renal impairment, expected elevations in urea and creatinine at the patient's baseline need not be repeatedly flagged up for review.

Prior to piloting such a system it is essential to work with the software provider to ensure that all the required results are downloaded into the application, to pre-define the thresholds for urgent and non-urgent laboratory abnormalities and to establish a clear pathway for managing abnormal results. While the system is easy to use it is important to establish a training programme for existing and new staff with the support of an IT help desk to manage day-to-day operational issues. To ensure that abnormal results are identified promptly it is necessary to implement a system for the daily review of results by a designated clinician. Where non-urgent abnormalities are forwarded by e-mail within the secure network it is important to have a system in place for when individuals are on leave. To overcome this we ensured that copies of these e-mails were also sent to the secretarial team so that results are forwarded to another clinician at times when the regular clinician is unavailable. As an additional safeguard TA Monitor™ also produces a highlighted list of abnormal results that do not appear to have been reviewed by the regular clinician within a pre-specified period of time. It is important that the individual reviewing the daily results also reviews these to ensure they have been acted upon.

Conclusions

Our Quality Improvement Project has shown that adopting an automated system for identification of laboratory abnormalities in HIV positive out-patients leads to faster review of abnormal results by clinicians. The electronic results checker has now been successfully introduced into routine clinical practice within our service with a duty rota in place to ensure that abnormal results are reviewed at least daily by a designated clinician. We highlight the importance of piloting such systems concurrently with existing systems and safeguards to identify any processing errors and to troubleshoot use in practice prior to full implementation. We advocate clinician engagement in the development and piloting of such software to facilitate subsequent ease of use, for example through modification of thresholds for reporting of abnormalities. We anticipate that the sharing of our experience and methodology will be of use to those seeking to implement similar systems in the provision of HIV-related care, or in other clinical settings tasked with monitoring for laboratory abnormalities in large patient cohorts.

Conflicts of interest

Prof. Robert Miller is Editor-in-Chief of the British Journal of Hospital Medicine.

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