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## **Results from a project to develop systematic patient focused clinical pharmacy services. The Lund Integrated Medicines Management (LIMM)-model**

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### *Background*

As people get older polypharmacy increases and there is an increased risk of adverse drug events, drug interactions, low medication adherence, increasing economic burden, hospital admissions and even drug related deaths [1]. It is also stated that the problems of inappropriate pharmacotherapy are expected to grow in the future as new drugs are introduced, new uses for old drugs are found, and as the population lives longer with an increased risk of chronic medical conditions. Poor communication of medical information suggests that between 40-85% of elderly patients have at least one error in medications when they are transferred between primary and hospital care [2-6]. In order to improve quality in the use of medications in society, and for individual patients there is a need to identify problems and errors in structures and processes to improve the outcome of care and to reduce errors [7].

A systematic analysis of potential problems and limitations during the standard patient medication care process was performed by the Drug and Therapeutics Committee at Lund University hospital in 1999. This followed admission, the hospital stay, and post discharge. After confirmation of the problems a project was initiated. The aim was to build a model based on systematic training, activities and responsibilities to identify, solve and prevent drug related problem (DRP) in the health care process, starting when a patient is admitted to hospital. For patient based clinical pharmacy services we identified no systematic research or models focusing on all these aspects.

This is an overview of the results which have been published in 17 separate publications [2-6, 8-19]. Readers are encouraged to follow up specific results by referring to tables 2 and 3 for the referenced summary.

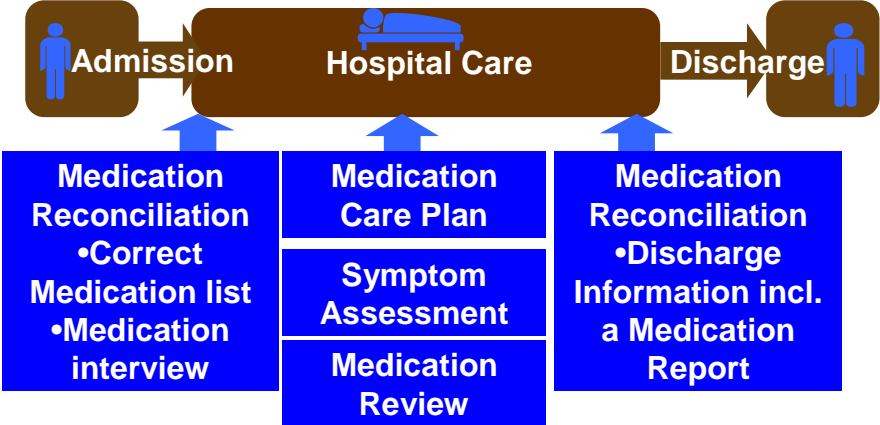
### *Methods*

A systematic analysis of potential problems and limitations during the standard patient medication care process was performed in 1999. This followed admission, the hospital stay, and post discharge. We focused initially on the potential problems to assess their frequencies and clinical significance. We also started to improve the structure and process for each of three stages (admission, hospital stay, and after discharge) to improve patient and health care outcomes. For each part specific tools, checklists and responsibilities were developed and subsequently tested. The final structured model is team based and consists of systematic medication reconciliation, medication review, and oral and written communication as described in figure 1 and table 1. The clinical pharmacist was the catalyst for improvement in the patient care team, but each member had their specific responsibilities and the physician was responsible for changes in prescribing. Each part of the model was developed, introduced in the care team, and researched stepwise in cooperation between the key teams: pharmacy, medicine, and nursing, in hospital and primary care. The project was based on internal medicine wards at Skåne University Hospital in Lund and Landskrona Hospital, Sweden.

We used descriptive studies to investigate problems, comparative controlled studies to investigate improvements, blinded evaluators for studies on errors, consequences and clinical significance. Where possible we used validated tools. If not we developed and validated new

tools. The study size was based on power calculations where applicable. We analysed results using descriptive and comparative statistics, trend, regression and survival analysis, intention to treat and per protocol analysis, and also probabilistic decision tree models for health economic evaluations. The number of included patients in each of the studies ranged from less than 100 to almost 4000.

**Figure 1. The LImm-model**



**Table 1** The Lund Integrated Medicines Management model (LIMM-model). Activities performed in the hospital wards, responsible professional groups, and tools for performing the activities

<i>When and how often</i>	<i>Activity</i>	<i>Responsibility</i>	<i>Tool</i>
At admission, once for each patient	Admission Medication Reconciliation	Clinical pharmacist	LIMM Medication Interview Questionnaire, part 1-3 depending on medication, disease and patient characteristics  Part 1: identification of the most accurate patient medication list  Part 2: addition of questions concerning practical handling, knowledge and adherence  Part 3: addition of deepened questions concerning adherence and beliefs
During hospital stay, continuously for each patient	Medication Review and monitoring	Clinical pharmacist	LIMM Medication Review Form
	Symptom Assessment	Nurse (or clinical pharmacist)	LIMM Symptom Assessment Form
	Lead the team and organize a treatment plan based on the Symptom Assessment, the Medication Review and Reconciliation	Physician	Documented in the patient health record
At discharge, once for each patient	Discharge Medication Reconciliation	Physician	LIMM Discharge Information Form, including a Medication Report and a Medication List
At regular intervals	Quality control of Discharge Medication Reconciliation	Clinical pharmacist	LIMM Quality Control form for Discharge Medication Reconciliation

### *Results*

Nineteen scientific publications and manuscripts have been produced from the development and also formed the basis for four PhD- and more than 30 MSc-thesis. The model has been shown to improve the process of care, i.e. it identifies and solves drug related problem, reduces medication reconciliation errors, and improves medication appropriateness. A summary of benefits in the admission and hospital care process is presented in table 2 and in the discharge process in table 3. For each comparison there is significant improvement at least on  $p < 0.05$  level.

The model also improves clinical outcomes. Health care contacts and hospital readmissions due to medication errors were reduced by at least 50 per cent [13,16], however total readmissions were not affected [14]. It also saves time, at least 2-3 hours per patient, for physicians and nurses in hospitals, in primary and community care [17]. The model also

generated cost savings of €370, for each intervention cost of €42 and gained utility of 0.005 [18]. The probability that the intervention would be cost-effective at a zero willingness to pay for a QALY gain would be 98%. Finally physicians and nurses were very satisfied with the process and the pharmacist contribution [10,11,17]. The model has been adapted to primary care medication review by pharmacists and a randomised controlled study showed a decrease in potential inappropriate medication among the elderly [19].

**Table 2.** Activities on admission and during hospital stay. Summary of potential process benefits studied.

<i>Potential benefit</i>	<i>Results and references</i>
The clinical pharmacist identifies DRP systematically	As a mean 1.9 DRP (mainly errors in medication lists) were identified using the L IMM- Medication Interview form (MIF) part 1. They also identify as a mean 7.6 DRP using the L IMM Medication Review form (MRF) [8]. MIF part 1-3 can be used clinically and for research purposes [9]. The Clinical Pharmacist identifies as a mean 6.5 DRP using the MIF and MRF [10].
Identifies errors that would not be identified by standard care	Using MIF part 1, as a mean one error in medications lists were identified which normally would not be identified by standard care [6]. Using MRF and L IMM Symptom Assessment form, 8 DRP were identified which would not be identified by standard care [11].
Recommendations from the pharmacist to the physician to solve and prevent DRP is performed systematically	81 and 62 % of real DRP identified using MIF part 1 and MRF respectively were presented and recommended. [8]. 56% of all DRP identified using MIF part 1 and MRF were presented and recommended [10].
The physician complete the pharmacist recommendations systematically	90[8] and 64% [10] of the recommendations were completed by the physician.
The pharmacist recommendations are clinically significant	Among real DRP 83 and 49 % of recommendations were ranked as "somewhat significant" or higher and "significant" or higher respectively [8].
Patient treatment becomes more appropriate	Medication Appropriateness Index (MAI) was improved and the number of inappropriate drugs during hospital stay was reduced [13] and also 2 weeks after discharge [12].
Physicians and nurses are satisfied with the pharmacist in the team and the benefit for the patient	The stated benefit for the patients and for the health care team, and also the pharmacist performance was valued as high with a median and range within 5-6 on a 6 level scale (1=no, 6=large benefit) [10,11]
Hospital readmission decreases	Hospital readmission within 3 months due to DRP decreased by 55%, from 12 to 5,6 [13]. Total readmission was not affected [14].

**Table 3.** Activities at discharge. Summary of potential process benefits studied.

<i>Potential benefit</i>	<i>Results and references</i>
Medication Report (without quality assurance) reduces error rates in medication lists	The proportion of patients without and error (measured based on what patients really takes) in the medication lists increased from 34 to 68 % [3].
Decreased risk of clinical consequences	The proportion of patients with moderate or high risk of clinical consequences was reduced from 32 to 16 % [3].
Quality assured Medication Report in the L IMM-Discharge Information (DI) decreases error rates further.	The total number of errors decreased by 45% from 12.0 to 4.8 of medications. The proportion of patients without errors increased from 63 to 73% [5].
The patient receives high quality DI written by physicians	Error rates in medication lists and Medication Reports decreased somewhat at the University Hospital wards during one year follow up but the number of patients who received the information was still low (31 and 27%) [15].
Health care contacts after discharge decreases	The proportion of patients seeking care due to errors in medication lists decreased from 8,9 to 4.4% [16].

### *Discussion*

For more than a decade the L IMM-model has been developed, researched and the benefit in the process and in some outcomes established using high quality methods and design for a team approach. During this period several hundred pharmacists, physicians and nurses have been involved. Although the pharmacist is the catalyst and the lead professional to get the process running, the role physicians and nurses is fundamental for success. The model is transferable to similar health care systems and outcomes can be guaranteed with the use of the tools, checklists and other support systems developed using L IMM process indicators and – standards.

A recent Cochrane review concluded that it is uncertain whether medication review reduces mortality or hospital readmissions, but medication review seems to reduce emergency department contacts [1]. However, the cost-effectiveness of this intervention is not known and due to the uncertainty of the estimates of mortality and readmissions and the short follow-up, important treatment effects may have been overlooked. The review also states that medication review should preferably be undertaken in the context of clinical trials and that high quality trials with long follow-up are needed before medication review should be implemented [1].

In our work we have not had the possibility to perform the high quality trials called for by the Cochrane review. Our team approach with routines, responsibilities and trust have been designed over several months to be effective and safe. It is therefore not possible to randomize a patient to a control group. A team based randomized study can therefore only be performed in clusters and we have not had the financial and organisational power to perform such a study. This is of course a limitation in the evidence base for the model. However, to our knowledge there are no high quality studies on team based model interventions in health care at all where real patient outcomes have been studied. Interrupted time series has been suggested as a way to analyse outcomes. This is however problematic when the number of events (outcomes) in each cell is very low. Mortality and hospital readmissions due to DRPs are such outcomes (13,14).

The focus in this paper has been on the process of drug therapy. According to Donobedian [7] the structure of care also is very important for the quality and outcome. As part of the structure we need pharmaceuticals and diagnostic tools with a high level of evidence. We also need educated and trained pharmacists, physicians and nurses. With this in mind, several courses have been developed at Lund University for students and practitioners. The-LIMM-model has had large impact on pharmacist education with a full scale MSc Pharmacy program. Here the LIMM-model is the educational platform for training pharmacotherapy, communication, clinical skills etc. [20]. The model has also received several national awards including best innovation in Swedish health care, the gold scalpel. In the southern Sweden each hospital has employed a number of additional clinical pharmacists, paid by the local authorities, to perform medication reviews according to the LIMM-model. Very recently there was an amendment to the Swedish constitution and also a national patient safety agreement that healthcare must perform medication review and medication reconciliation in care transitions, and have economic incentives for this. This is expected to have a large impact on the need for clinical pharmacists. Good for both patients and the pharmacy profession.

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