Decision support systems for the treatment of community-acquired pneumonia

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Submitted January 2009

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Abstract

Delay to antibiotic treatment of community-acquired pneumonia (CAP) greater than 4 hours following hospital admission is associated with a 15% increase in mortality. Paper-based guidelines have been widely introduced to improve CAP care, but these interventions have under-performed due to poor compliance in complex clinical workflows. Unlike passive paper-based guidelines, alerting systems based on computer-based decision support systems (CDSS) have the capacity to actively draw attention to delayed clinical processes. Formal consideration of local workflow is key to the design and successful implementation of CDSS.

I used workflow analysis techniques to develop an evidence-based alerting system designed to reduce the delay to treatment of CAP in the emergency department (ED) of an Australian tertiary hospital. A sample of 6 CAP patients were observed during October 2001 to derive a structural process flow model, which was refined via stakeholder interview. A deterministic process flow model was then developed using an existing retrospectively compiled CAP database, consisting of 246 patients admitted June-December 1998 and 146 patients admitted May-December 2000. A stratified control sample presenting with respiratory symptoms (n=74, January-December 2003) was collected for the assessment of diagnosis and chest x-ray (CXR) accuracy.

Treatment delay greater than 4 hours was associated with failure to diagnose CAP in the ED, the absence of CXR evidence, low triage score, delayed CXR, and failure to treat in the ED. ED physicians only identified 54-57% of those discharged with CAP. Radiologists only reported CAP features in 47% - 67% of initial CXRs for these patients.

I hypothesised that a CDSS-based alerting system, composed of a CAP early diagnosis model (EDM) and a simple risk model (CRB-65), would identify enough CAP patients to reduce the percentage treated after 4 hours. I constructed an evidence-based naïve Bayesian EDM (sensitivity = 36%, specificity = 93%). It was able to identify 24% of CAP patients that died in hospital, 38% of those with antibiotics delayed greater than 4 hours, and 26% of those with CXR delayed greater than 4 hours. CAP-specific risk models were equivalent to the Australasian Triage Score (ATS) in predicting mortality.

I simulated alerting policy by combining the CDSS with the deterministic process flow model. Alerting for treatment at triage or initial physician assessment, when the EDM was positive, approximately halved the median treatment time of 5.53 hours, and decreased the number treated after 4 hours (62%) by 1/3. Treating EDM-positive patients as ATS category 2 produced a similar effect.

Current triage practices, embodied mainly by the disease-independent, sign and symptom based ATS are too coarse to deal with conditions such as CAP, where there is high diagnostic uncertainty and delays in diagnosis and treatment are critical determinants of outcomes. Better outcomes may be achieved with quicker diagnostic and treatment workflows via: analysis of current diagnosis and treatment workflows, analysis and correlation of a comprehensive set of patient symptoms, signs and risk factors for the specific disease, and improving triaging and subsequent workflow through a disease-specific CDSS based on early diagnostic models derived from the previous analyses.

Acknowledgements

To my supervisors

Dr Malcolm Pradhan, MBBS, PhD Health Informatics; Director of Health Informatics, Faculty of Health Sciences, The University of Adelaide; VP Research & Development Alcidion Corporation, *and*

Associate Professor Robert Adams MBBS, MD, Grad Cert Health Econ, FRACP; Senior Lecturer, Discipline of Medicine, The University of Adelaide; Health Informatics, The University of Adelaide; Respiratory Physician, The Queen Elizabeth Hospital; Chair, Metro Clinical Sub-committee, South Australian Safety & Quality Council

thanks for your continued insight, patience and support.

Dr Jeff Faunt MBBS, FRACP; Senior Consultant, Royal Adelaide Hospital; Head of the Royal Adelaide Hospital Quality and Safety Unit, *and* the **Royal Adelaide Hospital Community Acquired Pneumonia Working Group**, *and* the **Royal Adelaide Hospital Quality and Safety Unit**

for access to clinical data and pneumonia working group meetings, as well as consultation over workflow models.

Dr Michael Davey MBBS, FACEM; Assistant Medical Director, Emergency Department, Royal Adelaide Hospital; Clinical Lecturer in Emergency Medicine, The University of Adelaide, *and*

Dr Marie Kuhn ABIM, ABEM, FACEM (deceased) former Director of the Royal Adelaide Hospital Emergency Department

for access to the Royal Adelaide Hospital Emergency Department for observational studies, access to the Emergency Department clinical data system, and for review and discussion of workflow modelling.

Royal Adelaide Hospital Information Technology Department

for access to clinical information system data.

Royal Adelaide Hospital Medical Records Unit
for access to patient case notes.

Professor Gary Wittert, MBBS, FRACP, Head of The University of Adelaide School of Medicine *and* **The University of Adelaide Department of Medicine**
for ongoing support and access to office space.

Brita Pekarsky, BA Health Economics, Hons
for continued support, friendship and draft review.

Dr Michael Edmonds, MBBS, Hons Medical Science
for continued support and friendship.

Dr Matthew Sinnott, BSc, PhD Experimental Physics
for continued support and friendship.

Dr Jayde Llewelyn, MBBS, FRACGP
for extreme patience and proof-reading.

This work was supported by an Australian **NH & MRC Dora Lush Biomedical Scholarship** (ID219405).

Parts of this work were submitted as peer reviewed conference papers and presented at the Australian Health Informatics Conferences in 2000, 2003, 2005, and at the 3rd Australasian Conference on Safety and Quality in Health Care in 2005.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Dr. Scott R. Clark