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TITLE

elCID: An electronic Clinical Infection Database to support integrated clinical services and research in infectious diseases

RUNNING TITLE

elCID integration of infection service and research

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CONFLICT OF INTEREST

DM and CR are employees of Open Health Care UK (OHCUK), the company that designed elCID. The other authors have no financial relationship with OHCUK.

HIGHLIGHTS

- Multiple hospital infection teams routinely collect disparate and independent data
- We developed a secure web based multi-user integrated data collection system (elCID)

- We highlight its utility to improve clinical infection services and support research

Dear Editor

King and colleagues recently reported in this Journal their use of electronic syndromic surveillance for the management of surgical infection, highlighting the potential of routine data collection to improve clinical services and inform research within infectious disease practice[1]. The care of patients with infectious diseases is complex and frequently dependent on multi-disciplinary input from infectious diseases physicians, microbiologists and virologists[2,3]. These teams add significant value[4] and result in improved patient outcomes and reduced expenditure[5,6]. Data collected on these different aspects of the clinical service are fragmented across patient lists, paper records of phone or clinical consultations, and isolated electronic databases of patients attending specialist outpatient services, such as Outpatient Parenteral Antimicrobial Therapy (OPAT). As a result, routine clinical data are often not collected systematically or in a format that can be interrogated easily to derive meaningful insights into teams' clinical activity [7]. This fragmented data collection creates a barrier to gathering large, prospective datasets that can be used to shape clinical practice, drive audit and facilitate research[7]. This is further compounded by shortcomings in traditional performance metrics, such as length of stay or the number of patients seen in outpatient clinics, which fail to reflect the significant volume of clinical workload provided by infection teams through key services such as ward consultations and antibiotic stewardship.

We developed an integrated clinical data entry system, the **e**lectronic **C**linical **I**nfection **D**atabase (elCID)[8], that allows real-time prospective data collection of clinical activity in our Division of Infection. The database is accessed via a web browser, which allows both multiple user and remote access to elCID whilst storing all information behind the Trust's secure firewall. The system is used to maintain inpatient lists, record consultations, and track patients seen in specialist clinics such as the OPAT service. Integral to the system is the ability to capture coded entries within all fields, in particular diagnoses, antimicrobials and investigations, thereby facilitating robust prospective data collection.

The main purpose of introducing elCID was to capture the full spectrum of clinical workload across an infection service at a large tertiary referral centre. To that effect, elCID brings together disparate silos of clinical data collection into a single, rapidly searchable database resource permitting unprecedented interrogation of our clinical practice. However, the benefits of the system go further, having vastly improved the quality and transparency of communication between the Division's teams, audits of day-to-day clinical practice are now rapidly and routinely performed using high quality prospectively collected data, and research study data collection can be conducted within the main database, facilitating improved integration

of the clinical and academic arms of the Division. We have provided three case studies to illustrate the impact of elCID.

Case study 1: Impact of elCID on Division workflow and quality of service delivery

Utilising elCID, we were able to visualise an output of the departmental workload generated in real-time. This permitted us to both quantify our caseload to hitherto unachievable levels of accuracy (Table 1), but also demonstrate the interconnectedness and multidisciplinary nature of care provided to all 2589 patients (Figure 1). This step change in performance metrics has enabled the Division to reassess workload requirements, including the redeployment of junior doctors across our various teams. Concurrently, elCID has also facilitated a number of improvements to the delivery of routine clinical care. Ward- and telephone-based clinical advice is now remotely accessible and searchable. Free-text searching has revealed that around 10% of clinical reviews recommended stopping antimicrobial prescriptions, an intervention difficult to quantify from paper records. In addition, the system can automatically transfer coded clinical information between inpatient and outpatient episodes resulting in significant time-savings across patient's complete clinical journey.

Case Study 2: Haematology Consult Service

Records of the clinical liaison service offered for patients with haematological malignancies had previously been captured on hand-written T-Cards. The switch to elCID has revolutionised our ability to capture and interrogate this dataset. In the first 12 months of elCID use, the haematology service generated 3,674 clinical reviews from which clinical advice was offered on 1,490 occasions. The clinical reviews also resulted in 799 antimicrobial prescription changes and infection control advice being offered directly during these ward rounds on 362 occasions. These figures are in sharp contrast to attempts to derive such information pre-elCID, namely a time-consuming, manual review of a limited subset of T-cards and subsequent extrapolation from a potentially unrepresentative and biased sample. In addition to the benefits of improved data capture, the system has improved provision of care for this patient cohort. By definition, the previous T-Card based system relied on single user, physical data capture that limited real-time collaborative reviews and clinical input into the care of patients. The switch to elCID has allowed faster, more detailed recording of clinical interactions that are remotely and contemporaneously accessible to clinicians in both microbiology and haematology departments.

Case Study 3: Integrated Clinical Research Platform

The modular nature of elCID allows research data to be collected alongside routine clinical data, reducing the need for additional research specific databases. User-specific access rights allow additional components of the database to be restricted to clinicians and academics participating in studies whilst simultaneously linking this research data to patients' underlying routine clinical data. As data are captured prospectively in a coded format, the system provides a platform to identify individuals meeting specified criteria and trigger referral to research nurses or additional data collection. Utilisation of such functionality helps to bridge gaps between provision of clinical care and participation in research, and has specifically been exploited by the Rapid Identification of Respiratory Tract Infection (RiD-RTI) European FP7 project that utilises elCID to both identify eligible patients for the study, as well as anonymously process and record research data collection[9].

Conclusions

Fragmented data presents a barrier to high quality patient care, service evaluation and research. The development of elCID has resulted in an integrated platform to address these key unmet needs, and its utilisation has provided a platform to both drive clinical service delivery and undertake audit and research. Adoption of elCID, or development of similar solutions, to record clinical activity should be considered widely across other Trusts in the UK with similar visions for data-driven improvement in quality and care delivery.

References

1. King, C., Aylin, P., Moore, L. S. P., Pavlu, J. & Holmes, A. Syndromic surveillance of surgical site infections--a case study in coronary artery bypass graft patients. *J. Infect.* **68,** 23–31 (2014).

2. Petrak, R. M. *et al.* The value of an infectious diseases specialist. *Clin. Infect. Dis. Off. Publ. Infect. Dis. Soc. Am.* **36,** 1013–1017 (2003).

3. Bursle, E. C., Playford, E. G. & Looke, D. F. M. Infectious diseases consultations at an Australian tertiary hospital: a review of 11,511 inpatient consultations. *Intern. Med. J.* **44,** 998–1004 (2014).

4. Vehreschild, J. J. *et al.* Evaluation of an infectious disease consultation programme in a German tertiary care hospital. *Infection* **41,** 1121–1128 (2013).

5. Schmitt, S. *et al.* Infectious diseases specialty intervention is associated with decreased mortality and lower healthcare costs. *Clin. Infect. Dis. Off. Publ. Infect. Dis. Soc. Am.* **58,** 22–28 (2014).

6. Sharma, R., Loomis, W. & Brown, R. B. Impact of mandatory inpatient infectious disease consultation on outpatient parenteral antibiotic therapy. *Am. J. Med. Sci.* **330,** 60–64 (2005).

7. De Lusignan, S., Hague, N., van Vlymen, J. & Kumarapeli, P. Routinely-collected general practice data are complex, but with systematic processing can be used for quality improvement and research. *Inform. Prim. Care* **14,** 59–66 (2006).

8. Electronic Clinical Infection Database (elCID). at <http://elcid.openhealthcare.org.uk>

9. RiD-RTI Rapid Identification of Respiratory Tract Infections. at <http://www.rid-rti.eu/rid-rti/home_page>

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TABLE 1

Summary characteristics of patient population recorded on eICID including sources of underlying infection, cultured organisms and prescribed antimicrobials.

Age	
Median	50
Min-Max	0-95
Interquartile range	34-65
Source of infection	**% of patients**
Urinary tract	20
Skin & soft tissue	20
Respiratory	20
Tropical	10
Gastrointestinal	7
Blood stream	5
Bone + joint	4
Neurological	3
Other	3
Cardiac	1
Organisms cultured from sterile site	**% of cultured organisms**
Escherichia coli	19
Pseudomonas aeruginosa	11
Klebsiella sp	9
Coagulase negative staphylococcus	8
Staphylococcus aureus	8
Enterococcus sp	5
Alpha haemolytic streptococci	5
Candida sp	4
Enterobacter sp	4
Beta haemolytic streptococci	2
Streptococcus pneumoniae	2
Stenotrophomonas sp	2
Antimicrobials prescribed	**% of total antibiotics**
Piperacillin tazobactam	17
Meropenem	8
Co-Amoxiclav	6
Teicoplanin	6
Ciprofloxacin	5
Cefuroxime	5
Flucloxacillin	5
Gentamicin	4
Clarithromycin	4
Metronidazole	3
Ceftriaxone	3
Clindamycin	3

Figure 1

Network diagram representation of clinical input (edges) into individual patient episodes (blue nodes) by different Infection teams at UCLH (red nodes). Dark blue nodes represent patient episodes involving one clinical team and light blue nodes represent patient episodes involving >one clinical team.

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Infectious Diseases - inpatients

Tropical Diseases

Infectious Diseases - liaison

HIV - inpatients

Microbiology - haematology

Virology

HIV - liaison