A FRAMEWORK FOR THE DISCHARGE OF PATIENTS FROM THE ADULT EMERGENCY DEPARTMENT

By

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LIST OF ABBREVIATIONS

CPOE (Computer Physician Order Entry)

DC123 (Discharge 1-2-3; a commercial ED discharge writing solution)

ED (Emergency Department)

EMR (Electronic Medical Record)

PAML (Pre Admission Medication List)

CHAPTER I

INTRODUCTION

Medicine is an information intense discipline. To diagnose and successfully treat a patient in the emergency department, the clinician must first already have a firm grasp of thousands of diseases in his or her head. He must take a thorough history and physical from the patient. Information from the patient tends to be inaccurate or incomplete. He often needs to clarify further from the patient multiple signs and symptoms to form a differential diagnosis based on assimilating the two above information. He then usually orders lab tests to further narrow down the differential diagnosis using a Baysean approach of prior and post probabilities. Upon forming the most likely diagnosis, he must then formulate a best treatment plan, which usually involves the right medications given over the correct duration. Couple that with the need to make sure the medication given is covered on the patient's insurance formulary. This is the reason why it takes on average 7 years to train a clinician for independent practice of emergency medicine following graduation from college.

Given the enormous cognitive load, it is not surprising that errors occur in medicine. One study states that on the inpatient side alone, drug related adverse reactions account for upwards of 44,000 deaths in the US. Another study cites that if the medical error related deaths in health care were compared to a major commercial airline, it would be like having one 747 crash from a major airplane crash per day every day of the year.

It is not always the fault of the always the fault of the physicians that these errors occur. Overcrowding in emergency departments across the US is already an increasing problem in the US. Emergency department physicians must now additionally contend with fatigue in increasingly interrupt driven environments. Strong data exists showing very strong, linear correlations of both fatigue and interruptions with chances of committing medical errors.

While interruptions and fatigue are more difficult to remedy, I propose cognitive load as a third factor which can more easily remedied given the right resources. What if, right at discharge, the clinician can be reminded of a patient's allergies? What if decision support could be provided for

certain diagnosis given the right set of labs and order? What if pathways existed upon discharge to enforce standard of care? These are but a few of virtually infinite examples of how electronic frameworks can assist clinicians in making better decisions for patient care.

In this project I seek to investigate errors in the emergency department. The project is divided into three distinct parts

I. Literature Review: Adverse Events at the Time of Discharge

II. Elderly Patients with Potentially Adverse Drug Events in the Adult Emergency Dept

III. Vanderbilt Discharge Writer: An integrated framework for discharge of patients from the ED.

In Section I, we perform an exhaustive literature search to report on adverse events involving direct care from the emergency department. In it we review some 3,500 abstracts to determine what adverse events are most reported in literature, what process(es) they involve, and tabulate on the demographics cited. We seek to answer the question of what are the most common factors leading up to errors in the Emergency Department.

In Section II, we perform and report on an electronic retrospective chart review. Using the Beers List of potentially inappropriate medications in the elderly, we evaluated the appropriateness of medications prescribed to the geriatric population, both in the community and in our own emergency department.

In Section III, we describe the creation, implementation, and adoption of an entire electronic ED Discharge framework based on work done section I and II of this project. We outline the motivation behind the design of such an interface at our institution. We report on its integration with the entire electronic data infrastructure at the hospital. We conclude with a status report on its adoption rate as well as future directions that may be taken with this new platform.

CHAPTER II

ADVERSE EVENTS AT THE TIME OF DISCHARGE:

A SYSTEMATIC LITERATURE REVIEW

Introduction

Medical errors harm 1.5 million patients annually[1]. Estimates from the Institute of Medicine 2006 report says these errors cost $3.5 billion annually. These conservative estimates concern the inpatient population. They do not even include ambulatory patient population nor the ED. One can only imagine what the actual costs are of medical errors are.

The emergency department remains one of the most vulnerable environments for medical errors. Staffing shortages, ED overcrowding, episodic care, and unreliable patient histories are all reasons cited by current literature as contributing factors to medical errors in the ED. The crisis only worsens with time.

Much has been written regarding ED patient outcomes. These include malpractice statics, QA/QI studies, and diagnosis specific outcome studies, etc... These help document the final outcomes of a broken system but fails to illuminate why these errors occur. In other words, what are the processes leading up to these errors?

According the "Swiss Cheese Model" of human errors, any system can be thought of as having multiple layers of defenses against errors. The layers are imperfect. Errors occur when the faults within these layers coincide to allow "a trajectory of accident opportunity". The emergency department is no exception. It is a complex system with many layers of imperfect defenses against errors. For instance, order of magnitude dosing errors occur when poor clinician handwriting combines with lack of drug dose checking in the hospital pharmacy and lack of nursing oversight.

In this systematic literature review, we chose to study the ED discharge process because we believe it to be the focal point of ED care because all processes in the ED culminate in the discharge process. It is the last check point before the patient leaves the hospital.

Methods

We focused on original research studies that described the clinical outcomes of medical errors that could be identified at the time of discharge among adult ED patients. We considered studies where the ED provider was involved in the process. We excluded articles comparing skill sets between clinicians and specialists, and studies that focused on unusual case presentations with a prevalence of fewer than ten cases annually. We excluded editorials, reviews, abstracts, case reports, letters, or legal briefs.

Literature Search

We searched PUBMED® MEDLINE® for articles between 1966 and Feb 28, 2007 using keywords and MeSH® terms. The query included two broad search concepts, "emergency medicine" and "medical error," which were represented with the following terms:

(1) *Emergency medicine:* "emergency medical services"[MeSH] OR "emergency medicine"[MeSH] OR "emergency department" OR "emergency service"

(2) *Medical error:* "fatal outcome"[MeSH] OR "medical errors"[MeSH] OR "Liability, Legal" [MeSH] OR "malpractice" [MeSH] OR "error" OR "legal"

The two search concepts were combined with a Boolean AND. Studies were limited to publication in English language.

Review of Studies

The review included two phases. In the first phase two reviewers examined independently whether the title and abstract of citations returned by the MEDLINE query met inclusion criteria. Disagreements among the two reviewers were resolved through consensus discussion. An abstract that was deemed not to provide sufficient information to allow resolution during the consensus discussion, was retained for further consideration. In phase two, the full text of considered studies were retrieved. The two reviewers independently examined the full text information and studies that did not meet the eligibility criteria were excluded from further consideration. Disagreements between the reviewers were again resolved by consensus discussion. References within the included articles were reviewed to identify additional studies.

Study Analysis

Descriptive information collected from the articles included the time and duration of the study, setting, annual ED patient volume, sample size, and study location (urban, rural, suburban). Methodological

aspects collected from the studies included the study design, the sampling methodology, the primary outcome, description of intervention, and availability of a control group, if applicable.

To characterize the studies we categorized each article according to two axes: 1) the examined ED process and 2) the type of adverse event. Criteria to categorize the examined ED process were adapted from a previous study and include test ordering, test interpretation, process associated with establishing a general diagnosis, medications within the ED, therapeutic intervention, disposition process (e.g., follow-ups or lack thereof; patient education), poor documentation, communication, patient examination, prescription writing, and other. Criteria to classify the type of adverse events included patient complaint, return visits, malpractice, death, and other. A study may have examined multiple criteria of ED processes or adverse events; thus, the criteria were mutually non-exclusive.

Each reviewer independently abstracted the descriptive, methodological, and study characterization information from the full text articles using a data abstraction form. Disagreements among the reviewers were resolved during consensus discussions.

Results

The PUBMED query returned 3,557 abstracts, from which the full text of 36 articles were retrieved (Table 1). From the bibliographies of the 36 articles we identified two more potentially relevant articles from the bibliography and pulled the full text of these articles also for review. Upon reviewing the full texts of the articles, three articles did not meet inclusion criteria. This left us with a final list of 35 articles(Figure 1).

The most frequent study environment was a single center, urban, academic setting. Twenty one articles were single center studies and fourteen articles involved multi-center studies. Twelve studies took place in urban settings. One took place in suburban setting. One took place in rural setting. One took place in urban and suburban setting. One study took place in urban and rural settings. Two studies took place in all settings - urban, suburban, and rural. Seventeen articles failed to specify setting. In terms of academic affiliation, 11 studies took place solely in academic settings. Four studies took place in university affiliated settings. One study took place in both academic and university settings. Four studies took place in both academic and nonacademic settings. One study took place in all three settings(academic, university affiliated, nonacademic). Fourteen articles failed to mention academic affiliation.

Twenty eight articles applied a retrospective study design and seven applied a prospective one.

In terms of ED processes involved in errors leading to ED discharge, no one process stood out. Among the most frequent processes cited responsible for errors in the ED were general diagnosis (18 articles), test interpretation (16 articles), and therapeutic intervention (15 articles). In contrast, inter-personnel communication (8 articles), test ordering (11 articles), and patient education (6 articles) accounted for lower frequency of processes cited as leading to ED errors.

In terms of adverse outcomes(figure 3), 14 articles cited death, 10 articles studied malpractice, 16 articles focused on return visits / hospital admission, and 3 articles spoke of patient complaints. Fourteen articles did not fit the above categorizations or did not focus specifically on any of the above adverse outcomes.

Cross tabulation of processes cited to adverse events cited is shown in figure 2. Little pattern emerged other than "general diagnosis/judgment call", "test interpretation" and "therapeutic intervention" consistently being in the top three to four categories associated with worst outcomes death and malpractice.

Discussion

Review of current research literature on ED errors showed a significant bias towards studies that are academic, urban, single center, and retrospective. Ironically, most emergency health care in the US is provided in nonacademic EDs in rural areas. More research need be conducted in nonacademic, rural EDs. The retrospective nature of the majority of the research literature on ED errors is also sub-optimal. Such studies may associate alleged processes with predefined outcomes, but are weak in establishing a cause-and-effect relationship between the two. For example, if IV sedation is associated with four-fold increase in death rates in the ED, it does NOT imply that IV sedation is harmful. Rather, sicker patients requiring sedation have worse outcomes, and IV sedation is but a confounder. More prospective, randomized, blinded studies need be done that establish a firm cause-and-effect relationships between specific processes and outcomes in the ED.

James Reason, in his landmark 1990 book "Human Error" spoke of the "Swiss Cheese Model" for medical errors. Before errors and associated harm can occur, multiple process faults must line up in order for errors to occur. For example, in order for a patient to accidently receive a medication that he is allergic to, the triage nurse must forget to document the allergies in the chart, the physician must write for it, and the pharmacist must forget to check for it on the computer before dispensing it to the patient. The ED is no exception. Errors in the emergency room involve multiple processes. In a recent article studying

liability claim from 4 different liability insurers covering emergency room physician, Kachelia et al mention the median number of process breakdowns and factors contributing to ED errors is two.

One application of this knowledge may be to implement an ED "exit check" system to catch process problems before patient gets discharged. Such a system would have to be comprehensive, minimally intrusive to work-flow, and demonstrate a return on investment. Integration of such an advisor with an electronic health record physician order entry in the emergency room would be ideal. Again, implementation of such a model is missing in current literature.

Limitations of systematic literature review

This literature review does have some inherent limitations. Searches were done solely in PubMed. New articles are coming out that may answer some of the questions posed above. The search terms used in PubMed was a complex one. The classification of processes leading to ED was somewhat arbitrary. Lastly, publication bias tends to favor the more severe outcomes and most of the valuable insights may lie in unpublished root-cause-analysis being discussed privately within individual hospitals.

Table 1: Results of Literature Review

Article Demographics				Study Settings and Characteristics								
Ref Num	1st Author	Dur	Primary outcome	Loc	Acad	Sample Size	Age	ED Vol.	# Ctr	Control	Sampling	Perspective
5	Forster	ns	phone interview: adverse event = worsening or new sx, revisit to ED, readmitted to hospital, or died	u	ac	2288	>18 y	55000	s	cc	conv	prosp
32	Sklar	10y	rate of unanticipated death in patient discharge from ED within 7 days	u	ac	117	>10 y	71594	s	na	consec	retro
14	Kachalia	22y	tabulation of system process breakdowns leading to closed malpractice claims	ns	ac, nac	122	all	ns	m	cc	random	retro
24	Nunez	ns	unscheduled returns, post-ED distination, patient dissatisfaction	ns	ac	500	>14 y	115000	s	cc	consec	retro
11	Hallas	2y	Characterize diurnal variation in error of diagnosis of fractures	ns	uaf	1323	ns	ns	s	cc	consec	retro
24	Masoudi	2y	Failure to identify high risk ECG findings	ns	ns	1684	ns	ns	m	na	consec	retro
34	White	5y	Role assigned code for alleged problems of care	u	ac	74	all	60000	s	na	consec	retro
3	Elshove-Bolk	8y	categorization of errors leading to malpractice claims	ns	ac, nac	256	ns	ns	m	na	consec	retro
6	Gaddis.	ns	drug interactions	u	ac	200	all	26500	s	na	conv	retro
35	Wolff.	2y	adverse event post ED visit, both pre and post intervention	r	ns	20050	ns	9000	s	ncc	consec	retro
1	Bizovi	<=1y	prescription writing errors	u	ac	3920	ns	45000	s	ncc	consec	retro

Table 1: Results of Literature Review (Continued)

9	Guly	4y	diagnostic errors	u	ns	953	ns	ns	s	na	consec	retro
28	Pope	ns	rate of MI in patients mistakenly discharged from ED	u, su, r	ac, uaf	1855	≥30	ns	m	na	conv	prosp
4	Espinosa	6y	Rate of radiograph interpretatioun errors in ED by ED Clinician	ns	ns	115508	ns	ns	s	na	consec	retro
2	Chin.	<=1y	Inappropriate Medications found in and ED: Inappropriate, drug disease interactions, written in ED, not written in ED	u	ac	898	≥65y	ns	s	na	conv	prosp
22	Liaw	<=1y	Characterization of revisits within 72h of ED discharge	u	ac	485	adult	100000	s	na	random	retro
10	Gwynne	ns	malpractice claims	ns	ns	105	all	ns	m	na	consec	retro
13	Hulbert	3y	Malpractice	ns	ns	32	ns	200000	m	na	consec	retro
7	Goh	ns	Return to ED	ns	ns	166	3-67y	80000	s	na	consec	retro
18	Khan.	ns	unrecognised but remediable problems in patient discharged from A&E department	u	ns	97	>80 y	ns	s	na	conv	prosp
8	Goldberg	ns	frequency and nature of existing moderate adverse drug interactions in incoming ED patient population	u, su	ac, nac	205	ns	190000	m	na	random	retro
31	Rusnak	7y	misdiagnosis leading to claims	ns	ns	132	1-66y	ns	m	cc	consec	Retro
17	Kelly	ns	physician error types causing patient revisits	u	ac	206	all	55000	s	na	consec	retro

Table 1: Results of Literature Review (Continued)

15	Karcz	2y	cause of claims, cost, preventability	ns	ns	199	ns	ns	m	na	consec	retro
23	McCarthy	2y	missed MI in EDs	u, su, r	ac, uaf, nac	1050	>30	ns	m	ncc	conv	retro
12	Hu	<=1y	factors associated with revisit rate (4.9%)	u	uaf	1099	ns	92126	s	na	consec	retro
26	O'Dwyer	ns	unsched return to ED	ns	ns	235	all	ns	s	na	consec	retro
27	Pierce	ns	characterization of frequencies and reasons for return visits to ED within 48 hours	ns	uaf	569	adult	65000	s	na	consec	retro
30	Rusnak	4y	process: other: various aspects	ns	ns	65	ns	ns	m	cc	consec	retro
16	Keith	ns	Frequency and Nature of ED revisits within 72 h	su	ac	407	ns	ns	s	na	consec	retro
9	Richmond	2y	patient complaint & malpractice claims	ns	uaf	72	all	99200	m	na	consec	retro
20	Lee	8y	AMI sent home from ED	u, r	ac, nac	140	≥ 25 y	ns	m	cc	conv	prosp
21	Lerman	<=1y	frequency and nature of patient revisits to the ED within 72h of original visit	ns	ns	255	ns	ns	s	na	consec	retro
33	Trautlein	4y	causes of substandard care	ns	ns	200	ns	ns	m	na	consec	retro

Legend

Location(Loc): u=urban, su=suburban, r=rural, ns=not stated
Academic Affiliation(Acad): ac=academic, nac=nonacademic, uaf=university affiliated, ns=not stated
Number of Centers(# Ctr): s=single, m=multiple
Location(Loc): u=urban, su=suburban, r=rural, ns=not stated
Controls(Ctrl): cc=concurrent, ncc=nonconcurrent, na=not available or stated
Sampling: conv = convenience sample, consec = consecutive sampling Perspective: prosp = prospective, retro = retrospective

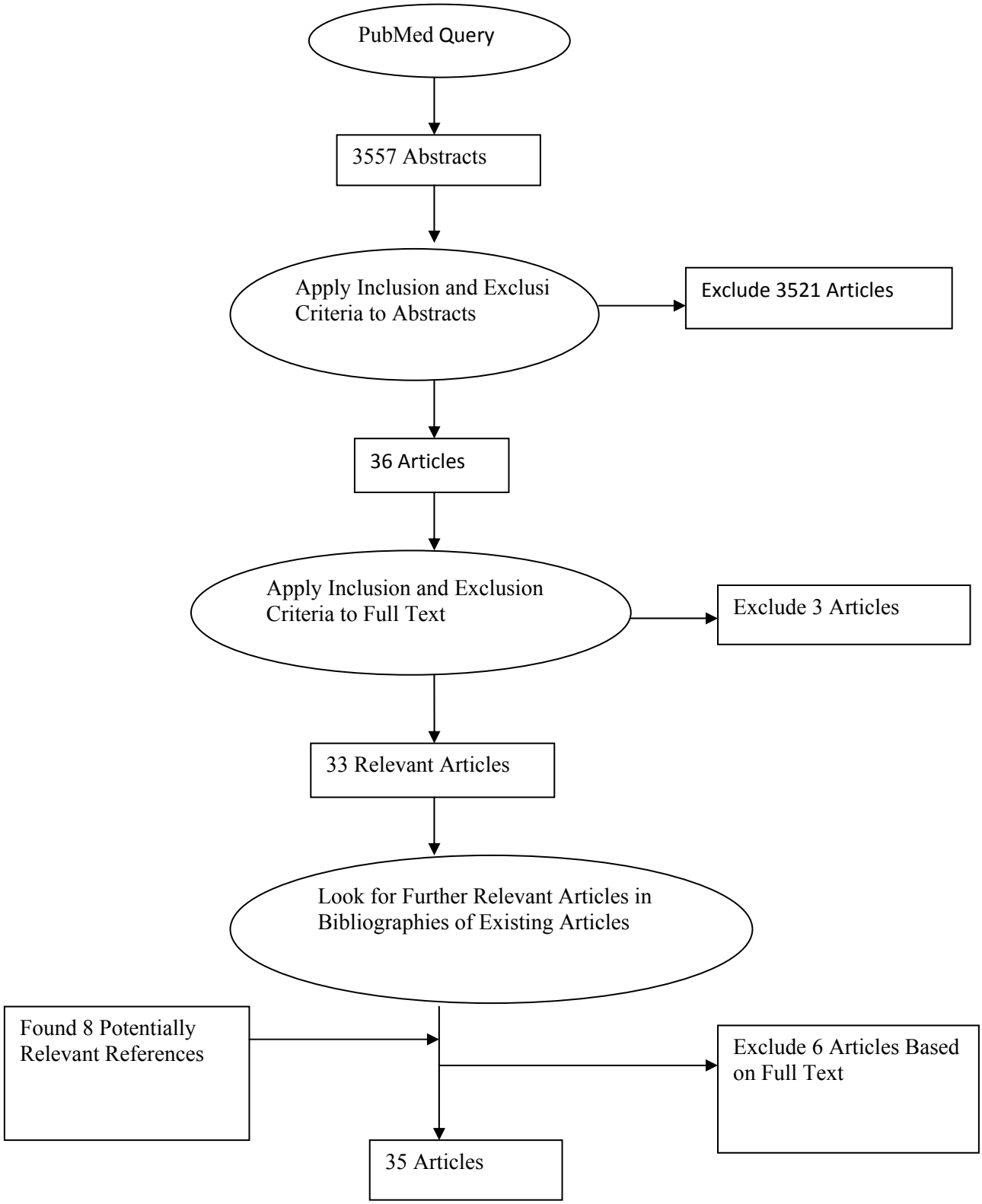

Figure 1: Literature Review Article Selection Schema

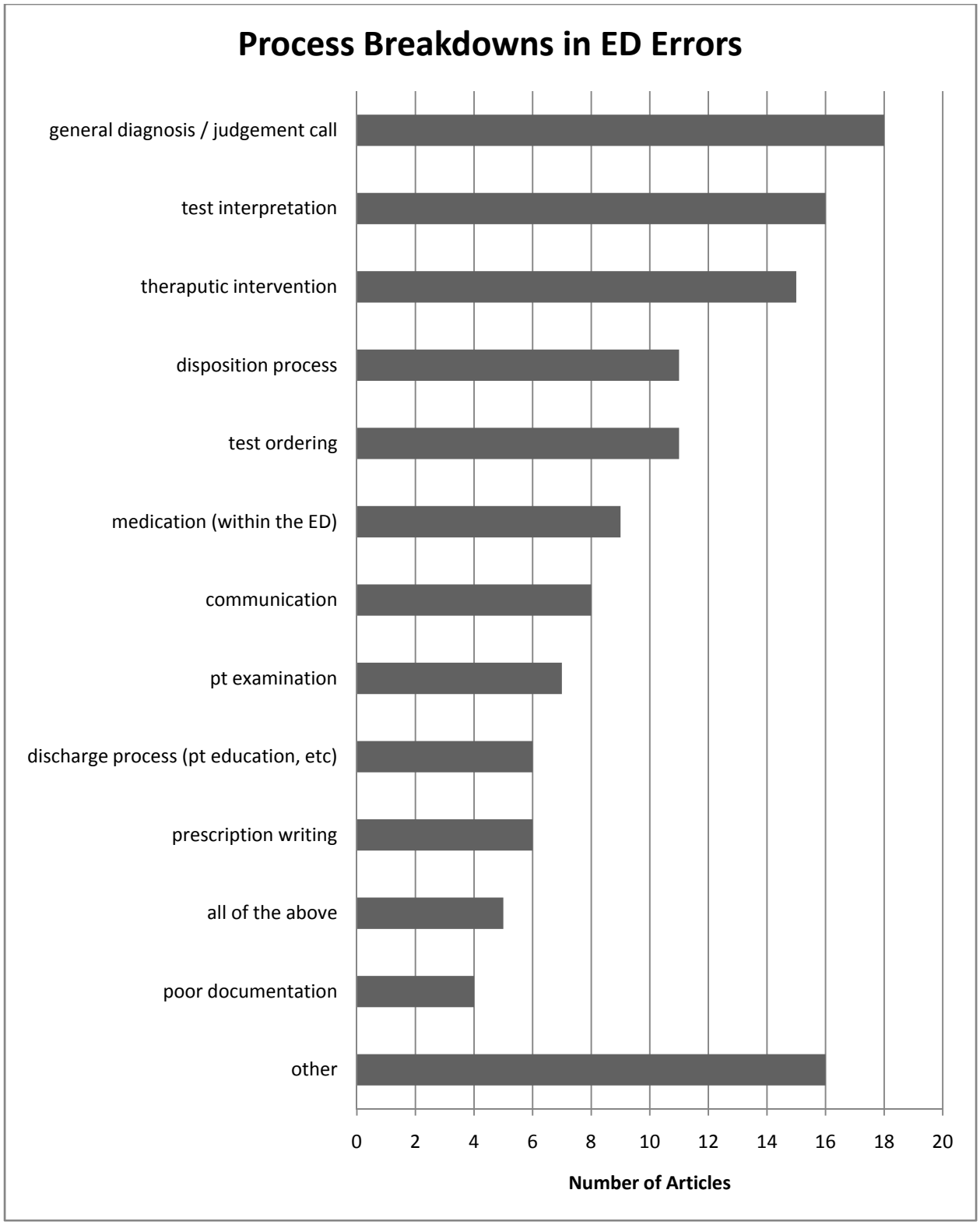

Figure 2: Processes and Adverse Events

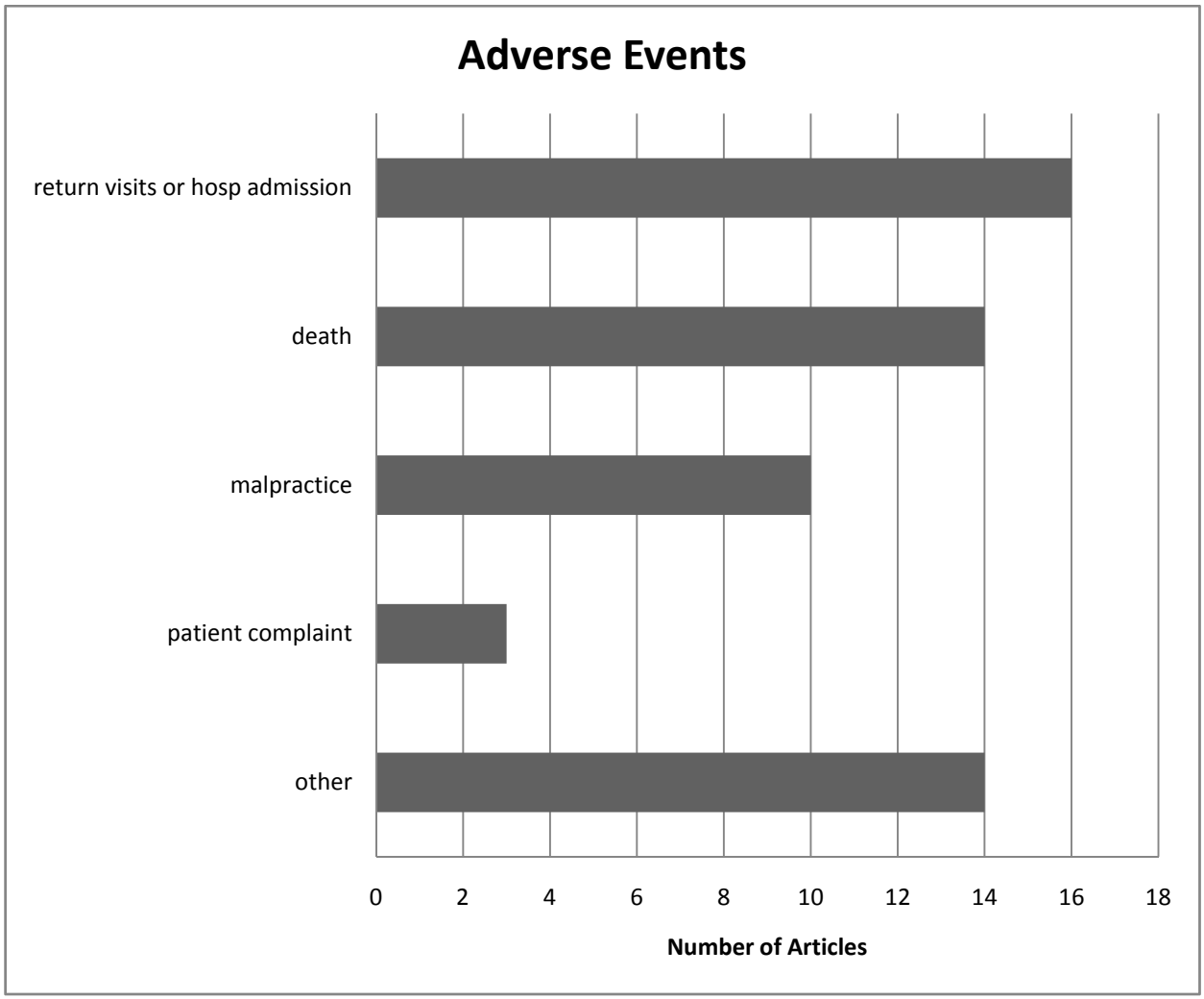

Figure 3: Adverse Events

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CHAPTER III

EVALUATION OF POTENTIALLY INAPPROPRIATE GERIATRIC PRESCRIBINGH PRACTICES IN A TERTIARY CARE ACADEMIC EMERGENCY DEPARTMENT

Introduction

Geriatric populations present a particular challenge to the practice of medicine. Older patients tend to live with more chronic diseases, each of which can require treatment with medications, potentially resulting in adverse side effects from medication-medication interactions. In addition, changes in physiology and cognitive capacity that occur in elderly populations can exacerbate known prevalent side effects as well as causing adverse events specific only to this population. [1]

As a result of these issues, an expert consensus panel of geriatricians developed a guideline in 1994 recommending medications to avoid in the elderly.[2][3] This guideline, coined the Beer's List, was initially developed for patients older than 65 years living in nursing homes. In 2003, it was expanded to include diseases-drug interactions and include as well those living outside of nursing homes(Table 2).[4] The Beers criteria is the gold standard guideline for the avoidance of medications that can potentially cause significant adverse events among the elderly population.

There have been a number of studies that have studied the prevalence of age-drug interactions in the outpatient clinic population. However, to our knowledge, there have been no studies that have evaluated either the prevalence of pre-existing PIMs or the emergency department(ED) prescribing incidence rates among Beers criteria medications in a geriatric population A substantial proportion of ambulatory care is provided by the ED, and such care is administered by clinicians frequently under significant time pressures and that are previously unfamiliar with the patient[6][7].

In this study, we sought to determine both the prevalence of potentially inappropriate medication use of patients presenting to a tertiary care, academic emergency department as well as the incidence of new PIM prescribing among ED physicians.

Methods

Study Setting

This study was performed in the Emergency Department of Vanderbilt University Medical Center Emergency Department in Nashville, TN. An electronic whiteboard was installed in 2002 that tracks patient demographics as well as interfaces with the ED computerized physician order entry system. Patient medications were collected by two methods. First, patient self-reported pre-existing medications were collected by an electronic tool called the Pre-Admission Medication List (PAML). ED prescription writing was performed by Discharge 1-2-3 (insert version number, and city/state of company origin), which is a vendor computerized order entry application for ED discharge that also generates discharge instructions (Figure 4). All prescriptions from this application were logged into a database.

Patient Sample

All patients aged 65 or greater that presented to the adult Emergency Department from January 1st, 2007 to December 31st, 2008 and subsequently discharged directly to home from the ED were candidates for inclusion in this study. Patients of interest were those in whom discharge medication prescribing was the responsibility of an ED physician. For this reason, patients were excluded from the study if they were admitted to the hospital but continued to be boarded in the ED, if they left the ED against medical advice, or if they left the ED after being triaged but before being seen by an ED physician.

Data Collection

Patient workflow while in the ED is shown in Figure 1. Patient cases were identified by applying the following criteria to the Vanderbilt ED Whiteboard database:

- Age ≥ 65 at time of discharge from Vanderbilt Adult ED
- Discharge Date between 1/1/2007 and 12/31/2008 (inclusive)
- Patient discharged directly home from ED (did not get admitted into inpatient service)

All self reported pre-existing patient medications were collected from the PAML's application program interface (API) using the PERL scripting language(version 5.1.0). The free text medication lists were then spell checked for misspellings with open source GNU ASPELL (version 0.60.6). The reference vocabularies that were used with ASPELL included the standard American English vocabulary and a

dictionary using the FirstDataBank (Hearst Corp, San Francisco, CA) lexicon, which included generic and proprietary drug names of all medications on the market in the United States. All relevant PAML records during the study period were linked to patient case information through the use of their medical record number.

The MS SQL database populated by the Discharge 1 2 3 application was queried for all prescribed medications matching each patient's medical record number during the study period. No spell checking was required because Discharge 1-2-3 had a controlled drug vocabulary to begin with.

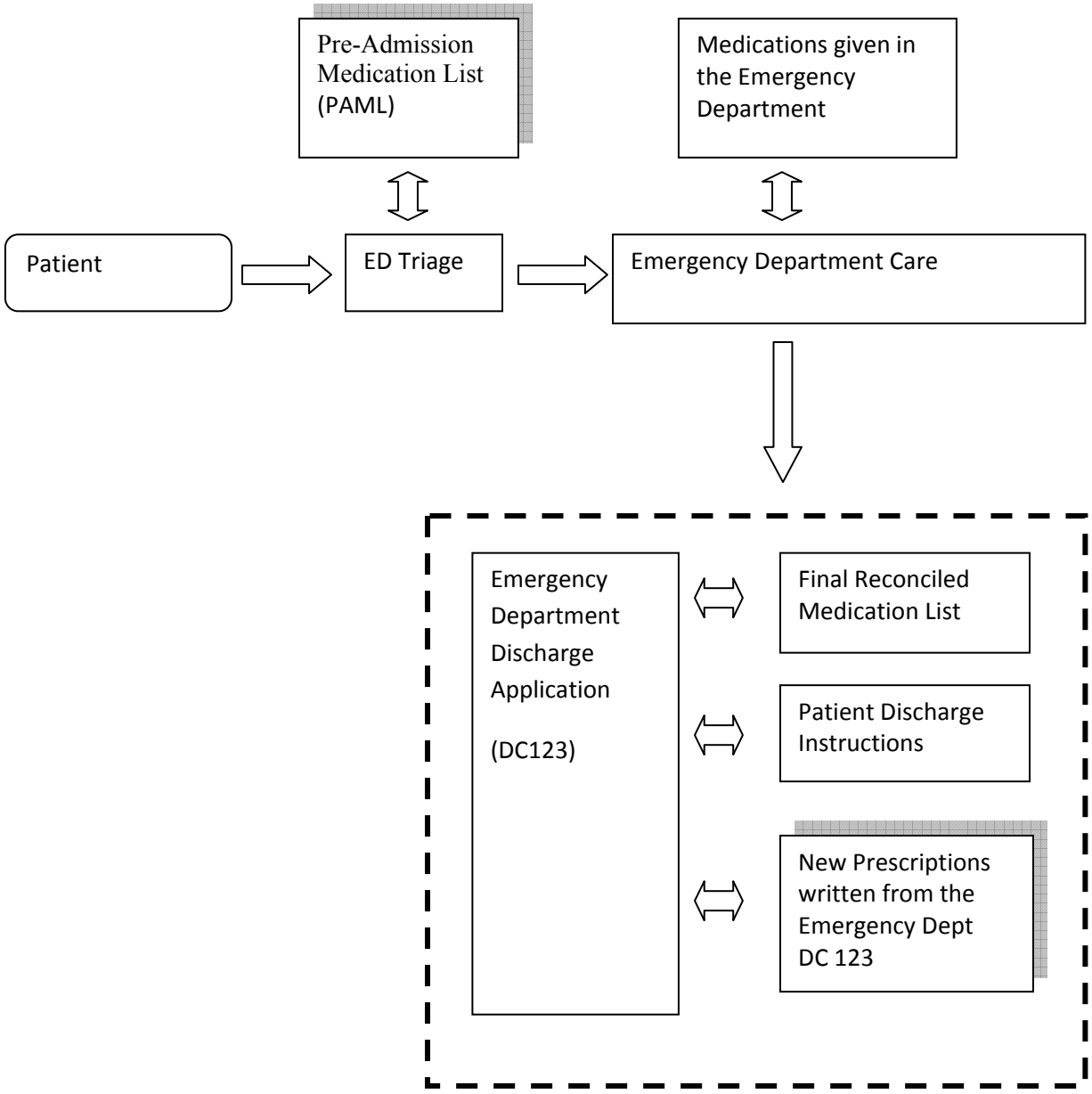

Figure 4: Patient Workflow Through the Vanderbilt Emergency Department

Results

The Discharge 1-2-3 Medication Database query revealed that 2485 out of 5430 cases in the same above time period received at least one script written from the Vanderbilt Adult ED. Of these, 80 (80/2435 = 3.2%) cases resulted in having one or more beers list medication(s) being given upon discharge. These medications did not have to be spell checked. A categorization of the beers medications from the 80 cases is shown in table 4.

Per our Emergency Department Whiteboard census, 5430 cases walked through the Vanderbilt Department of Emergency Medicine between 1/1/2007and 1/1/2009 and was directly discharged home, either alone or driven home by someone. Of these patients, 3901 patient were able to provide a pre-admission medication list. Of these, 357 (357/3901 = 9.15%) patients had at least one Beer Medication on their list. The medications were categorized into respective pharmacologic categories and shown in figure 3. Top Beers List medication matches on the pre-existing medication list included benzodiazepines(95/357), antihypertensives (54/357), muscle relaxants / antispasmodics (32/357), antiemetics (25/357), antihistamines (21/357), miscellaneous (21/357), NSAIDs (20/357), laxatives (14/357). A summary of the above is listed in table 3.

Table 2: Summary of 2002 Beers Criteria of Inappropriate Medications Regardless of Condition

Common Beers List Medications considered potentially inappropriate regardless of disease or condition (partial list)	
Narcotics: Darvocet, Demerol, Talwin **Benzodiazepines:** Ativan, Serax, Xanax, Restoril, Halcion, Librium, Valium, Librax **Antihistamines / Hypnotics:** Elavil, Doxepin Milltown **NSAIDS:** Indomethacin, Toradol **Antihypertensive:** Doxazosin, Procardia, Adalat, Clonidine	**Muscle Relaxants:** Skelaxin, Soma, Robaxin, Flexeril **Antiarrythmics:** Digoxin, Persantine, Disopyramide, Amiodarone **Anticlotting agents:** Ticlopidine **Antispasmodic drugs:** Bentyl, Levsin, Donnotal, Librax **All barbiturates** (except when used to control seizures)

Analysis

Both the pre-existing medication and discharge medication lists were evaluated to determine whether they contained any medications that were considered inappropriate regardless of condition (Table 3, Table 4) based on 2002 Beers Criteria. This was performed by a PERL regular expression matching algorithm based upon the known standardized generic and trade medication names in the FirstDataBank. The beers medications were then summarized by category and saved to a database.

Table 3: Pre-Admission Medication List Matches, Sorted by Pharmacologic Categories

Pre-Admission Medication List Beer List Matches, sorted by pharmacologic categories
n = 3901 matches = 351 (351/3901 = 9.0%)

96 : benzodiazepines
- 30 alprazolam
- 19 lorazepam
- 18 diazepam
- 8 temazepam
- 7 chlordiazepoxide
- 4 flurazepam
- 4 quazepam
- 3 clorazepate
- 2 halazepam
- 1 meprobamate

54 : antihypertensive
- 22 clonidine
- 15 nifedipine
- 12 doxazosin
- 2 methyldopa-hctz
- 2 guanethidine
- 1 methyldopa

32 : muscle_relaxant
- 11 cyclobenzaprine
- 7 hyoscyamine
- 6 carisoprodol
- 4 methocarbamol
- 4 metaxalone

25 : anti_emetic
- 25 promethazine

21 : antidepressant
- 15 amitriptyline
- 6 fluoxetine

21 : antihistamine
- 13 diphenhydramine
- 8 hydroxyzine

20 : NSAIDs
- 15 naproxen
- 2 ketorolac
- 2 pentazocine
- 1 oxaprozin

15 : miscllaneous
- 15 ferrous sulfate

14 : laxative
- 13 bisacodyl
- 1 belladonna

12 : cardiac
- 12 digoxin

10 : bowel antispasmodic
- 9 dicyclomine
- 1 clidinium

7 : anticholinergic
- 7 oxybutynin

7 : antiarrythmic
- 7 amiodarone

7 : antibiotic
- 7 nitrofurantoin

5 : narcotic
- 4 propoxyphene
- 1 meperidine

3 : hypnotic
- 3 doxepin

1 : H2_blocker
- 1 cimetidine

1 : anticoagulant
- 1 dipyridamole

Table 4: Discharge 1-2-3 Medication List Matches, Sorted by Pharmacologic Categories

Discharge 1-2-3 (ED Prescribed) Beer List Matches, sorted by pharmacologic categories n = 2485 matches = 80 (80/2485 = 3.2%) 2855 patients did not have any meds prescribed at all		
63 : benzodiazepines 39 diazepam 15 lorazepam 9 alprazolam 6 : muscle relaxant 3 metaxalone 3 carisoprodol	3 : antidepressant 3 amitriptyline 3 : nsaid 2 indomethacin 1 ketorolac 2 : narcotic 2 propoxyphene	2 : antihypertensive 1 nifedipine 1 clonidine 2 : anticholinergic 2 oxybutynin 1 : antihistamine 1 diphenhydramine

Discussion

Comparing and contrasting the pre-existing medication list(PAML) and the discharge prescription list (DC123) gives us quite a few insights. Benzodiazepines appear to be the biggest offender on both lists. The incidence of potentially inappropriate beers list medications appears at twice the frequency in the community than in the Adult ED. Not surprisingly, there were as well many more types of medications potentially miswritten in the community as opposed to those written from the adult emergency department where benzodiazepines were by far the predominant miswritten medications.

Another interesting contrast is that the frequency we report for the community (9%) appears much lower than that found in the literature in the general outpatient community. While the reasons are not completely clear, it is possible that other literature either different population, different methods (including more than just table 1 of Beers List criteria), or different incarnation of beers criteria (ie 1994 version). The first explanation may be most plausible. It would be interesting to study the difference in

demographics of those patients showing up in the ED as opposed to those that never do. This would shed some light on the discrepancy between our results and those of others.

There were a number of limitations in this study. Though we were able to adjust for indication based dosing on the discharge medications and cross off those meds appropriately used, we were not completely able to do so with PAML. Most of the time, the lists were found to contain a medication but the patient was unable to provide us with any information as to what it was being taken for. Secondly, due to free text nature of PAML, it often is lacking in complete prescriptions descriptions ("ferrous sulfate" as opposed to "ferrous sulfate 325mg po tid"). For certain beer list criteria, this limitation makes it difficult to determine if a medication was misprescribed or not on the bases of either dose or indication.

Finally, we have recently replaced the vendor based ED discharge solution with a comprehensive internally developed electronic tool. The vendor based solution suffers from lack of integration. As a stand alone application, the user has to remember patients' medications and problem lists while writing new prescriptions. This system has been designed to have the medications and problem list visible at all times, and to generate a pop up reminder and/or passive reminder when the user prescribes a Beers list medication. This system will undergo a prospective, randomized trial in order to determine whether it can decrease the incidence and prevalence of Beers criteria medication usage in the geriatric population seen in the ED.

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CHAPTER IV

AN INTEGRATED FRAMEWORK FOR THE DISCHARGE OF PATIENTS FROM THE ADULT EMERGENCY DEPT

Introduction

The Emergency Department(ED) is one of the most challenging places to practice medicine. Physicians in the ED take care of multiple patients, typically of high acuity, while working with little or no information in regards to past medical history. Couple this with overcrowding as seen in most EDs[1] and it becomes easy to see why medical errors can occur.

A recent literature search revealed that medical errors tend to follow the so-called "Swiss-cheese" model[5] , and that on average two to five processes must fail concurrently for an adverse patient event to occur (see Chapter I). Fortunately, most errors occurring in one process are typically caught by another process. For instance, a physician writes an order for patient B to receive penicillin. However, he really meant for patient A to receive the penicillin, and in fact patient B has an allergy to penicillin. The astute nurse draws up the penicillin, but right before administering the penicillin notes the patient's arm band alerting her to a penicillin allergy. She stops herself seconds from pushing the penicillin through the IV. Had the nurse not been as astute, the patient would have suffered an adverse event. In this instance, two processes needed to concurrently fail before an adverse event happens.

The ED is full of such intertwined systems operating as checks and balances against medical errors. Example include allergy lists, automatic pharmacy dose checking, pre-existing medication lists, etc...

Unfortunately, far too often these nuggets of information tend to be scattered among multiple, disparate silos that do not talk to one another. Physicians still are required to rely a large part on their memory to prevent medical errors despite these technologies and/or processes.

Such is the case at Vanderbilt. We have an electronic triage system which captures the patient's pre-existing medication list, allergies, and chief complaint along with his/her demographics info. We have a fully functional order entry system, a home grown EMR, and even a vendor based discharge template system for writing prescriptions and patient instructions (Figure 5). The EMR and the order entry system were both developed in house and, to a limited extent, interface with each other. However, the discharge system knows nothing of the patient's EMR nor the orders written in the order entry system. Should there be an incidental finding in the ED that require follow-up but does not require hospitalization, the onus is on the clinician's memory to manually type it into the discharge application. The same goes with allergies and medications prescribed using the discharge program. The current system provides no safeguards against prescribing outpatient medications that the patient may be allergic to.

We believe the discharge process to be the focal point for preventing errors in the ED[2][3]. It is the logical place where all processes in the ED tie together. It can, and in fact should, serve as the final check point before the patient leaves the ED and care is transitioned to the outpatient arena[3][4] (Figure 6). For instance, JCAHO requires that medication lists be reconciled at the time of discharge. ED Clinicians should be required to review all orders done in the ED as well as lab results prior to discharging the patient. Unfortunately, the current vendor based solution not only lacks such functionality, it actively

promotes errors because licensing agreement forbids it from being installed accross the LAN - it must be installed on a stand alone workstation.

This paper documents the process by which we developed a solution that successfully replaces a vendor based solution with an in house solution for patient discharge. It ties together all aspects of patient care - medication lists, problem lists, allergy lists, lab results, orders, prescription writing, patient instructions, and discharge planning - into one comprehensive web based program. In this paper we document our objectives for such a system, the process by which we architected the system, how we rolled out the system, and present a status report as to current functionality of the system. We conclude by mentioning the future directions we hope to take with such a system.

Design Objectives

Build upon well established GUI conventions of the web

One of the greatest barriers to adoption is poor user interface design. Back in the days of desktop applications being predominant (as opposed to web applications), many different user interfaces exist which resulted in many different user interface designs with little consistence between them. The current vendor based discharge solution in the Emergency Department was no exception. Input boxes seemed randomly placed on different parts of the screen. Login screen required the use of the mouse to click on large on screen numeric keypad. Tabs of content were intertwined with buttons on the right side of the screen which created new pop-up windows. The list goes on and on.

In our application we seek to design a user interface based on well established web interface heuristics. Navigation between different parts of the application should occur using a top navigation bar / tab or left hand sided navigation pane. Content should be formatted in predictable columns, usually two but definitely no more than three. Text areas for querying should always be located on the top or left hand side of content pane. Blue, underlined words indicate hyperlinks to content.

Accessibility

The emergency department is a place where space is at a premium. Due to restrictive licensing agreements, the current solution requires a completely separate workstation on which to run the discharge program. Current software licensing was a function of number of workstations the application was installed on and prohibited installation of the program across the LAN. This required six additional computers to be placed in the adult ED. Often the user is left with the unpleasant task of not only documenting on the regular computers, but also re-logging in physically on a different machine to do discharge documentation on a different computer. We seek to remove this limitation in our application and make it run-able from any computer attached to our intranet.

Integrate information between disparate information resources

Given the high cognitive workload in an interrupt driven environment, the chances of clinician error is high given reliance on memory. In our application we integrate fully with the EMR, the CPOE, the patient's self reported medication list, the prescription writer, and the patient instructions. Information from disparate resources are all integrated into ONE consistent display within ONE application. Reliance of memory is minimized using this approach.

Serve as a platform for decision support

One of the virtues of having a in-house solution is having the ability to modify the code at will to suit one's purposes. As an academic institution, it is our interest to enhance patient safety via real time decision support. As such, the code is written in well documented open source languages built upon well documented open source database technologies. The optimal discharge program would then be extensible by user written plug-ins that provide decision support a multiple points during the discharge.

Foster Research

Current vendor system does a poor job at fostering research. The only communication between the vendor application and our EMR is the PDF file that gets generated when the application. And even though a database does exist in the application itself, it is of such poor granularity that research requires the users to have extensive ability to parse text. In our application we seek to output the data in our EMR's native format and in addition save to a fully relational database to facilitate standard SQL based queries and does not require any additional text parsing to extract meaningful data.

Facilitate Transition of Care

One of the greatest weaknesses of the current system is the inability to automatically relay the relevant patient information to the next provider apart from using the fax machine to fax the paper copy of the discharge documents. Optimal care of the patient requires good coordination between the ED clinicians, nurses, case managers, and follow up physicians[4]. The optimal discharge application would be able to electronically relay the structured pieces of information between the care providers.

System Description

Architecture

The system is built upon a standard MVC paradigm, which stands for “Model”, “View”, “Control”. It is a well established, three tiered software engineering concept which seeks to isolate the data (the “Model”) from the code that manages the business logic (the “Control”), and to isolate the from the latter from the code that deals with data display and user interface (the “View”). This separation of code is pivotal for manageability and extensibility especially once the code base becomes sufficiently large.

Whereas many vendors choose to use one single language in which to implement the MVC paradigm, we used multiple languages to capitalize on the inherent strengths of the respective languages.

For the “Model”, we used Microsoft SQL to deal with the patient instruction database, MySQL to deal with the EMR database, and Oracle SQL to deal with the enterprise prescription drug and formulary database. Fortunately, all these databases were SQL variants and utilized virtually identical SQL syntax.

For the “Control”, we used PERL 5 as the language of choice to implement the business logic. It is extremely well documented on the web, is the same language used by our EMR, and is extremely succinct due to advanced language features like closures, dynamic typing, and ability to have nested hashes. It also has many powerful pre-built modules on the web (Comprehensive Perl Archive Network) which further cuts down on coding and documentation. Furthermore, these libraries already include extensive support for connectivity to the aforementioned databases.

For the “View”, we utilized JavaScript, HTML, and CSS to properly render on the web browser. We made use of jQuery, which is a succinct, Ruby-like JavaScript library that dramatically cuts down on coding and allows us to extensively utilize AJAX (Asynchronous Javascript and XML) for desktop like performance in a web application. The AJAX is used by the “View” to communicate with the “Model” via a combination of straight text and JSON (javascript object notation – a much more succinct alternative to XML) over a secure socket layer connection. The CSS allows us to further separate the content from style within the “View” and not only fosters code manageability but also allows display of vast amounts of information that would otherwise not fit on the screen.

Functionality and Integration

EMR Data Elements

The application embedded within the EMR at Vanderbilt called StarPanel. Displayed at all times on the right hand side of the screen are three boxes: Problem List, Medication List, and Allergies. Theses boxes are color coded to be the same (very light pink) to isolate it from the rest of the interface (yellow). Excess text otherwise not visible from the three respective windows can be viewed by using the scroll bars at the right side of the three boxes. The patient's name, room assignment, age, gender, and chief complaints are also displayed prominently at all time across the top to minimize wrong-patient errors (Figure 7).

Discharge Instructions

A standard set of legally sound ED specific discharge instructions are accessible by typing in a query in the “Search Instructions” box, which autocompletes the user's input. The user has a choice of clicking on

“English” or “Spanish” before clicking on the “Insert” button. Once an instruction is inserted, the user can navigate to it using the links on the left lower pane (Figure 7). The user has the ability to edit the instructions on the right hand side to further customize it.

Prescriptions

The prescriptions tab(Figure 8) allows the user to query the FirstDataBank and Infoscan databases to write prescriptions that match a patient's formulary. Once again, the text fields are all autocompleted and reduce chances of spelling errors. When the user types in a drug name, the appropriate medications, both generic and brand name, show up on the left pane. Brand name is labeled with a pink “B” while generic is labeled with a green “G”. Red balls indicate items not covered by patient's insurance while green or blue balls indicate coverage and copay cost. Clicking on the appropriate medication form on the left populates the “Matching Directions” on the top right based on FirstDataBank's indication based dosing information. Clicking on instructions on the top right then inserts the almost complete prescriptions into the “Prescription” area below. All that is left for the user to do is to indicate who much medication to dispense and click on “Insert Prescription” to insert the official prescription into the shopping cart like area under “Prescribed Drugs”. The user is free to re-edit any previously written medications below by clicking on the notepad icon, or to delete the script all together by clicking on the red 'X'. Note that once again, the user is given opportunity to tweak the prescription to his or her own satisfaction.

Medication Reconciliation

The medication reconciliation tab (Figure 9) allow the user to view the patient's self reported medication list obtained at triage and then compare it to the list of medications just written. If, on further

questioning the patient, the user does not agree the medication list, he or she is allowed to further edit the list. A checkbox below forces user to acknowledge that he or she has reconciled the medication lists and is ready to proceed. This satisfies the JCAHO requirements for medication reconciliation.

Followup

This pane allows the user to either query for (autocomplete) or click on a rolodex picklist to select appropriate followup for patient (Figure 10). In case the followup is not in the local provider database, the user can click on the "Yahoo Phonebook" to query the internet for providers' names. Hovering over the entries on the left hand side brings up a business card like preview of the entire entry. Clicking on the entries on the left inserts it on the pane to the right. In case the patient does not have any primary care physicians, the ED clinician can click on "Insert all uninsured PCP" or "Insert All Dental" on the bottom.

Excuses

The calendar on the left is navigate-able forwards and backwards indefinitely (Figure 11). With just a single click on the appropriate date on the calendar, the user is able to create an excuse letter documenting when the patient is allowed to return to work or school. Furthermore the user is allowed to write for patient's restrictions either by single clicking text on lower left pane or by free text in the right lower white box.

Structured Discharge Summary

A good ED discharge program allows the clinician to review pertinent orders and lab results prior to discharge without making the user get out of the application. On the SDS pane (Figure 13) Once again,

the user is allowed to add or delete to orders for accuracy. Furthermore, upon scrolling, the user is allowed to view repeat information summarizing the previous tabs indication what handouts were given, what prescriptions were written, and discharge medications given.(Figure 12). Lastly, at the very bottom of the tab there is a box allowing the clinician to freehand messages to the follow-up physician. The user is required to navigate this tab before going on to preview and print.

Preview / Print

The user is given one last opportunity to view the application before submitting it back to the EMR and to the printers for printing. The output of the application is shown. Prescriptions(Figure 14) are sent to the print tray containing protected paper while patient instructions(Figure 15) are sent to normal paper.

A very important aspect of this application is flexibility in all respects. Not only is the user given opportunity to override template defaults at all stages, the user is also given opportunity to decide which printer the printout is going to. This feature is handy because numerous physicians work on both pods of the emergency department.

Downtime Protocol

In event of downtime, the old discharge application is used. The eliminates the need to ever go back to paper. Only if the electrical power goes out completely, including the electrical generator in the hospital, does the ED ever have to go back to paper.

Status Report

As of the writing of this paper, the discharge application has been deployed in the Vanderbilt Adult ED for two months and has been used to discharge 991 patients thus far. The application runs concurrently to the old system, which will get turned off as soon as the application reaches adoption rate of > 90%. Currently, adoption rate is at 15% and is rising.

Discussion and Conclusion

There is an old saying: "The whole is greater than the sum of its parts". This adage holds true in the ED, where high volume, high intensity, and high rate of interruptions intersect. The human mind is fallible and medical errors occur as a function of interruptions, fatigue, and/or simple oversight. Having information alone is not enough to prevent medical errors. In fact, having too much information may facilitate medical errors as physician accidently mix information from one patient with that of another. Our hope is that we can enhance patient safety through the integration of information into a meaningful interface that offers both active and passive reminders.

Initial impressions from the early adopters have very positive. Attending physicians like the idea of having an orderly progression of steps to ensure everything is taken care of for the patient and are excited at the prospect of using the application for reminders. Residents like being able to dictate from the application given its ability to integrate information, and appreciate not having to move to a separate computer to do discharges. Hospital administrators are happy because now JCAHO requirements are met regarding medication reconciliation.

Our experience with an integrated ED Discharge writer is limited to a single, busy, academic ED environment with all the electronic resources at our disposal. More rural hospitals may not have as many electronic resources available. However, we believe such a system would still be very valuable used as a platform for creating a complete checklist of things to do before final patient discharge and for acting as a springboard for simple but important alerts like allergies and medication lists.

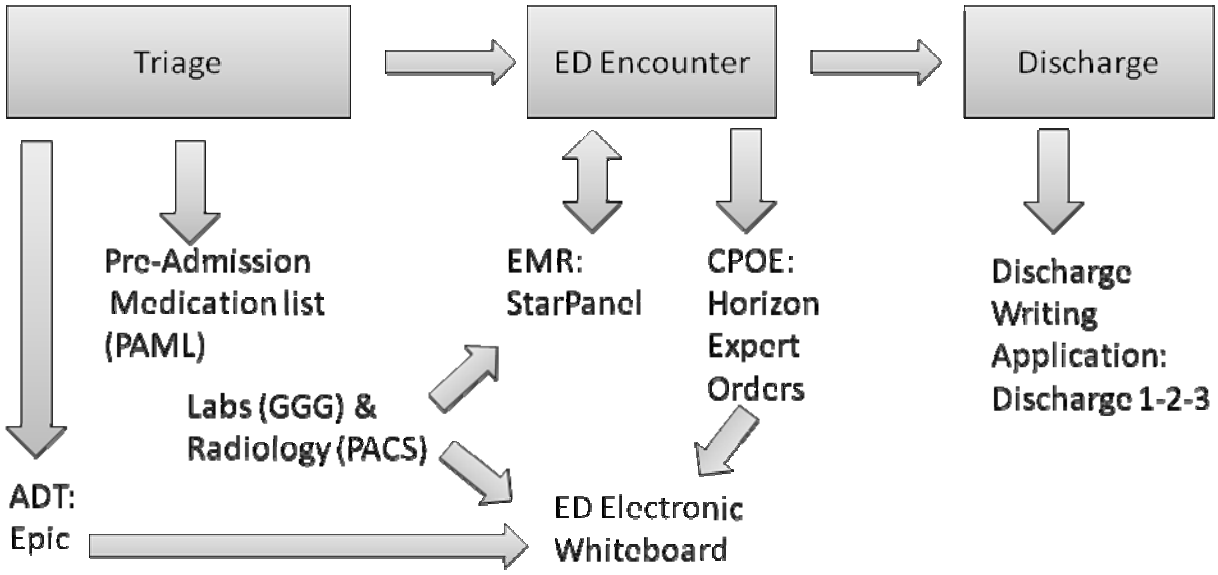

Figure 5: Original Vanderbilt Emergency Department Information Flow Schema

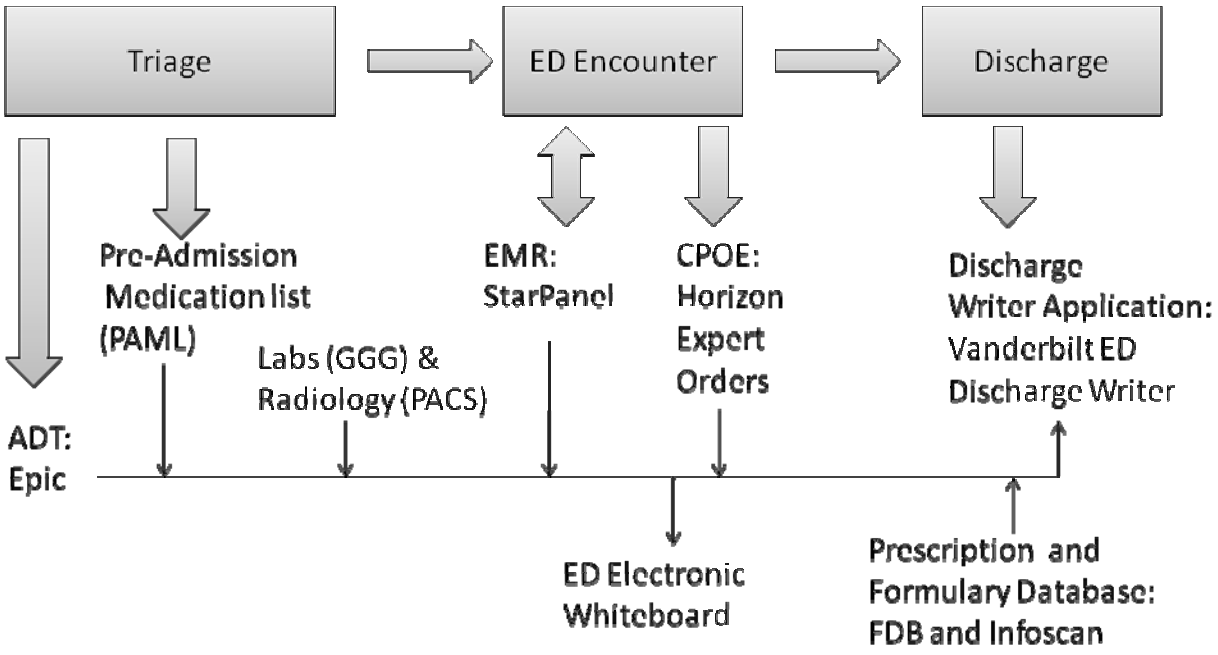

Figure 6: New Vanderbilt Emergency Department Information Flow Schema

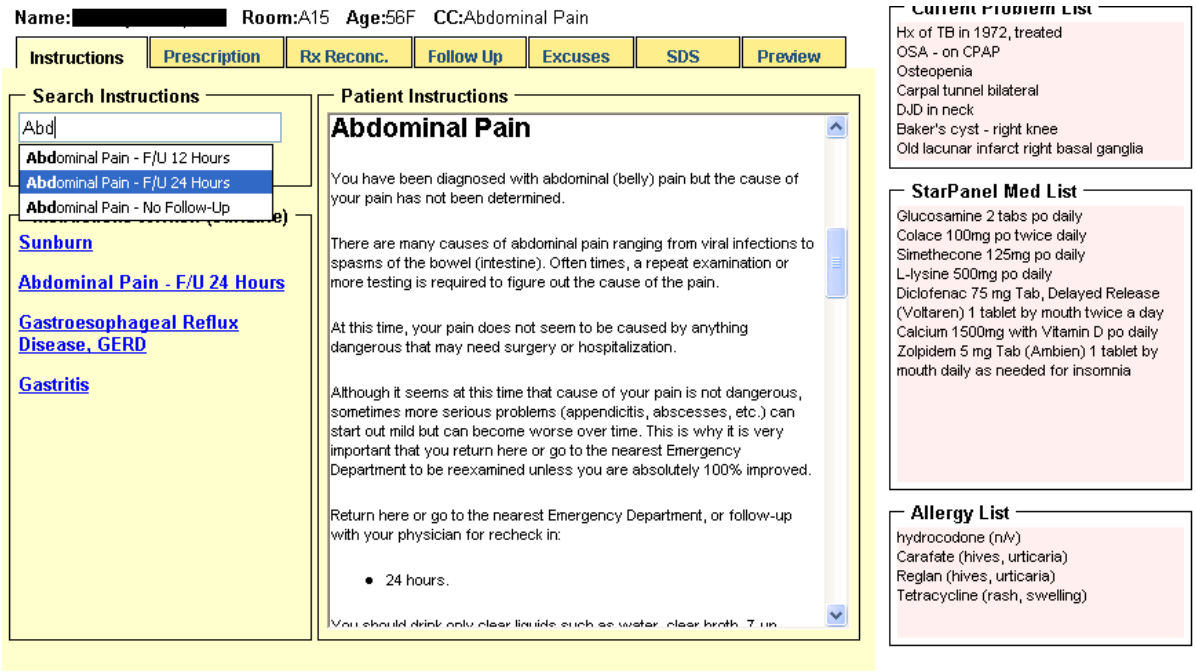

Figure 7: Instruction Tab of Discharge Writer

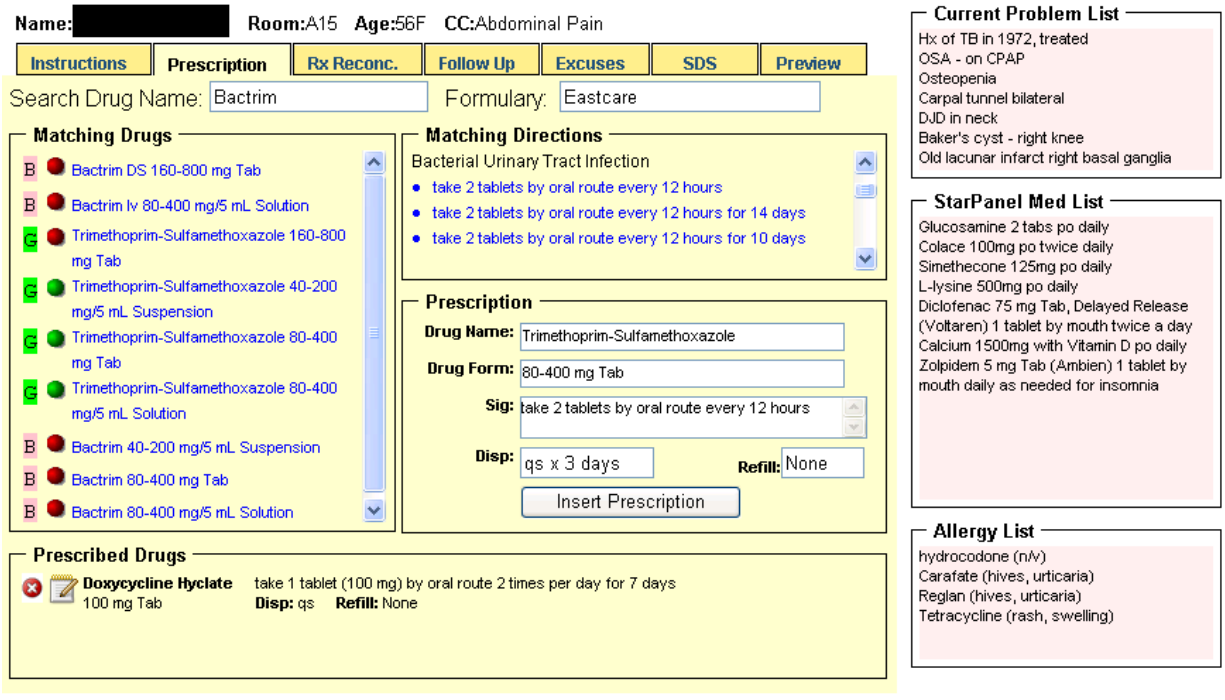

Figure 8: Prescription Tab of Discharge Writer

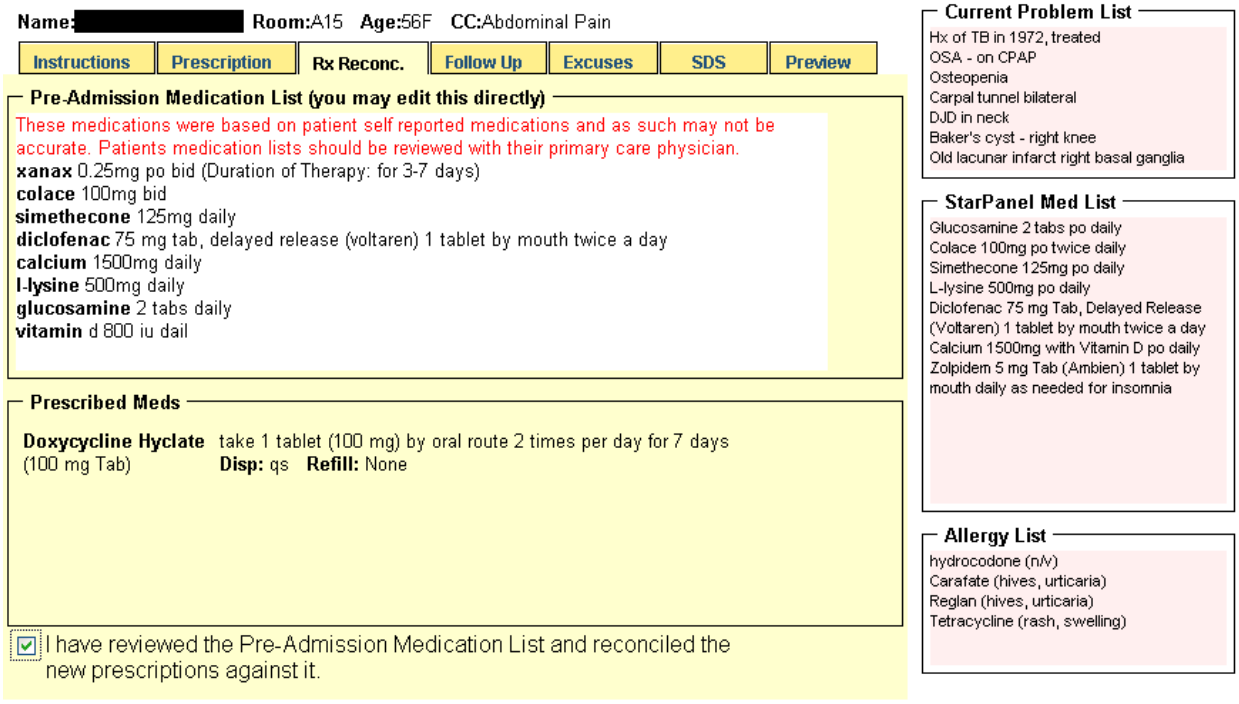

Figure 9: Medication Reconciliation Tab of Discharge Writer

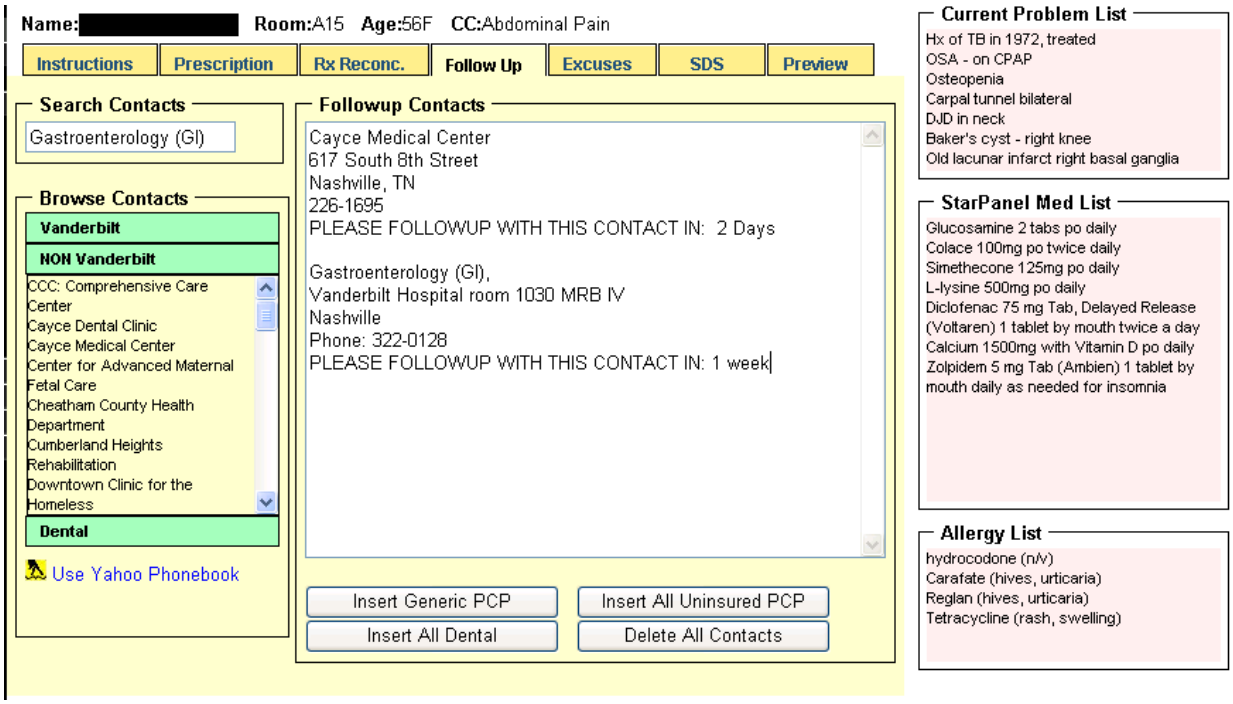

Figure 10: Follow Up Tab of Discharge Writer

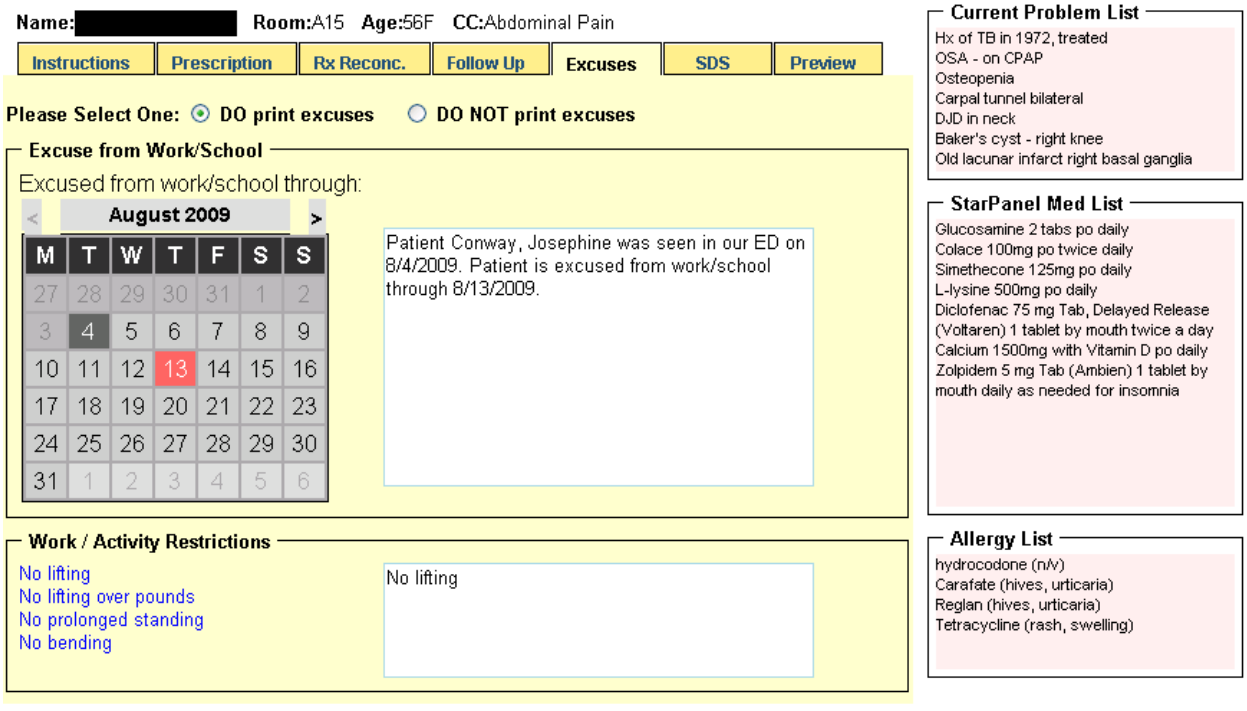

Figure 11: Patient Excuses Tab of Discharge Writer

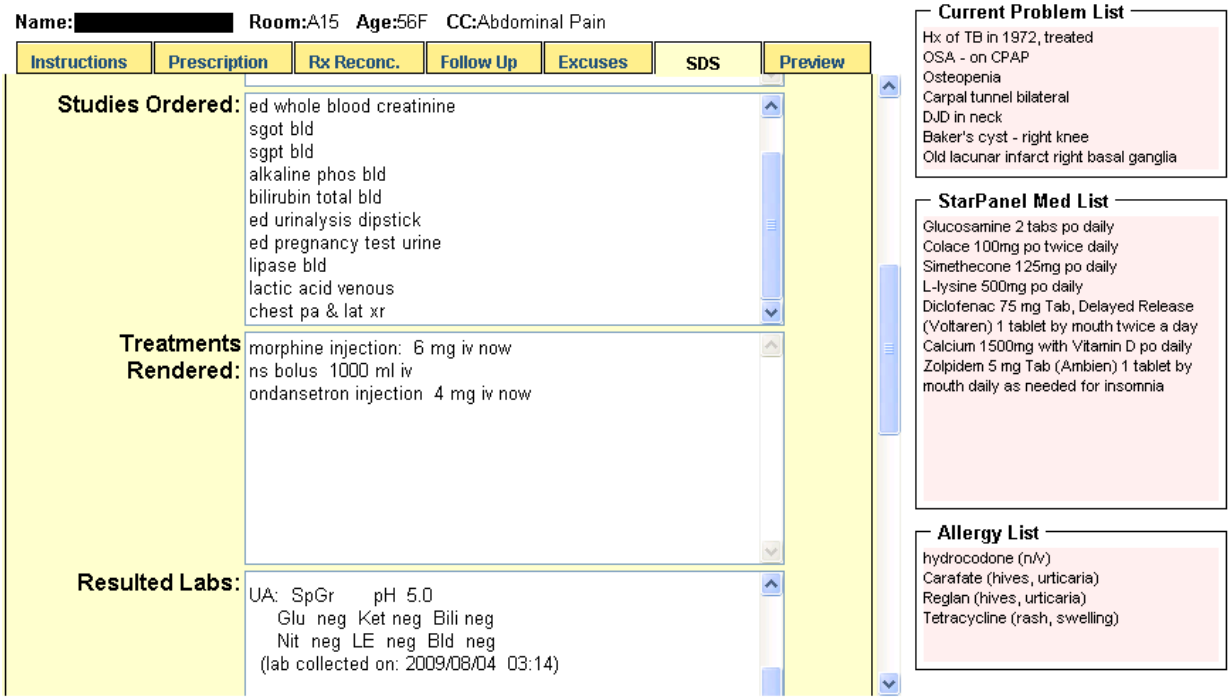

Figure 13: Structured Discharge Summary Tab of Discharge Writer

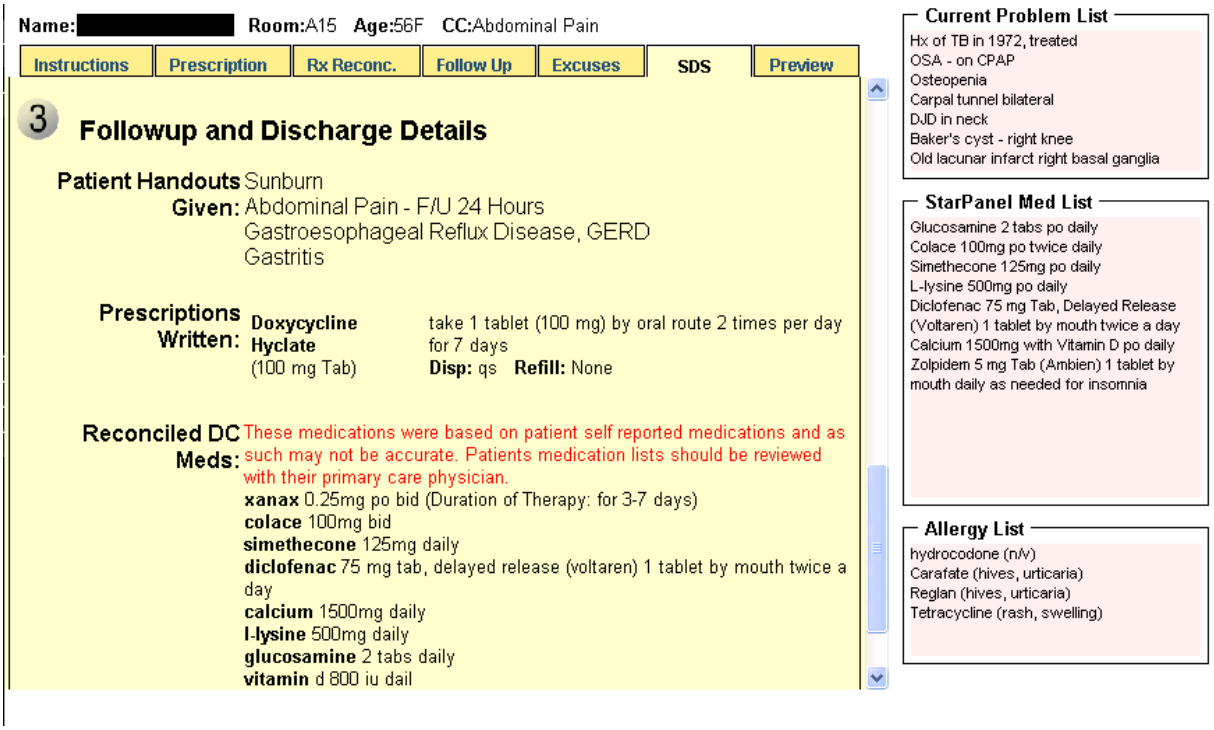

Figure 12: Structured Discharge Summary Tab of Discharge Writer

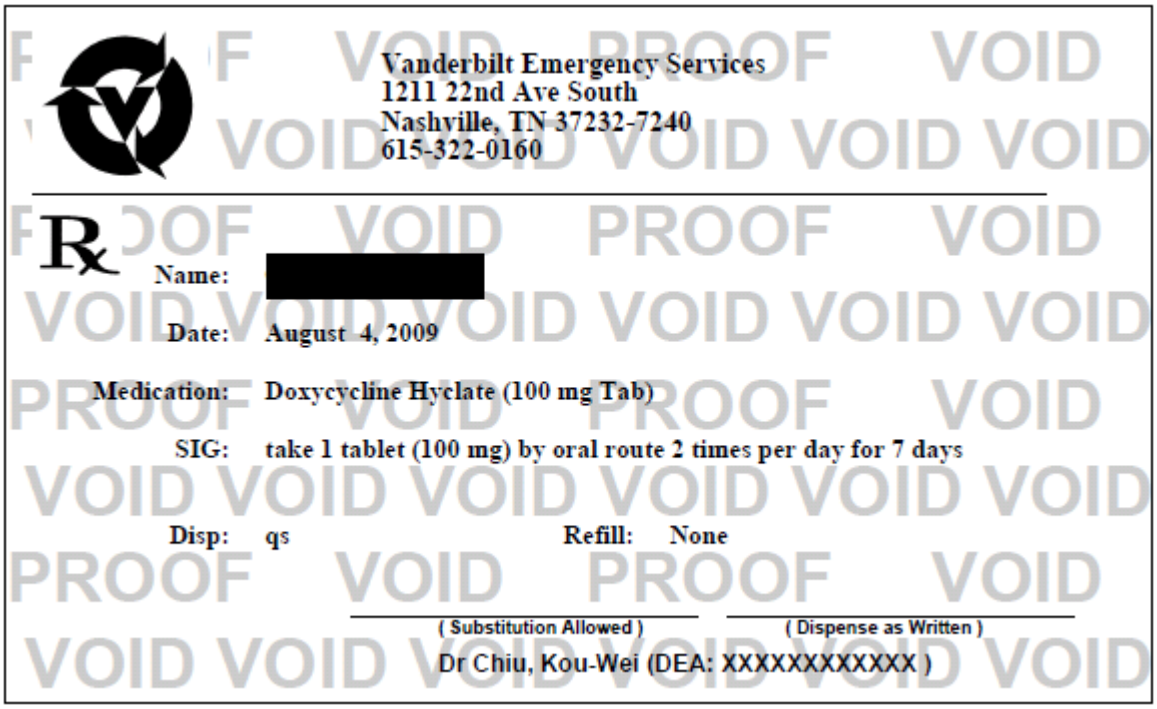

Figure 14: Sample Prescription

Vanderbilt Emergency Services
1211 22nd Ave South
Nashville, TN 37232-7240
615-322-0160

[redacted]

Discharge Instructions

Sunburn

You have been diagnosed with a sunburn.

A sunburn is a first-degree burn. "First-degree" means that the burn involves only the most superficial, or top, layers of the skin.

Repeated sunburns, suntans, or very severe sunburns can lead to permanent skin damage and even skin cancer. Avoid prolonged exposure to the sun without proper skin protection. If you plan to be in the sun you should always wear a hat and put sunscreen with an SPF of at least 15 on all areas of skin exposed to the sun. Make sure to reapply the sunscreen periodically as directed on the sunscreen bottle, especially after swimming or sweating.

The basic care of a sunburn is similar to that of a first-degree burn. Use a moisturizing lotion or a lotion with aloe vera to the affected skin every 2 hours. To help with the pain, you can take ibuprofen 600mg every six hours.

YOU SHOULD SEEK MEDICAL ATTENTION IMMEDIATELY, EITHER HERE OR AT THE NEAREST EMERGENCY DEPARTMENT, IF ANY OF THE FOLLOWING OCCURS:

- Foul drainage or odor from the burned skin.
- Pain with movement of the extremity and/or swollen lymph nodes (nodules found along the groin, armpits and neck).
- Fever, chills, increasing pain and/or swelling.

Abdominal Pain

You have been diagnosed with abdominal (belly) pain but the cause of your pain has not been determined.

There are many causes of abdominal pain ranging from viral infections to spasms of the bowel (intestine). Often times, a repeat examination or more testing is required to figure out the cause of the pain.

At this time, your pain does not seem to be caused by anything dangerous that may need surgery or hospitalization.

Although it seems at this time that cause of your pain is not dangerous, sometimes more serious problems (appendicitis, abscesses, etc.) can start out mild but can become worse over time. This is why it is very important that you return here or go to the nearest Emergency Department to be reexamined unless you are absolutely 100% improved.

Figure 15: Sample Patient Instruction Sheet

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CHAPTER V

CONCLUSION

Errors are a serious and common issue in medicine. In this project, we chose to focus on those errors occurring at the time of discharge from the ED. We began by studying the nature of errors in the ED. We found that most errors cited in literature tended to come from urban, academic centers. There was a skew towards the reporting of more serious errors like death and malpractice. We also found that errors tended to follow James Reason's "Swiss Cheese Model". The practice of medicine has many checks and balances at different phases of care by different care providers. On average two to five processes had to fail simultaneously before errors occurred.

We the proceeded to investigate one such error: The Beers List. Adverse drug events are more common in elderly patients because of issues such as polypharmacy and increasing drug sensitivity due to decreasing drug clearance with age. Our electronic query of two years of medication lists brought in by our elderly patients in the ED indicate that approximately 9% of these patients are on potentially inappropriate medications. Our emergency department was prescribing potentially inappropriate medications at a rate of approximately 3%.

While 3% does not appear to be a high number, every single mortality resulting from a preventable adverse drug event is one too many. We initially attempted to study the implementation of a reminder

system to remedy this error in our ED. However, our vendor solution was not amenable to interface customizations.

Consequently, we decided upon creation of a totally novel framework for the discharge of patients from the Vanderbilt Adult Emergency Department. We drew out our ideals: 1) integrate with our EMR, 2) integrate with our CPOE, 3) utilize industry standard drug prescription database and insurance formulary information, 4) facilitate transfer of care via a contacts manager, 5) create a granular data stream to a database that is queryable for research purposes, and 6) allow arbitrary plugins to create clinical reminders. While it appeared to be a daunghting task, the dream was realized. Two years later, using the latest in open source technology such as PERL, MYSQL, and JavaScript/jQuery, we created a Web 2.0 based framework embedded into our web based EMR (StarPanel) that did just that. It is far beyond the prototype stage. As of the writing of this paper, 990 patients have been successfully discharged using this application over the last two months since it was initially implemented. Through the integration of information from multiple sources into one, coherent interface, we strongly believe that the implementation of this system is already decreasing medical errors at the time of discharge from our ED.

We already envision many possibilities with this new platform. We can prospectively study different types of clinical reminders and compare their efficacy in further decreasing medical errors. One obvious example would be to study Beers List reminders on such a system. This was the original aim of this whole platform. This was the original aim of the platform until time ran out. We can also monitor patient data on a very granular basis and do biosurveillance. Bioterrorism and influenza season prediction are just to examples of possibilities with this system. Many other possibilities exist. The only limitation is one's imagination and the resources to support it.