A COMPUTERIZED PNEUMOCOCCAL VACCINATION REMINDER SYSTEM IN THE ADULT EMERGENCY DEPARTMENT

By

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CHAPTER I

INTRODUCTION

The U.S. Preventive Task Force and Healthy People 2010 developed national guidelines emphasizing the importance of preventive care (1, 2). Preventive care guidelines are used to help clinicians know who is at risk for a disease, who should receive a vaccination, and provides a recommended approach on how to treat a disease. Guidelines are based on evidence from clinical trials or expert opinion. Despite the evidence-based recommendations, guidelines and preventive services remain under utilized (3). Computerized and paper-based reminders have been used to increase the use of preventive care procedures, including vaccination (4-6).

Improving immunization rates has been studied using several different techniques. Computer-based clinical decision support systems (CDSS) are used to help the decision-making process of clinicians. The systems match electronic patient data with stored algorithms to help determine treatment recommendations (7, 8). CDSS have improved clinician performance using prompts for preventive care procedures (7, 8). Although, studies of vaccine delivery methods indicate that the use of standing orders is the best way to improve vaccination coverage in office, hospital, or long term care settings (9), clinician prompts have also been effective at increasing vaccination rates in both the inpatient and outpatient settings (10, 11).

Approximately 60-87% of pneumococcal bacteremia is associated with pneumonia infection. Pneumococcal infections cause 3,000 cases of meningitis, 50,000 cases of bacteremia, 500,000 cases of pneumonia, 7 million cases of otitis media, and 40,000 deaths annually (12). Vaccination against pneumococcal infection has been shown to be cost-effective (13), primarily reducing the burden of invasive pneumococcal disease. The Centers for Disease Control and Prevention (CDC) created guidelines for pneumococcal vaccination in 1997 (12).

The CDC defines high-risk patients as those older than 65 or younger persons who are immunocompromised, have a chronic illness such as diabetes, or have received a transplant (12). The CDC recommends that high-risk patients receive a second vaccination if they were originally vaccinated younger than 65 or more than 5 years ago. Patients older than 65 with an unknown vaccination status should receive only one dose of the pneumococcal vaccine (12). Pneumococcal vaccination is safe and re-vaccination produces little, if any side effects (14).

Only 55% of high risk patients have been vaccinated against pneumococcal disease (15); Healthy People 2010 calls for 90% vaccination for patients older than 65 and 65% vaccination for patients under 65 with a chronic disease (1). Based on pneumococcal vaccination orders from 2003 and 2004 the current vaccination rates in the Vanderbilt primary care clinics are about 60% for adults older than 65 years (16).

The emergency department (ED) provides care for many patients at high-risk for pneumonia and has been suggested to be a suitable environment for a pneumococcal vaccination program (17). Only limited investigations exist in the ED (18) and experiences with implementing computerized vaccination reminders have not been reported. For many patients the ED is the sole health care provider and represents the only opportunity for vaccination. The ED faces major challenges that decrease the chance of implementing a successful and sustainable vaccination program. The ED environment is characterized by an interruptive, multitasking, communication- and information-intensive work pattern, which is further exacerbated by the nation's overcrowding burden, and the shortage of nurses and inpatient beds. These factors and the perception that the ED is an inappropriate setting for offering preventive care measures are a considerable challenge to an ED-based vaccination initiative (19). Only 266,000 patients received a pneumococcal vaccination in the ED from 1992-2000 (20).

In spite of these challenges, the ED remains an opportunity for vaccinations; the American College of Emergency Physicians has recommended pneumococcal vaccination programs (21) and the Centers for Medicare and Medicaid Services reimburse ED-based vaccine administration. However, experiences with pneumococcal vaccination programs in the ED remain limited. One ED, which had a 3% vaccination baseline, implemented a paper-based system that increased the vaccination rate by 35% (18).

Patient surveys have provided positive responses for receiving the vaccination during their ED visit (22). However, some patients believe the vaccination is not necessary, prefer that it be given by their primary care physician, are unsure of their vaccination status, confuse pneumococcal vaccine with the influenza vaccine, or have reimbursement concerns (23). These challenges may require educational efforts that compete with other ED care priorities. Referring patients outside of the ED has been shown to be an ineffective method of increasing vaccination (24).

The goal of this project was to design and implement a computerized reminder system in the adult ED of Vanderbilt University Hospital. I hypothesized that a computerized reminder system can increase vaccination rates for eligible patients 65 and older who visit the adult ED. The goals of the study included fitting the prompts into the work-flow using the informatics infrastructure and requiring a minimal amount of extra input from nurses and physicians for each patient encounter. The adult ED currently uses a computerized triage application (25), an order-entry system (26), a computerized patient record (27, 28), and an order-tracking system. The four information systems will be used to relay information concerning the patient's vaccination status.

The specific aims of the project were to:

1) Perform a systematic review of the biomedical literature for preventive care reminders systems.
2) Perform an assessment of the vaccination status of high-risk patients who attend the Vanderbilt primary care clinics.

3) Perform a readiness assessment of the adult ED by surveying physicians and nurses.
4) Design and implement an electronic reminder system for high-risk patients.
5) Prospectively evaluate the system in the Vanderbilt adult ED.

Chapter II addresses aim one and describes previous reminder system implementations and their success rate through a systematic review of the literature. This chapter provides background for reminder systems focused on preventive care in the inpatient and outpatient setting. Chapter III addresses aim two. This chapter describes an immunization registry created using a keyword search to identify patients with prior pneumococcal vaccination in the primary care clinics. Chapter IV addresses aim three, and describes a survey given to all ED faculty, residents, and nurses. The survey was designed to collect their attitudes and beliefs on pneumococcal vaccination in the ED and the best way to implement a reminder system. Chapter V addresses aim four, designing the reminder system to implement in the ED. This chapter describes the system in detail and how it interacts with the electronic medical record (EMR) already in place at Vanderbilt. Chapter VI addresses aim five and looks at a prospective evaluation of the reminder system. The system targeted patients 65 and older presenting to the adult ED during the study period. Chapter VII addresses the implications of the research, limitations, and directions for future studies.

CHAPTER II

PROMPTING CLINICIANS: A SYSTEMATIC REVIEW OF PREVENTIVE CARE

Introduction

The US Preventive Task Force developed guidelines to facilitate the dissemination and implementation of preventive care measures among health care providers (1, 2). Opportunities for offering patients preventive care measures exist during every encounter with the health care system (29), such as vaccinations during primary care visits (30), prophylactic aspirin and vaccinations prior to discharge from the hospital (5), or vaccinations during an emergency department visit (18). However, preventive care measures remain underutilized (5, 31, 32) and clinicians struggle with finding time to be compliant with offering the numerous recommended exams and procedures when a patient's primary visit reason is unrelated to prevention (3). For example, the Healthy People 2010 target for colorectal cancer screening is 50%, but only 35% of eligible people have a screening exam (1), Similarly, the 26% influenza and 49% pneumococcal vaccination rate for hospitalized patients aged 65 years and older are far below the 90% target (11).

Different implementation approaches to increase preventive care measures have demonstrated various levels of success. Successful approaches include organizational change interventions, financial incentives, or patient and provider reminders (33-35). With the increased implementation of clinical information systems in recent years,

broader adoption and application of information technology for patient care, including preventive care applications, can be expected. In the ambulatory setting computer-based reminders increased the implementation of some preventive care measures, but failed in others (7, 36). In an outpatient setting computerized prompts were more effective at increasing influenza vaccination rates when compared to paper-based reminders (37). Balas et al. examined the effect of various intervention techniques for prompting physicians. The study included reports from 1966 to 1996 and found that the average rate difference for computer-generated reminders did not differ from non-computerized prompting approaches.

Although a recent national survey (38) suggested that the application of information technology is associated with increased physician reminder use, there is limited information whether the recent focus on implementing clinical information system has provided the infrastructure to implement and apply computer-based reminder systems for preventive care. The goal of this systematic literature review was to update the study by Balas et al., which included 13 preventive care measures from the US Preventive Task Force, and examine whether the types and characteristics of reminder systems for preventive care have changed as more clinical information systems are applied for patient care.

Methods

Literature Search

The current study was conducted using an adaptation of the study methodology from Balas et al. to perform a systematic review of the literature regarding 16 preventive medicine reminders to clinicians (4). Eligible studies for inclusion were randomized controlled trials that targeted clinicians and had a reminder system for at least one of 16 preventive medicine procedures. The procedures included fecal occult blood testing; mammography; Papanicolaou smear; influenza, pneumococcal or tetanus vaccination; diabetes mellitus management; cholesterol screening; hemoglobin or blood pressure management; cardiac care; smoking cessation; glaucoma screening; alcohol abuse counseling; prenatal care; or tuberculosis testing

Electronic literature searches for the period January 1, 1997 to December 31, 2004 were performed using the publicly available databases PUBMED® (MEDLINE®) (39), CINAHL® (40), ISI Web of Science™ (41), Health and Psychosocial Instruments (9), and the Health Reference Center (42). In MEDLINE, all search terms were defined as keywords and Medical Subject Headings (MeSH®) unless otherwise noted; in the remaining databases, the search terms were defined only as keywords. The search was limited to studies published in English. In each database we searched for the combination of the following three concepts: (1) preventive care measure, (2) reminder system, and (3) randomized clinical trial.

(1) *Preventive care measure*: preventive health services, immunization, vaccination, smoking, smoking cessation, mass screening, mammography, prenatal care, hypertension, blood pressure, diabetes mellitus, alcoholism, substance-related disorders, vaginal smears, hypercholesterolemia, glaucoma, or occult blood.

(2) *Reminder system*: checklist (text word), encounter forms (text word), tags (text word), triggers (text word), reminder systems, alert (text word), reminder (text word), leaflets (text word), stickers (text word), messages (text word), or tailored messages (text word).

(3) *Randomized clinical trial*: random$ (truncated text word), group$ (truncated text word), random allocation, randomized controlled trial (publication type), or clinical trial (publication type).

Review of Identified Studies

The title and abstract of all articles identified using the keyword searches were retrieved and reviewed by two of four independent reviewers (JWD, DLS, SR, DA). Disagreements between two reviewers were resolved by consensus among all four participating reviewers. The bibliographies of identified systematic reviews and meta-analyses were reviewed and additional relevant studies were included. The full text of included articles was obtained and two reviewers (JWD, DA) independently scored each article using the assessment methodology that was applied during the previous study (4). Disagreements were resolved by consensus discussion. The validated assessment instrument includes ten criteria evaluating the study characteristics (randomization

techniques, testing, withdrawals, effect variables) and assigns a score between 0 and 100 (43). Five criteria examine the methodology and characteristics of the study design. Articles scoring below 50 were excluded from further consideration (43).

Reminder implementations were classified as "paper-based," "computer-generated," or "computerized." Paper-based reminders included the use of memos, stickers, or a slip of paper within the patient's chart. Computer-generated reminders included application of computerized algorithms to identify eligible patients, but the prompt was printed out and placed in the patient chart to remind the clinician. Computerized reminders included prompts that were entirely electronic, i.e., computerized algorithms identified eligible patients, and prompts were provided upon access to the electronic clinical information system.

Analysis

The articles from the previous review (1966 to 1996) were combined with the more recent articles identified during the current search (1997 to 2004). In studies with more than one preventive care prompt, each intervention was analyzed separately for the effect of the prompt on the given procedure. For example, if a vaccination study compared a paper-based versus a computer-based implementation approach, each approach was counted and examined individually. For each study, effect size was calculated by subtracting the control or baseline data from the largest increase in effect. Odds ratios were converted into percentages for data analysis measures. Agreement among reviewers

to consider articles based on title and abstract was high (0.96 to 0.99), as determined by Yule's Q $\left[Yule'sQ = \frac{OddsRatio - 1}{OddsRatio + 1} \right]$ (44).

Results

The literature search produced 1,535 articles during the time period from 1997 to 2004 (Figure 1). The PUBMED search contributed 1,308 articles, CINAHL 148, Health and Psychological Instruments three, the Health Reference Center two, and ISI Web of Knowledge 74. After removing 131 duplicate articles, 1,404 were unique. Of the 11 excluded articles, nine scored less than 50, one examined only the system design, and one had no clinician prompt. One paper had no numerical results and was not included in the effect size calculations (45). We combined the 24 trials with the previous 37 studies for a total of 61 studies, which included 273 preventive care interventions (range: 1 to 16). Nineteen (30%) studies evaluated three or more preventive measures, three (5%) examined two measures, and the remaining 39 (64%) looked at one measure. Table 1 shows the detailed characteristics of the included studies.

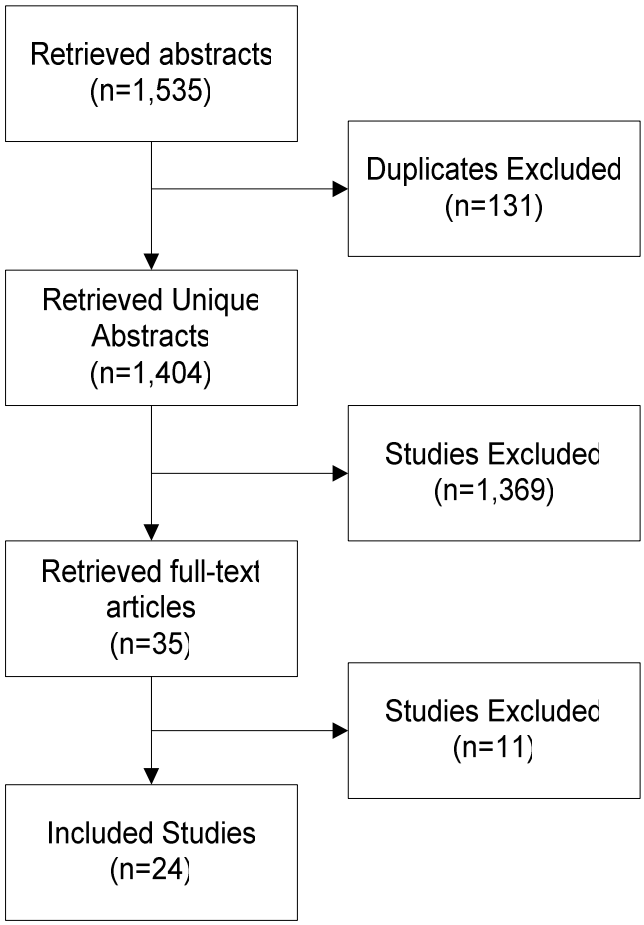

Figure 1: Flow diagram of included and excluded studies.

Key for Table 1

Specialty:	FP - Family Practice
	IM - Internal Medicine
	Card - Cardiology
Provider Type:	NP - Nurse Practitioner
	MDa - Attending Physician
	MDr - Resident Physiciants
Care Measure:	CaScr - Cancer Screening
	Chol - Cholesterol Management
	Immun – Immunizations
	HgB - hemoglobin management
	CC - Cardiac Care
	NoSmok - Smoking Cessation
	BP - Blood Pressure management
	GS - Glaucoma Screening
	TB - Tuberculosis testing
	DiabM - Diabetes Management
	OBG – Obstetrics/Gynecology
	Alcohol – Alcohol abuse counseling
	NS – Not Specified

Table 1: Study Characteristics

Source	Author	Year	Targeted Action	Institution Study Locations
(46)	Ansari	2003	CC	San Francisco Veterans Affairs Medical Center
(47)	Bankhead	2001	CaScr	Birmingham; North of London; West of London
(15)	Barnett	1983	BP	Massachusetts General Hospital
(48)	Becker	1989	Immun, CaScr, GS	University of Virginia
(49)	Burack	1994	CaScr	Wayne State University
(50)	Burack	2003	CaScr	HMO Practice sites in Detroit, Michigan
(51)	Burack	1998	CaScr	HMO Practice sites in Detroit, Michigan
(10)	Burack	1997	CaScr	Wayne State University
(28)	Buschbaum	1993	Alcohol	Medical College of Virginia
(52)	Chambers	1989	CaScr	Thomas Jefferson University
(53)	Chambers	1991	Immun	Thomas Jefferson University
(54)	Cheney	1987	Immun, CaScr, Chol	University of California, San Diego
(6)	Cohen	1982	Immun, CaScr	Case Western
(55)	Costanza	2000	CaScr	University of Massachusetts Medical School
(56)	Cowan	1992	Immun, CaScr, Chol	University of Illinois
(57)	Cummings	1989	NoSmok	University of California, San Francisco
(58)	Daley	2004	Immun	The Children's Hospital, Denver, CO
(59)	Demakis	2000	BP, DiabM, CC, NoSmok	Veterans Affairs Medical Centers (12)
(5)	Dexter	2001	Immun, Heparin, Aspirin	Wishard Memorial Hospital
(11)	Dexter	2004	Immun	Wishard Memorial Hospital
(60)	Eccles	2002	Angina	North East England General Practices
(61)	Filippi	2003	Antiplatlet drugs for Diab	Italy
(30)	Frame	1994	Immun, CaScr, Chol	University of Rochester (NY)
(62)	Hambidge	2004	Immun	Denver Health Medical Center
(63)	Headrick	1992	Chol	Case Western
(64)	Landis	1992	CaScr	Mt Area Health Education Center
(65)	Litzelman	1993	CaScr	Regenstrief
(66)	Lobach	1994	DiabM	Duke Family Medicine Center
(67)	MacIntyre	2003	Immun	The Royal Melbourne Hospital
(68)	Manfredi	1998	CaScr	Primary care practices in the Chicago area
(45)	McDonald	1976	BP, Chol, HgB, DiabM	Regenstrief
(69)	McDonald	1976	BP, DiabM, CC	Regenstrief
(70)	McDonald	1984	Immun, CaScr, HgB	Regenstrief
(71)	McDowell	1989	CaScr	University of Ottawa
(72)	McDowell	1989	BP	University of Ottawa
(73)	McPhee	1989	CaScr	University of California, San Francisco
(74)	Morgan	1978	Prenatal care	Massachusetts General Hospital
(75)	Murray	2004	BP	Indiana University School of Medicine
(76)	Myers	2004	CaScr	318 primary care practices Pennsylvania, and NJ
(77)	Nilasena	1995	DiabM	Salt Lake Veterans Affairs Hospital, University of Utah
(78)	Ornstein	1991	Immun, CaScr, Chol	Medical University of South Carolina
(79)	Pierce	1989	CaScr	Guy's and St Thomas's Hospitals
(80)	Pritchard	1995	CaScr	University of Western Australia
(81)	Rhew	1999	Immun	West Los Angeles VA General Medicine ambulatory clinic
(82)	Robie	1988	CaScr	Wake Forest University
(83)	Rodewald	1999	Immun	Primary care practices in the Rochestor area
(84)	Roetzheim	2004	CaScr	HIllsboro County Clinics
(85)	Rosser	1991	Immun, CaScr, BP, NoSmok	University of Toronto/University of Ottawa
(86)	Rosser	1992	Immun	University of Toronto/University of Ottawa
(87)	Rossi	1997	BP	Veterans Affairs Medical Center Puget Sound, Seattle Washington
(88)	Shaw	2000	Immun	Children's Hospital, Boston
(89)	Shevlin	2002	Immun	Grady Memorial Hospital, Atlanta, Georgia
(90)	Simon	2001	CaScr	Detroit Health Department Primary Care Clinics
(91)	Soljak	1987	Immun	New Zeland
(92)	Somkin	1997	CaScr	Kaiser Permanente Medical Care Program of Northern California
(93)	Tape	1993	Immun, CaScr	University of Nebraska
(94)	Taylor	1999	CaScr	University of Washington, Seattle
(95)	Thompson	2000	CaScr	Veterans Affairs Medical Center Puget Sound, Seattle Washington
(96)	Tierney	1986	Immun, CaScr	Regenstrief
(97)	Turner	1990	Immun, CaScr	East Carolina University
(98)	Williams	1998	CaScr	Primary Care Practices in the Southeast

Table 1: Continued

Institution	Study Loc	Patients	Number	Characteristics	Specialty
PUB	outpatient	169	301	MDa, MDr, NP	IM, Card, NP
PUB	outpatient	1158	13	MDa	FP
PUB	outpatient	115	48	MDa, RN	IM
ACAD	outpatient	563	80	MDr	IM
PUB	outpatient	2725	25	MDa	FP, IM, OBG
PUB	outpatient	2471	20	MDa	FP, IM, OBG
PUB	outpatient	1471	20	MDa	FP, IM, OBG
PUB	outpatient	2890	25	MDa	FP, IM, OBG
ACAD	outpatient	214	83	MDr	FP
ACAD	outpatient	1262	30	MDr, MDa	FP
ACAD	outpatient	686	30	MDr, MDa	FP
ACAD	outpatient	200	75	MDr	IM
ACAD	outpatient	2138	22	MDr	FP
ACAD	outpatient	1655	480	MDa, MDr	FP, IM, GP
ACAD	outpatient	107	29	MDa	FP
PUB	outpatient	916	44	MDa	FP, IM
ACAD	outpatient	420	NS	MDa, MDr	Ped
PUB	outpatient	12989	275	MDr	GP
ACAD	inpatient	6371	202	MDa, MDr, RN	FP
ACAD	inpatient	3777	212	MDa, MDr, RN	GP
PUB	outpatient	4851	NS	MDa	
PUB	outpatient	15343	300	MDa	GP
PUB	outpatient	1666	12	MDa, PA	FP
PUB	outpatient	2665	NS	MDa, MDr	GP
ACAD	outpatient	240	33	MDr	IM
ACAD	outpatient	57	24	MDa, MDr	FP
ACAD	outpatient	5407	176	MDr, MDa	IM
ACAD	outpatient	359	58	MDr, MDa, PA, NP	FP
PUB	inpatient	131	NS	MDa	GP
PUB	outpatient	4554	87	MDa	GP
ACAD	outpatient	189	9	MDr	IM
ACAD	outpatient	301	63	MDa, MDr, RN	IM
ACAD	outpatient	775	115	MDr, MDa	IM
ACAD	outpatient	789	32	MDa, MDr, RN	FP
ACAD	outpatient	2803	32	MDa, MDr, RN	FP
ACAD	outpatient	1936	62	MDr	IM
PUB	outpatient	279	5	MDa/RN teams	OBG
ACAD	outpatient	712	NS	MDr, MDa	
PUB	outpatient	2992	470	MDa	GP, FP
ACAD	outpatient	164	35	MDr	IM
ACAD	outpatient	7397	49	MDr, MDa	FP
PUB	outpatient	276	7	MDa	FP
PUB	outpatient	383	12	MDa	GP
PUB	inpatient	3502	NS	RN, MDa	GP
ACAD	outpatient	356	41	MDr	IM
PUB	outpatient	2741	NS	MDa	GP
PUB	outpatient	1196	NS	MDa	GP
ACAD	outpatient	5883	36	MDa, MDr	FP
ACAD	outpatient	5242	32	MDr, MDa, RN	FP
PUB	outpatient	719	71	MDa, NP, MDr	IM
ACAD	outpatient	595	52	MDr	GP
ACAD	inpatient	534	NS	MDr, MDa	
PUB	outpatient	1717	NS	MDa	GP
PUB	outpatient	2988	40	MDa	FP
PUB	outpatient	7077	NS	MDa	FP
ACAD	outpatient	1809	49	MDr, MDa	IM
ACAD	outpatient	314	49	MDr, MDa	
PUB	outpatient	1109	4	MDa, MDr, LPN	IM
ACAD	outpatient	6045	138	MDr	FP
ACAD	outpatient	423	24	MDr	IM
PUB	outpatient	5789	507	MDr	

Figure 2 displays the number and type of published studies grouped in 5-year intervals. The total number of studies increased in the 2000-2004 period as compared to previous periods. During the most recent period, 9 studies applied paper-based interventions and 7 computerized methods, while the number of computer-generated approaches declined to 3 reports.

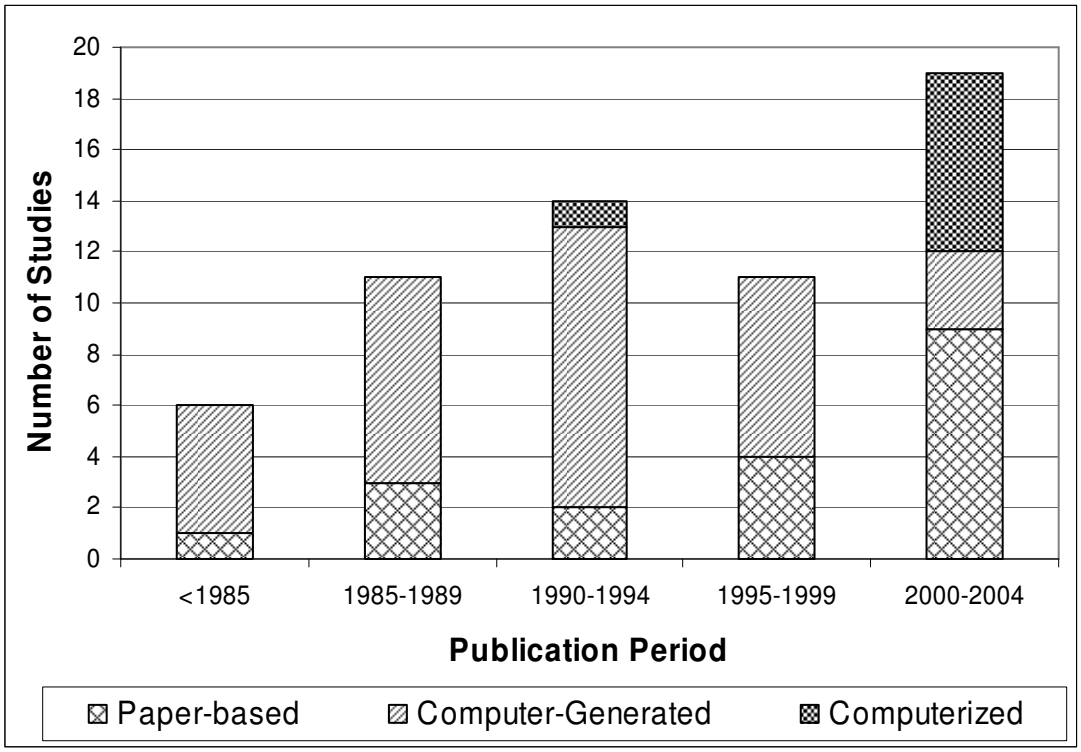

Figure 2: Studies by publication year.

With a total of 112 studied interventions cancer screening (fecal occult blood testing, Papanicolaou smears, and mammograms) was the most frequent type of preventive care measure, followed by 67 vaccination interventions. Table 3 displays the effect for

measures that were examined by more than two studies. The average effects for measures examined by two studies or less were: ranged from 5% to for prenatal care to 14% for alcohol abuse counseling. Prompting clinicians were most effective for blood pressure screening (average: 16%), followed by vaccinations (average: 15%), and diabetes management (average: 15%), which includes HbA1c levels, blood glucose, eye and foot care, nutrition counseling, and weight management. Mammography reminders had the smallest effect (average: 10%).

The methods of prompting clinicians are shown in Table 2. Computer-generated prompts were the most frequent clinician reminder approach and accounted for 34 studies (56%), followed by 19 paper-based (31%), and 8 computerized studies (13%). The three examined prompting approaches demonstrated a similar average increase in completing preventive care measures (Table 4). Paper-based reminders were applied in 80 interventions and resulted in a 14% average increase of preventive care compliance. Computer-generated reminders were implemented 145 times and had an average increase of 12%. Computerized reminders were employed in 48 interventions and resulted in a 13% average increase.

Table 2: Study Type and Location

Study	Paper-Based	Computer Generated	Computerized
Ansari (46)			Display
Bankhead (47)	Flag, GP Letter		
Barnett (15)		Front	
Becker (48)		Front	
Burack (49)		In-chart	
Burack (50)		In-chart	
Burack (51)		In-chart	
Burack (10)		In-chart	
Buschbaum (28)		Front	
Chambers (52)		Front	
Chambers (53)		Front	
Cheney (54)	Front		
Cohen (6)	Front		
Costanza (55)	Quarterly Reports		
Cowan (56)	Front		
Cummings (57)		Front	
Daley (58)		Front	
Demakis (59)			Display
Dexter (5)			Display
Dexter			Display
Eccles (60)			Display
Filippi (61)			Display
Frame (30)	Front		
Hambidge (62)	Tagged		
Headrick (63)		Front	
Landis (64)		Front	
Litzelman (65)		Front	
Lobach (66)		Front	
MacIntyre (67)	Memo		
Manfredi (68)	Tagged		
McDonald (45)		Front	
McDonald (69)		Front	
McDonald (70)		Front	
McDowell (71)		Front	
McDowell (72)		Front	
McPhee (73)		Front	
Morgan (74)		Front	
Murray (75)			Display
Myers (76)	Letter		
Nilasena (77)		Front	
Ornstein (78)		Front	
Pierce (79)	Tagged		
Pritchard (80)	Tagged		
Rhew (81)		Front	
Robie (82)	Front		
Rodewald (83)	Tagged		
Roetzheim (84)	Tagged		
Rosser (85)		Front	
Rosser (86)		Front	
Rossi (87)		Front	
Shaw (88)		Front	
Shevlin (89)	In Chart		
Simon (90)	In Chart		
Soljak (91)		Patient List	
Somkin (92)	In Chart		
Tape (93)			Display
Taylor (94)		Front	
Thompson (95)	Patient List		
Tierney (96)		In-chart	
Turner (97)		Patient Carried	
Williams (98)		Front	

Table 3: Effect of prompting clinicians for preventive care procedures with more than two reported interventions

Preventive care measure	Number of Interventions (Number of studies)	Average % difference (range)	Standard Deviation
Vaccination	67 (24)	15 (-15 to 50)	13
FOBT	23 (16)	12 (-11 to 37)	13
Papanicolaou smear	39 (20)	12 (-24 to 48)	17
Mammogram	51 (23)	10 (-18 to 49)	15
Blood Pressure	25 (9)	16 (-8 to 59)	18
Cholesterol	8 (6)	15 (-1 to 54)	17
Diabetes Management	27 (8)	15 (5 to 51)	10
Smoking Cessation	6 (3)	23 (3 to 44)	16
Cardiac Care	25 (4)	20 (-8 to 59)	11

Table 4: Comparison of prompting techniques

Primary Reminder Method	Number of interventions (Number of studies)	Average difference % (range)	Standard Deviation
Paper-based	80 (21)	14 (-18 to 46)	15
Computer Generated	145 (32)	12 (-24 to 59)	13
Computerized	48 (8)	13 (-8 to 60)	18

Of the 61 studies, 35 studies prompted only the clinician, 17 interventions combined the clinician prompt with a patient reminder, and 9 studies examined the effects of prompting the clinician in one study group compared to reminding both the clinician and patient in the other group. To remind patients, 15 mailed reminder letters, and eight studies notified patients via telephone. One study put up fliers and posters for the patients, one study visited patients at their homes to encourage vaccinations, and another study chose to educate patients on the importance of preventive care to encourage their return visits. Table 5 summarizes the effectiveness of clinician reminders only, and the combined approach of clinician and patient reminders. The average increase in preventive care procedure compliance was larger when prompting only the clinician (14%) compared to prompting both the clinician and the patient (11%) All but two of the studies prompted the physician before the patient appointment or at the time of order entry.

Table 5: Type of prompt for physician and patients

Prompt	Number of Interventions (Number of studies)*	Average difference % (range)	Standard Deviation
Clinician only	178 (44)	14 (-18 to 60)	16
Clinician and Patient	112 (26)	11 (-24 to 45)	13

* - The total number of interventions exceeds 273 because nine studies, evaluating various numbers of preventive care measures, compared the effect of a unique prompting technique in a clinician only group versus a combined clinician and patient group.

Thirty-three of the studies were set at academic medical centers, while the remaining 28 studies were utilized in non-academic hospitals and clinics. Five studies (9.6%) were performed in an inpatient setting, and the remaining 56 studies were in primary care clinics. In the inpatient studies, vaccination strategies were most often studied. The number of facilities ranged from 1 (39 studies) to 1,655 hospitals or practice groups.

Thirteen studies looked at the cost analysis of the reminders. Eleven of these studies confirmed the cost-effectiveness of the reminders; although only one mentioned the benefit of increased immunization was worth a slightly higher cost (83). Of these reminders, four were paper-based, nine were computer-generated, and none were computerized.

Discussion

This systematic review summarized findings from 61 randomized controlled clinical trials using reminders to increase preventive care. Overall the number of published reminder studies in outpatient and inpatient settings steadily increased from 6 reports prior to 1985 to 19 reports since 2000. Overall the prompting of clinicians continues to demonstrate a positive effect on the delivery of the 16 preventive care measures. In recent years, the reminder strategies shifted from paper- to computer-based approaches.

Approaches that included a paper-based reminder component (paper-based or computer-generated) remained the most frequent implementation strategies (87%) and had a similar

average effect as computerized reminders (14% versus 13%). In studies that included a paper-based component, a reminder sheet is attached on the front of the patient chart or tagged the paper chart in some form, indicating that the paper-record remains an important source of information and documentation instrument in many hospitals and clinics. To implement preventive care measures that require multiple steps during a visit, paper-based solutions can be easier integrated with the clinical workflow as compared to designing an information technology solution that depends on the provider's workstation use. Paper-based implementation strategies are effective when the number of targeted preventive care measures is limited. With increasing numbers of preventive care measures, the paper-based process may quickly reach its limitation. However, clinical workflow processes that rely on paper charts may continue to favor paper-based implementation strategies.

Computer-generated reminders were the most common type of reminders (56%). In recent years, however, computer-generated prompts decreased, while computerized reminders increased. The recent increase in applying computerized reminder strategies suggests that clinical information systems are increasingly providing the infrastructure to implement preventive care reminders. Computerized reminder systems require an electronic medical record throughout the practice or hospital; however, only 7-13% of physicians are using an electronic medical record system (99). Implementing preventive care measures using computerized reminders may overcome some of the paper-based implementation challenges. Although clinical information systems may provide an easier to scale and more sustainable infrastructure, they work best when clinicians can complete

all steps involved in offering preventive care measures, avoiding the need to switch between paper-based and electronic means. For example, adoption of computerized reminders may be higher if systems apply computerized algorithms for eligibility screening, prompt clinicians at the right time, offer quick ordering processes, and facilitate documentation. Unfortunately the availability of such advanced information system environments remain the exception rather than the rule.

As each encounter with the healthcare system provides an opportunity to offer preventive care measures, keeping pace with the many different recommendations and various schedules remains a major challenge for busy clinicians that are expected to focus on a patient's current reason for the visit. Although clinical information system can keep track of the various recommendations and schedules, they may lead to "prompting fatigue" as an unintended consequence. An additional challenge is the fragmentation of health care information, which requires providers to repeatedly verify the patient's eligibility, a time-consuming task even for one preventive care measure. As the healthcare sector applies more information technology, sharing information among providers may lessen that burden in the future.

In the studies looking at a cost analysis of reminders, eleven studies found them to be cost-effective. Of these reminders, four were paper-based, nine were computer-generated, and none were computerized. The computer-generated reminders have a higher start-up cost, however, once started, computerized reminders are cheaper to maintain than paper-based reminders.

In summary, this review showed an increasing trend of applying information technology for reminding clinicians to offer preventive care measures. As information technology reminder solutions may provide a better scalable and more sustainable model for the increasing burden of following different preventive care guidelines, more studies examining the effect of clinical information systems on supporting computerized reminder solutions for preventive care measures are needed.

CHAPTER III

CREATING AND VALIDATING A PNEUMOCOCCA VACCINATION REGISTRY

Introduction

Pneumococcal infection is caused by *Streptococcus pneumoniae* and affects both children and adults. Pneumococcal pneumonia affects 500,000 patients each year of which 40,000 die (12). Pneumococcal infections are associated with 60% to 87% of pneumonia infections (12). Vaccination against pneumococcal infection has been shown to be a cost-effective preventive measure (13). If the 23 million elderly patients eligible for vaccination were immunized in the United States, it is estimated that $194 million in medical expenses would be saved. The U.S. Preventive Task Force and Healthy People 2010 have developed national guidelines emphasizing the importance of preventive care (1, 2). Every encounter with the health care system is an opportunity to provide preventive care services, yet actual preventive services remain under-utilized (3).

Background

Healthy People 2010 set a goal of 90% vaccination rate of high risk patients for pneumococcal infection, and a 65% vaccination rate for patients younger than 65 years with a chronic disease (1). The Center for Disease Control defines high-risk persons as people older than 65 years of age or younger persons who are immunocompromised, have a chronic illness such as diabetes, or have received an organ transplant (12). The Center for Disease control recommends that high-risk patients receive a second

vaccination if they were vaccinated originally more than 5 years ago and were younger than 65 years of age at the time. Patients older than 65 with an unknown vaccination status should receive only one dose of Pneumovax (12). A 2003 report produced by the Center for Disease Control reports that as of September 2002, only 55% of high risk patients were vaccinated (15). A 2003 retrospective study showed only 14% of patients presenting with pneumococcal bacteremia had been vaccinated despite being eligible for the vaccine (100). Pneumococcal vaccination is also a recommended routine childhood immunization. The pneumococcal 7-valent conjugate vaccine (PCV7, Prevnar) is used for pediatric patients, while the Pneumovax-23® (Merck), a polysaccharide vaccine that contains 23 serotypes of *S. pneumoniae*, is used in adults (101, 102).

An Immunization Registry (IR) tracks patients' immunization status and helps determine which patients are up-to-date and which are due for a vaccination. IRs are often utilized in pediatric clinics to help ensure that children are up-to-date with their vaccination schedule. A 2004 study of a pediatric emergency department showed that the presence of an IR would increase the opportunities for intervention in a large population of patients who were not up-to-date (103). IRs have also been shown to improve immunization rates in adult populations (104).

Several methods have been studied for improving immunization rates. Paper-based methods such as tagging the patient's chart have been successful at improving immunization rates (62, 83). Standing orders in the Emergency Department, in which nurses can vaccinate patients without a specific physician order, have been shown to

increase pneumococcal vaccination rates (105). A health maintenance flow sheet in the patient record is another effective method of increasing immunization rates (106). Computerized reminders were used to increase vaccination rates in inpatient settings (5); however, in these systems the patients are often screened by the nurses or clinicians, not by an automated or computerized system. Developing an IR for high-risk patients can help to automatically screen patients for vaccination status and generate computerized reminders using informatics tools.

The goal of this study is to develop a keyword search to parse the electronic medical record (EMR) to build an IR for pneumococcal vaccination. Then validate this search tool using a population of patients 65 years and older, seen in the primary care clinics. The purpose of the study was to expand the feasibility of a Pneumovax registry for use in primary care clinics that was not dependent on structured data entry.

Methods

Setting

Vanderbilt University Medical Center is a private teaching hospital with 75,000 primary care patient visits per year. Patient records are stored in our EMR called StarPanel(27, 28). The computer system integrates the patient record, clinic notes, problem lists, and care-giver team communication. The EMR problem list includes different sections including a preventive care section. The patient record includes the Immunization Record, Outpatient Orders, and Clinical Communications. Outpatient orders can be either

electronic or hand-written and then scanned into the EMR. The problem lists are used to provide a quick view of a patient's medical history including medications, major procedures, and preventive care. In StarPanel, clinicians can create their own panels. The panels are subsets of patient charts for an individual clinician or clinic and may contain all patients seen by that clinician or clinic. Vanderbilt has six associated outpatient adult clinics, each of which utilizes StarPanel. StarPanel has been used at Vanderbilt since 2001. Patient problem lists are updated at every appointment.

Population

All patients with a pharmacy order for Pneumovax or PCV7 in the outpatient clinics in 2003 or 2004 were included in the study. Patients older than 65 years with a visit to the Vanderbilt University primary care clinics in Nashville, Tennessee between January 2003 and December 2004 were included in the study. The registry was designed to capture all patients who received Pneumovax and it was recorded in the EMR.

Study Design

This study is a retrospective, cross-sectional study. Pharmacy orders for pneumococcal vaccination were used as the gold standard to develop and validate a keyword search. The orders consisted of all Pneumovax orders in the outpatient clinics in 2003, and they were used to derive a set of keywords for identifying patients who had received Pneumovax.

The keyword search was performed on the patient's entire EMR, and a second search restricted to the problem list, which is a subset of the EMR, was performed. The searches

were performed iteratively using the concepts “pneumovax,” “pneumococcal,” “pneumonia,” and “vaccination.” Possible misspellings and common transpositions were also considered. A regular expression was written in a Perl script to automatically search the entire patient record for any of the derived terms. The keyword search can be performed on an entire text record in real-time. Scanned order sheets, while part of the EMR, were not searchable using automatic methods, and therefore were counted as not documented in the final analysis of records. The final keyword search developed on the 2003 pneumococcal pharmacy orders was validated on the 2004 pharmacy orders.

As part of additional analysis, we applied the validated keyword search on all patients in the clinics older than 65. These patients had appointments in 2003 or 2004. The total numbers of visits per year and per patient were calculated. If a patient was in a panel and therefore had been seen in that clinic but had no appointments in 2003 or 2004, they were not counted in the final analysis. Appointments were tallied separately for 2003 and 2004, and patients could appear in both datasets. Patients were extracted from the appointment files if they were over 65 years of age. A patient’s age was calculated by year of birth subtracted from year of appointment.

The keyword search was also tested on a registry of diabetes mellitus patients as they are eligible for pneumococcal vaccination. The registry contains all patients who have at least two appointments in the last five years. All patients older than 65 matching the keyword search were placed into a Pneumovax registry, and all patients with a Pneumovax order were added to the registry.

Outcome variables

Our primary outcome was the number of vaccinations captured in the 2004 orders using a keyword search developed to capture pneumococcal vaccination orders in the EMR on the 2003 orders as a training set. Data measures included the accuracy of the keyword search for the 2003 pharmacy orders, the validation of the keyword search for the 2004 orders, the list of keywords and their variants, the number of patients older than 65 without Pneumovax documentation in their EMR, and the number of patients in the diabetes mellitus database without Pneumovax documentation in their EMR.

Analysis

Statistical analysis was performed using chi-squared and t-tests where appropriate. This study was approved by the local Institutional Review Board and Research and Human Rights Committee.

Results

Primary Analysis

Patients with Pneumovax Pharmacy Orders

Patient characteristics for the 2003 and 2004 Pneumovax pharmacy orders are shown in Table 1. The average age of patients vaccinated in 2003 was 57 and was 60 in 2004. For the remaining vaccinated patients, only 104 (8.7%) of them were younger than 18 in 2003. 55 (5.0%) were younger in 2004. Patient ethnicity was missing for 10% of patients in 2003 and 7% in 2004. The 2003 and 2004 patient characteristics with a pharmacy

order were not significantly different.

Table 6: Characteristics of patients with orders.

	2003 (n=1201)	2004 (n=1095)	p-value
Female	56.1%	56.3%	0.91
White race	849	813	0.057
Black race	210	181	0.54
Visits / patient	2.56	2.35	0.05
Age > 65 years	42.0%	48.3%	0.002

Comparison of Keyword Searches

Keyword searches developed using the 2003 Pneumovax orders, are shown in Table 2 along with some of the most common keywords and spellings used to develop the Perl regular expression. If the search terms composed of multiple words (e.g. p vax, pneumonia vax), zero or more spaces were allowed between the words. The most common misspelling was transposition of the E and U in “pneumo-.”

During derivation, 94% of vaccinations were captured, and 1.3% of the orders could only be found in scanned order sheets. In 5% of the orders, no electronic documentation was found to verify the vaccination had been given. The test set noted 96% of the Pneumovax orders, and only 2.6% of these were not seen documented somewhere in the EMR, with 1% of the orders being found only scanned into the EMR. Two more variations of Pneumovax were found “Pneumaovax” and “Pneumonia vaccine.” For orders not matching any keyword search, the EMR was manually searched for a record of immunization.

A search of the term "vax" on the 2003 orders resulted in 141 matching records. Sixty-five percent of the records matched some form of the word Pneumovax and these variants were incorporated into they keyword search. Fifty-seven percent of the records matched the term "Flu vax." Records also matched "tetanus vax" and "Hib-vax." The terms Pneumovax and pneumococcal returned most of the records in the searches, pneumonia was too general a term without being followed by "vax" or "vac."

Table 7: Keyword Search Terms

Concept	Search term	Variant	Misspellings
pneumonia	pneumonia		pneumonia
			pneumona
	pneumo		pnuemo
	PCV7		
pneumococcal	pneumococcal		pnuemococcal
vaccination	vac	vacc	
		pneumonia vac	pnuemonia vac
		pneumonia vacc	pnuemonia vacc
pneumovax	pneumovax	vax	vaxx
		p vax	
		pneumonia vax	pnuemonia vax
			pneumona vax
			pneumon vax
			pnuemovax
			pnumovax
		pneumo vax	pnuemo vax
			pnemu vax
			pnem vax

758 patients (63%) in the 2003 order set had a pneumococcal vaccination recorded in the immunization section of their EMR. The keyword search in 2003 resulted in 96% of vaccination orders being captured and 98% in 2004. Table 3 shows the keyword search

results for all of the terms found.

Table 8: Search Results 2003 orders

Search Term	Hits	Percentage Found
pneumovax	953	79.4
pneumococcal	860	71.6
pneumonia	640	53.3
vac	204	17.0
vax	141	11.7
pneumo	120	10.0
pvax	45	3.7
p\vax	45	3.7
p vax	28	2.3
pnumovax	26	2.2
vacc	24	2.0
pnuemovax	23	1.9
pnuemonia	22	1.8
pneumo vax	19	1.6
pneumonia vacc	9	0.7
pneumonia vac	6	0.5
pneumonia vax	5	0.4
pneumona	3	0.2
pnem vax	2	0.2
pnemu vax	1	0.1
pneumon vax	1	0.1
pnuemo vax	1	0.1
pnuemo	1	0.1

Table 4 shows results from the keyword searches for each of the patient subsets. The problem list search revealed only a small number of vaccinations are recorded in the Preventive Health section. Of the positive searches for the Pneumovax keywords, 21% stored that information in the problem list.

Table 9: Keyword search results for patients with Pneumovax orders

	2003 (n=504)	2004 (n=529)	p-value
EMR	486 (96%)	518 (98%)	0.06
Problem List	113 (22%)	112 (21%)	0.69

Secondary Analysis

Full Clinic Population

Patient characteristics for the 2003 and 2004 clinic visits were not significantly different (Table 5) as expected due to significant overlap. The average age of the patients seen in 2003 was 48 and was 49 in 2004. A 77% overlap was seen in the 2003 and 2004 patient visits older than 65 years of age, 9,174 patients were seen at least once in both years. The majority of the patients were white females with an average of 2.6 visits per patient per year. In 2003 and 2004, 3% of the patients were younger than 18. In 2003 and 2004 18% and 14%, respectively, of the patients' ethnicity were not entered or unknown.

Table 10: Patient Characteristics – Full Clinic

	2003 (n=28,635)	2004 (n=29,431)	p-value
Female	60.6%	60.0%	0.14
White race	19,167	20,593	<0.001
Black race	3,731	3,975	0.08
Visits / patient	2.64	2.56	<0.001
Age > 65 years	20.2%	20.1%	0.76

High-risk Patients

Applying the keyword search on all patients aged 65 years and older with an appointment in 2003 or 2004 revealed that 60% of the patients had evidence of vaccination in the clinics (Table 6). This leaves 40% of the eligible population without vaccination documentation. When the keyword search was run on the patients older than 65 with a clinic visit in 2004, only 63% of them had a Pneumovax recorded. The keyword search run on the diabetes registry also gave only 61% vaccination. Both of these patient populations should achieve a recommended 90% vaccination rate.

Table 11: Keyword search results high-risk patients

	2004 visits (n=6118)	DM Pts (n=2539)
EMR	3879 (63%)	1544 (61%)
Problem List	864 (22%)	313 (12%)

Discussion

This EMR search was used efficiently for detecting and recording pneumococcal vaccination status (94-96%); however, no standard entry exists for the vaccination status, leading to the increased risk for misspellings, false entries, typographical errors, and multiple representations of the same concept. No paper-chart review was performed in this analysis; it is probable that the undocumented 5% and 2.6% of patients from the 2003 and 2004 data have been recorded only in the paper chart. Similarly, recent clinic patients

older than 65 may have only had vaccinations recorded on a paper chart. The Pneumovax IR will help bring together all of the keyword variation and eventually the paper data.

We found that it is not sufficient to only examine the problem list to screen a patient for vaccination status. Only 20% of the orders matching the keyword search were recorded in the problem list, however, searching the entire patient record found 96% to 98% of the vaccination orders.

The IR can be used as a tool in developing a computerized reminder system. We chose to only search patients 65 or older, as this an easily defined and large subset of high risk patients who benefit from pneumococcal vaccination. Preliminary results using the keyword search on a registry of diabetes patients shows a 61% vaccination rate and a promising method to include chronic diseases in the registry. Future plans for this program include the addition of search strategies to detect patients with other chronic diseases defined by the Pneumovax recommendations from the Center for Disease Control as we have piloted diabetes patients. A patient's chronic disease and vaccination status can be used to predict if their clinician should be reminded about the patient's immunization needs. Expanding the registry to include all pneumococcal high-risk chronic diseases would increase accuracy of the registry and thus create a better tool for clinicians.

Conclusion

Currently the registry contains patients who have received a Pneumovax vaccination in

2003 or 2004 and those matched by the keyword searches of the 2003 and 2004 visits. A total of 4,768 patients matched at least one keyword in the search and were added to the immunization registry. All of the patients in the registry are 65 or older. The keyword search captured 98% of the patients in the 2004 validation set who had received pneumococcal vaccination. This search can be used to help create a reliable registry for the primary care clinicians. Applying the same keyword search found that 66% of eligible patients with an appointment in 2003 and 63% with an appointment in 2004 had been vaccinated with Pneumovax. Almost 40% of the patients seen each year are left unvaccinated. An immunization registry can help to bring the hospital up to meet the goals of Healthy People 2010.

CHAPTER IV

PROVIDERS' BELIEFS, ATTITUDES, AND BEHAVIORS

Introduction

Pneumococcal infections are a considerable cause of morbidity and mortality, including 3,000 cases of meningitis, 50,000 cases of bacteremia, 500,000 cases of pneumonia, and 40,000 deaths annually (12). Pneumococcal vaccination is safe, cost-effective and reduces the rates of invasive infections (107-112). High-risk patients are defined by the Centers for Disease Control and Prevention (CDC) as patients older than 65 years of age and patients younger than 65 with a chronic illness (12). Despite widespread recommendations, pneumococcal vaccination rates for high-risk individuals are 46-59% (1, 113-115) and remain far below the 90% vaccination goal of Healthy People 2010 (1, 31).

Interventions to increase pneumococcal vaccination include educational initiatives, provider feedback, organizational change, financial incentive, and reminders (33). Different provider reminder implementation approaches such as paper-based (106, 116-118), computer-generated (119, 120), or fully computerized (5, 11) strategies have been successful in increasing vaccination rates in various settings. To further increase vaccination rates, the CDC and the Centers for Medicare & Medicaid Services have promoted the implementation of standing orders (121, 122), which were effective in

various settings (11, 81, 118, 123). However, the implementation of standing orders may not be feasible in institutions that mandate a physician order (89).

The Emergency Department (ED) setting is a challenging environment for the delivery of vaccinations that are unrelated to the patient's primary reason for visit. Unlike primary healthcare providers, ED clinicians provide episodic care in a multitasking, communication-intensive setting where patient records frequently lack pertinent and quickly available information that would support a determination of a patient's vaccination eligibility. Due to additional challenges such as overcrowding (124, 125), or nurse shortage (126), and lack of hospital beds (127), the ED setting may not be perceived as an optimal setting for offering pneumococcal vaccination. From 1992-2002 an estimated 266,000 pneumococcal vaccinations were given in EDs nationally (20). However, many patients at high risk for pneumococcal disease frequently seek care in the ED representing a unique opportunity to offer the vaccine (19). The existing opportunities (17, 128) and the feasibility (18, 21, 105, 129) of an ED-based vaccination program have been demonstrated, and the American College of Emergency Physicians endorses ED-based vaccination initiatives (21). However, experiences in the ED setting remain scare, and there is very limited information about ED provider's attitudes, beliefs, behaviors, and perceived barriers for offering pneumococcal vaccination in the ED (19).

With the increased implementation of clinical information systems, it is conceivable that information technology in the ED may provide the infrastructure to overcome certain logistical barriers and facilitate recommended vaccination initiatives. The goal of this

study was to understand beliefs, attitudes and behaviors of ED health care providers prior to implementing a computerized reminder system in our ED.

Methods

Study Setting and Population

The adult ED at Vanderbilt University Medical Center in Nashville, Tennessee, is an academic, urban, Level 1 Trauma Center with more than 50,000 visits annually. All emergency medicine attending and resident physicians and full-time nurses were eligible. The ED did not have a pneumococcal vaccination program and provided pneumococcal vaccination for less than 1% of eligible ED patients.

Study Design

We designed an anonymous, self-administered survey to understand the attitudes and behaviors of emergency medicine clinicians. The survey was administered during a two-month period (December 2005 to January 2006) prior to the implementation of a computerized vaccination reminder system in the ED. The survey design was approved by the Vanderbilt University Medical Center Institutional Review Board.

Survey Content and Administration

The study survey was designed to elicit ED physicians' and nurses' attitudes and behaviors regarding pneumococcal vaccination in the ED. The survey was partitioned

into sections and included aspects from previous pneumococcal surveys and articles (18, 19, 118, 130, 131).

The survey included sections on participant demographics, vaccine recommendation and ordering practices, use of the computerized patient record, beliefs on vaccination importance, successful implementation strategies, methods to increase vaccination rates, factors to consider when offering the vaccine, and perceived barriers to administer the vaccine. Participant demographics and characteristics included age, gender, years in practice since certification for attending or level of training for resident physicians. Participants were queried for their influenza vaccination status for the current and previous season, as provider vaccination status has been linked to recommending vaccinations to patients (130). To assess participants' vaccine recommendation and ordering practices we collected the perceived frequency of recommending and ordering of influenza and pneumococcal vaccination in the ED. To assess the use of the ED information technology infrastructure for querying and verifying the patient's vaccination status, the survey inquired about frequency, location, and timing of workstation usage during a patient's ED encounter. We collected providers' opinions on ED patient's being up-to-date with recommended immunization schedule for tetanus, influenza, and pneumococcal vaccinations. We queried providers for preferred implementation strategies for an ED based vaccination initiative. The final sections asked participants to rate different approaches to increase vaccinations in an ED setting and perceived barriers that may prevent providers to offer them to ED patients.

Answers were measured on a 5-point Likert-scale ranging from "1- Strongly Agree," "2 - Agree", "3 - Neutral," "4 - Disagree," or "5 - Strongly Disagree"; or "1 - Always," "2 - Sometimes," "3 - Usually," "4 - Rarely," or "5 - Never," where appropriate. Space for free-text comments was provided after each section. The survey was pilot tested with three board-certified physicians and one resident (internal medicine and pediatrics).

The survey packet included a cover page, the 46-item survey that was color-printed on two pages, a non-monetary incentive, a hand-written note by the investigators and an opaque, uniquely numbered, sealable envelope. To indicate that the participant had responded, they were instructed to return the survey in the numbered envelope. An initial distribution in December 2005 was followed by contacting participants during one of their shifts during the following month. Prior to data entry, the survey was separated from the envelope, allowing for tracking non-responding participants while keeping responses anonymous. One investigator entered all survey data into a Microsoft Access® database. To examine the accuracy of data entry a 30% randomly sampled number of surveys were reentered by a second investigator, and showed high correlation ($\kappa = 0.998$, 95% confidence interval: 0.996-1.0).

Data Analysis

Exploratory analysis was conducted to assess the physicians' and nurses' beliefs and perceived behaviors regarding vaccinations, computer use during a patient's ED encounter, barriers to vaccination, successful reminder system strategies, and factors influencing vaccinating patients. Descriptive statistics were generated with frequencies

and percentages for binary variables, and means and standard deviations (SD) for continuous or five-point variables. Five-point variables were compared between the physician and nurse respondents by Mann-Whitney test. Spearman correlation coefficients were reported for the associations between five-point survey questions. Responses to influenza and pneumococcal vaccinations were compared using a Wilcoxon signed rank test. A probability value less than 0.05 was considered statistically significant.

Results

Demographics

ED physicians returned 68 (96%) of the 71 distributed surveys, and all 93 surveys given to nurses were returned (100%). Participants' demographics are shown in table 1. The mean age of physicians was 35.8 ± 7.9 years and the mean age of nurses was 40.7 ± 10.1 years. In the 2004/05 influenza season 91% of physicians (2005/06 season: 92%) and 61% (2005/06 season: 68%) of nurses reported receiving vaccination.

Table 12: Participant demographics

Attending physicians (n = 37)	
Age, mean (years)	37.9
Gender (female)	27%
Years since board certification	8.0
Resident physicians (n = 27)	
Age, mean (years)	32.0
Gender (female)	65%
PGY-1	33%
PGY-2	33%
PGY-3	30%
Fellow	4%
Nurses (n = 93)	
Age, mean (years)	40.7
Gender (female)	84%

Table 13: Survey Results	Physicians (n=68)		Nurses (n=93)	
Recommending patients to receive vaccine outside the ED	Mean[1]	SD	Mean[1]	SD
Influenza	3.3	1.1	2.9	1.2
Pneumococcal	3.9	0.9	3.3	1.1
Ordering vaccine during the patient's ED visit				
Influenza	3.9	0.7	4.3	0.9
Pneumococcal	4.7	0.5	4.3	0.9
Use of information system				
View patient information on computer before patient exam	1.7	0.7	2.1	1.0
View patient information on computer in the exam room	3.3	0.9	2.3	0.9
View patient's problem list	1.3	0.5	1.6	0.9
View patient's health maintenance section	3.1	1.1	2.6	1.2
View patient's immunizations section	3.5	1.0	2.9	1.3
In the ED population, importance of being up-to-date with immunization of				
Tetanus, without an injury present	1.7	0.8	1.7	0.9
Influenza	1.9	0.8	1.9	0.8
Pneumococcal	1.9	0.8	1.9	0.9
Believe that pneumococcal vaccination is:				
Cost effective for ED patients	2.1	0.8	2.4	1.1
Important for ED patients	2.1	0.9	2.1	1.0
Successful ED strategies for implementing a vaccine reminder system are				
Nurse standing order	2.5	1.2	3.0	1.2
Nurse standing order combined with physician notification	2.1	1.0	2.4	1.2
Physician order	3.0	0.8	2.2	1.0
Methods to increase vaccination rates in the ED				
Paper-based reminder	2.9	1.0	2.7	1.1
Computerized reminder	1.6	0.7	1.9	0.9
Improved documentation in the electronic medical record	2.1	0.8	2.1	1.0
Feedback on physicians' vaccination rates	2.8	1.1	2.9	1.1
Patient education	2.5	0.8	1.9	0.8
More ED staff	2.7	0.9	2.5	1.1
Physician education conferences	2.9	0.9	2.4	1.0
Important factors to consider when offering vaccination to ED patients				
Vaccine effectiveness	1.8	0.7	1.7	0.6
Patient's risk for illness	1.6	0.6	1.5	0.5
Vaccination adverse effects	1.6	0.6	1.6	0.6
Antimicrobial resistance	2.0	0.8	1.8	0.8
Recommendation from experts	1.8	0.8	2.0	0.8
Patient's request or interest for vaccine	1.8	0.7	1.7	0.6
Determining patient's vaccine status directly from patient	2.2	0.8	1.9	0.7
Determining patient's vaccine status in the electronic medical record	1.8	0.6	1.9	0.7
Barriers to offering vaccination to ED patients:				
Remembering to offer vaccination	1.5	0.6	1.9	0.8
Difficulty in identifying high-risk patients	2.4	0.9	2.4	1.0
Insufficient time to counsel	1.8	0.8	1.9	0.8
Too busy with other tasks	1.7	0.8	2.1	1.0
ED is inappropriate setting	3.3	1.1	3.1	1.2
Cost/reimbursement	3.0	0.9	2.6	1.0
Inadequate ED personnel	2.9	0.8	2.8	1.2
Medico-legal liabilities	3.2	0.9	2.7	1.0

[1] Likert Scale: 1 - Strongly Agree/Always; 2 - Agree Usually; 3 - Neutral/ Sometimes; 4 - Disagree/ Rarely; 5 - Strongly Disagree/Never

Vaccination Ordering Patterns

Table 2 displays the average Likert score answer and standard deviation for the survey questions for physicians and nurses. Comparing physician and nurse responses to recommending patients receive vaccinations outside of the ED, nurses were more likely to recommend influenza and pneumococcal vaccinations than physicians ($p=0.005$ and $p=0.003$). Physicians' responses to recommending influenza vaccination were positively associated with their responses to recommending pneumococcal vaccination ($p<0.0001$); however, physicians were more likely to recommend influenza vaccination than pneumococcal vaccination ($p<0.0001$). Similar findings were observed for nurses' responses ($p<0.0001$ for both).

When physicians agreed that it was important for patients to be up-to-date with recommended vaccination, they tended to recommend influenza ($p=0.010$) and pneumococcal vaccination ($p=0.014$), but they were neutral in ordering the influenza vaccine during the ED visit ($p=0.081$). There was a marginal significant association between the belief in the importance of being up-to-date and ordering the influenza vaccination ($p=0.081$). Nurses tended to recommend influenza ($p=0.004$) and pneumococcal vaccine ($p<0.001$); however, they did not tend to remind physicians to order influenza vaccination ($p=0.197$) when they felt it was important for the patients to be up-to-date with vaccination.

Physicians who were more likely to recommend that patients receive the pneumococcal vaccination, agreed on the cost-effectiveness ($p=0.004$) and the importance ($p=0.004$) of

the vaccine. These results were similar for nurses (cost-effectiveness: $p<0.001$; importance: $p<0.001$).

If nurses themselves were up-to-date with influenza vaccination, they were more likely to recommend pneumococcal ($p=0.02$) or tended to recommend influenza vaccination ($p=0.07$).
However, physicians' influenza vaccination status was not correlated with them recommending the influenza or pneumococcal vaccine to patients ($p=0.89$ and $p=0.90$, respectively).

Use of Information Technology

The computerized medical record was usually viewed before a visit by both physicians (1.8 ± 0.70) and nurses (2.1 ± 1.0). When in the patient's room, physicians sometimes (3.3 ± 0.9) accessed the medical record while nurses usually viewed the record (2.3 ± 0.9). Physicians almost always viewed the problem list (1.3 ± 0.5); however they accessed the health maintenance section only sometimes (3.2 ± 1.1) and the immunization section even less frequently (3.6 ± 1.0). Nurses reported similar usage of the problem list (1.6 ± 0.9), health maintenance section (2.6 ± 1.2), and immunization sections (2.9 ± 1.3).

Implementation Strategies

Physicians and nurses had differing opinions on an optimal implementation strategy for an ED-based vaccination program. Physicians agreed on a nurse standing order policy while nurses remained neutral ($p=0.001$). Nurses tended to agree with a physician order while physicians remained neutral ($p<0.001$). Both physicians and nurses agreed that a successful strategy for implementing a pneumococcal vaccination reminder system would include a combination of a nurse order with physician notification before administration ($p=0.243$).

Factors

When asked about important factors to consider when offering the vaccination to ED patients, physician and nurses agreed that all the mentioned factors were relevant. The strongest factors for physicians and nurses were the patient's risk for illness (physicians: 1.6 ± 0.6; nurses: 1.5 ± 0.5) and the vaccine's adverse effects when offering the vaccine to patients (physicians: 1.6 ± 0.6; nurses: 1.6 ± 0.6).

Barriers

Physicians agreed that remembering to offer the vaccination to eligible patients (1.8 ± 0.6) and being too busy with other tasks (1.8 ± 0.8) were major barriers to offering vaccines to ED patients. Nurses agreed that remembering to offer the vaccine (1.9 ± 0.8) and insufficient time to counsel patients (2.4 ± 0.9) were considerable barriers preventing them from vaccinating eligible patients.

Discussion

Offering pneumococcal vaccination in the adult ED may help to boost overall vaccination rates. However, in a study testing the feasibility of an ED based vaccination program, only 51% of 128 ED physicians indicated a willingness to provide pneumococcal vaccination to their patients and 93% indicated that they had never ordered or given the vaccine in the ED (19). Common reasons for failing to offer preventive care included the beliefs by clinicians that the ED was an inappropriate place for preventive care measures, lack of time or personnel, and concerns about adverse reactions. In contrast, another study found that 89% of eligible patients were willing to receive the pneumococcal vaccination while in the ED (22). Referring patients outside the ED for pneumococcal vaccination may be conceived as a potential solution to overcome existing barriers, but was not an effective measure for increasing vaccination rates (24).

The results of the survey indicate that physicians in our ED are willing to vaccinate patients during the ED visit, but may not have enough time, may be too busy, or may not remember to offer the vaccination during the visit. A nurse order combined with physician notification prior to administration was the most preferred implementation approach by both physicians and nurses. Despite recommendations of utilizing standing orders, ED staff preferred a combined approach that would share responsibilities in the pneumococcal vaccination process. These findings are key to assist in the development of an ED-based vaccination program, as provider acceptance of the tool is a primary determinant of the intervention's success.

Our survey is limited as we targeted physicians and nurses from one academic center, which may differ from vaccination practices and beliefs in other ED settings. Although the survey was performed as a readiness assessment study prior to implementing a computerized reminder system in an ED that has access to various information systems, we believe that nurses' and physicians' reported attitudes of pneumococcal vaccination practices are similar to other ED settings. Further our study was limited to associations among self-reported beliefs, attitudes, and behaviors of clinicians. We were not able to examine associations with pneumococcal vaccine administration as an outcome, because administering the vaccine in our ED is extremely rare, reflecting the national trend of low ED-based pneumococcal vaccination practices (20).

In summary, physicians and nurses did not differ significantly in many of their beliefs and practices regarding pneumococcal vaccination. Although ED staff had favorable attitudes and beliefs for offering pneumococcal vaccination to ED patients, various barriers encountered in and characteristic of the ED setting seem to hinder ED staff to provide the recommended preventive care measure. Applying information technology to overcome existing barriers may facilitate more efficient ED-based vaccination initiatives.

CHAPTER V

DEVELOPMENT AND IMPLEMENTATION

Introduction

Streptococcus pneumonia is one of the most common infectious diseases. In the US pneumococcal disease is associated with 500,000 cases of pneumonia, 40,000 deaths annually(12), and an average cost of $10,000 per hospital admission (128). Pneumococcal vaccination is a safe and cost-effective measure to lessen the impact of invasive disease (13). For the adult population, the Centers for Disease Control and Prevention (CDC) recommend pneumococcal vaccination for all patients ≥65 years old or <65 with a chronic illness(12). Current vaccination rates for high-risk patients remain around 60%, far below the 90% target rate set forth by Healthy People 2010(1),(15).

The emergency department (ED) provides care for many patients at high-risk for pneumonia and has been suggested to be a suitable environment for a pneumococcal vaccination program (17). Only limited investigations exist in the ED (18) and experiences with implementing computerized vaccination reminders have not been reported.

The goal of the study was to design and implement a closed-loop, computerized reminder system to increase pneumococcal vaccination rates in the ED by creating an integrated informatics environment that is embedded with the clinicians' workflow.

Background

Approaches for implementing vaccination programs

Vaccination reminder systems are often implemented in primary care. Various paper-based, computer-augmented, and computerized approaches have been implemented in the inpatient and outpatient environment in order to increase vaccination rates. Paper-based reminders are often placed on the paper chart as a flag, a sticker, or a sheet of paper (4). Physicians or nurses screen patients for eligibility. Computer-augmented reminders use computerized algorithms to identify eligible patients, but the prompt is printed out to remind the clinician. True computerized reminders are entirely electronic, i.e., computerized algorithms identify eligible patients, and prompts are provided upon access to the clinical information system. Vaccination reminder systems are often implemented in the primary care or inpatient environment. However, many patients use the ED as their primary care facility, and thus never have the opportunity to be vaccinated in traditional primary care environments (132).

Challenges for an ED vaccination program

For many patients the ED is the sole health care provider and represents the only opportunity for vaccination. The ED faces major challenges that decrease the chance of implementing a successful and sustainable vaccination program. The ED environment is characterized by an interruptive, multitasking, communication- and information-intensive work pattern, which is further exacerbated by the nation's overcrowding burden, and the shortage of nurses and inpatient beds. These factors and the perception that the ED is an

inappropriate setting for offering preventive care measures are a considerable challenge to an ED-based vaccination initiative (19). Only 266,000 patients received a pneumococcal vaccination in the ED from 1992-2000 (20).

In spite of these challenges, the ED remains an opportunity for vaccinations; the American College of Emergency Physicians has recommended pneumococcal vaccination programs (21) and the Centers for Medicare and Medicaid Services reimburse ED-based vaccine administration. However, experiences with pneumococcal vaccination programs in the ED remain limited. One ED, which had a 3% vaccination baseline, implemented a paper-based system that increased the vaccination rate by 35% (18).

Patient surveys have provided positive responses for receiving the vaccination during their ED visit (22). However, some patients believe the vaccination is not necessary, prefer that it be given by their primary care physician, are unsure of their vaccination status, confuse pneumococcal vaccine with the influenza vaccine, or have reimbursement concerns (23). These challenges may require educational efforts that compete with other ED care priorities. Referring patients outside of the ED has been shown to be an ineffective method of increasing vaccination (24).

Readiness assessment

To determine user vaccination practices and beliefs prior to system implementation in the ED, we conducted a survey among the ED nurses and physicians (133). The survey was

returned by >95% of ED staff members and helped to determine what type of reminder system was preferred. Although standing orders for pneumococcal vaccination programs are a successful and recommended approach (11), they were least favored among our ED nurses and physicians. The most favored approach was that the vaccine order remain the physicians' responsibility.

Design Objectives

The design objectives were influenced by the workflow of the vaccination program, which included the following steps: determining the patient's current vaccination status, establishing eligibility, informing and educating the patient, obtaining consent to vaccinate, communicating with the ED physician, verifying eligibility in the context of the ED visit, placing the order, administering the vaccine, and documenting the administration. In consideration of the described workflow, the ED reminder system had three main design objectives that we considered critical for a successful implementation.

1. *Integration with clinical workflow:* The approach should be embedded in the clinical workflow of the ED by making relevant patient information available when the health care provider and the patient are asked to make a decision. The system should avoid unnecessary interruptions of workflow.
2. *Closed-loop approach:* The informatics approach should take full advantage of the ED information technology infrastructure, allowing for a fully computerized solution for each step in the process. In an integrated approach, the information systems should support the ED staff by verifying vaccination status, screening patients, applying CDC

guideline criteria for determining eligibility, and ordering, administering, and documenting the vaccine administration. This documentation can be used to obtain and verify vaccination status for future encounters. This should provide the basis for a completely integrated, computer-based approach to the various required vaccination steps.

3. *Information display and data capture:* Information should be available at the right time, presented to the right individuals, and in the right format. For example, the triage nurse can verify current vaccination status with the patient during the computerized triage documentation while documented preventive care measures from the patient's electronic problem list are automatically displayed. Data entry and navigation should be minimal. Patients and providers should be able to easily opt out at any time during the process.

Following the design objectives, the system was developed in collaboration with ED nurses, physicians, and leadership members from the ED and the hospital. The system's initial implementation phase targeted the patients ≥65 and did not consider screening of patients <65 with co-morbidities who were eligible for vaccination. This approach was chosen to a) allow the ED staff time to adopt the vaccination program, b) test the feasibility of a closed-looped reminder system in the ED for a distinct set of patients at high risk, and c) create a sustainable information system infrastructure.

System Description

Setting

The Vanderbilt University Adult ED is an urban, academic, level 1 trauma center with 47 beds and >45,000 ED visits annually. The ED lacks a pneumococcal vaccination policy, resulting in a vaccination rate of <0.1% of eligible patients. The baseline pneumococcal vaccination rate for the targeted ≥65 years old patients is 49.8% upon their presentation to the ED.

Informatics infrastructure

The ED information infrastructure includes a computerized whiteboard, which provides the point of entry for the four information systems that were the basis for the computerized vaccination reminder (Figure 1). The four information systems include the electronic medical record (EMR)(27, 28), the computerized triage application(25), the computerized provider order entry system (CPOE)(26), and the order tracking application.

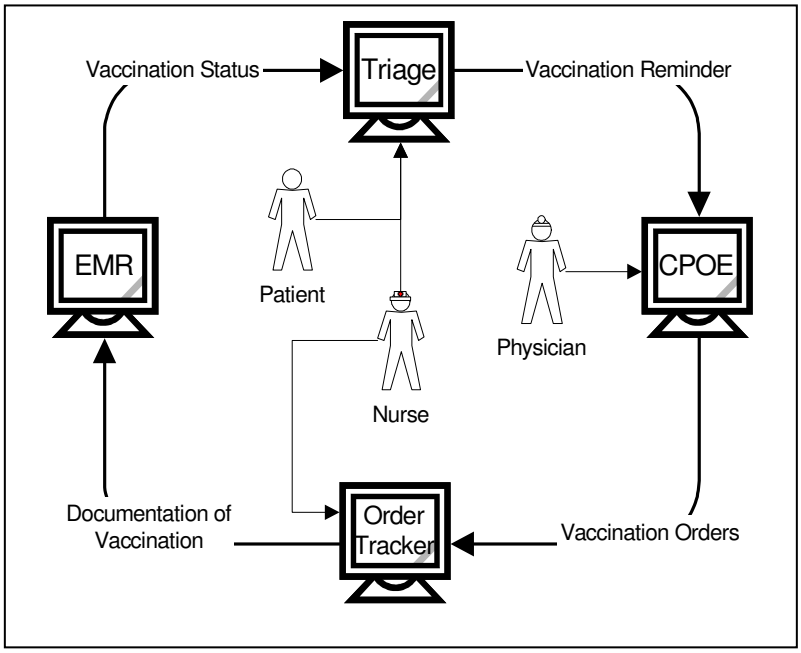

Figure 3: Closed loop information flow

Electronic Medical Record

Vanderbilt's longitudinal EMR includes patient information since 1994 (134) It represents the institution's primary repository for all patient information, including problem list, clinic notes, procedure notes, scanned documents, exam reports, and caregiver team communications.. The patient's problem list is semi-structured and includes sections for current problems and medications, past medical history, major procedures, and preventive care measures. The free-text preventive care section includes completed screening exams and the patient's current vaccination status.

Computerized Triage Application

The computerized ED triage application was installed in the summer of 2005 (25). The triage system captures triage data in mostly coded format. In addition to capturing the usual triage information (current and past medical history, current medication, pain assessment, vital signs, acuity level, chief complaint, etc.), the triage nurse completes an initial screening for diseases, domestic violence, and cultural needs, and assesses the patient's vaccination status. The triage application includes patient information retrieved from the problem list, such as allergies, medications, and the health maintenance record (including immunization status), which aids the nurse during the triage process. Figure 2 shows the embedded health maintenance section from the problem list. The pneumococcal vaccination screening question is mandatory for the targeted population, which was supported by the ED leadership team.

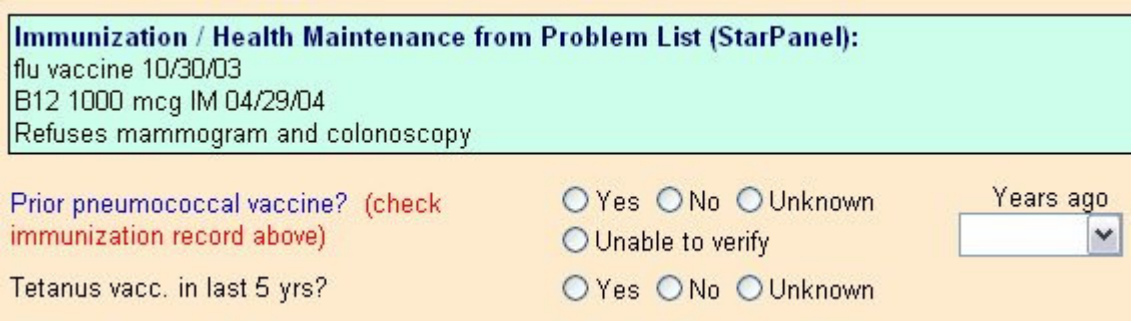

Figure 4: Pneumococcal immunization status screening in the triage application.

If a patient meets the CDC guidelines for vaccination, a reminder appears on the triage summary page (Figure 3). The summary page is displayed after completing the triage documentation and reminds the nurse about time-sensitive and critical tasks that need to be initiated early during a patient's ED encounter. The reminder prompts the nurse to

inform the patient about being eligible for the recommended vaccination. The nurse discusses if they would like to receive the vaccine during his ED visit. If the patient declines, the system captures a refusal reason. If the patient consents, the triage application sends a message to the CPOE system.

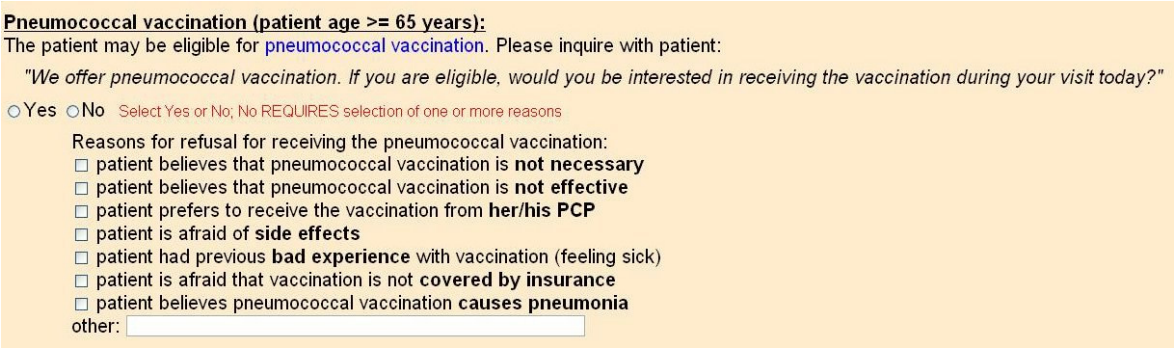

Figure 5: Triage vaccination reminder.

Computerized Provider Order Entry System

Vanderbilt's CPOE system is used in all inpatient wards and the ED. The CPOE system was implemented in the ED in spring of 2004(26). Currently >90% of all medication orders are entered by physicians. If eligible patients consent to receive the vaccine, the CPOE system prompts the physician to order the vaccine once, at the end of the first ordering session. We chose to apply the reminder to the first order session in case the CPOE system was used only once during an ED encounter. The end of the first session was chosen to lessen interference with the orders that are related to the patient's primary reason for the ED visit. The CPOE physician reminder is displayed in Figure 4. One mouse click is necessary to accept or decline the vaccination order; an additional mouse

click is necessary to choose a refusal reason from a pre-populated list. If the physician places the order, the order is sent to the order tracking system.

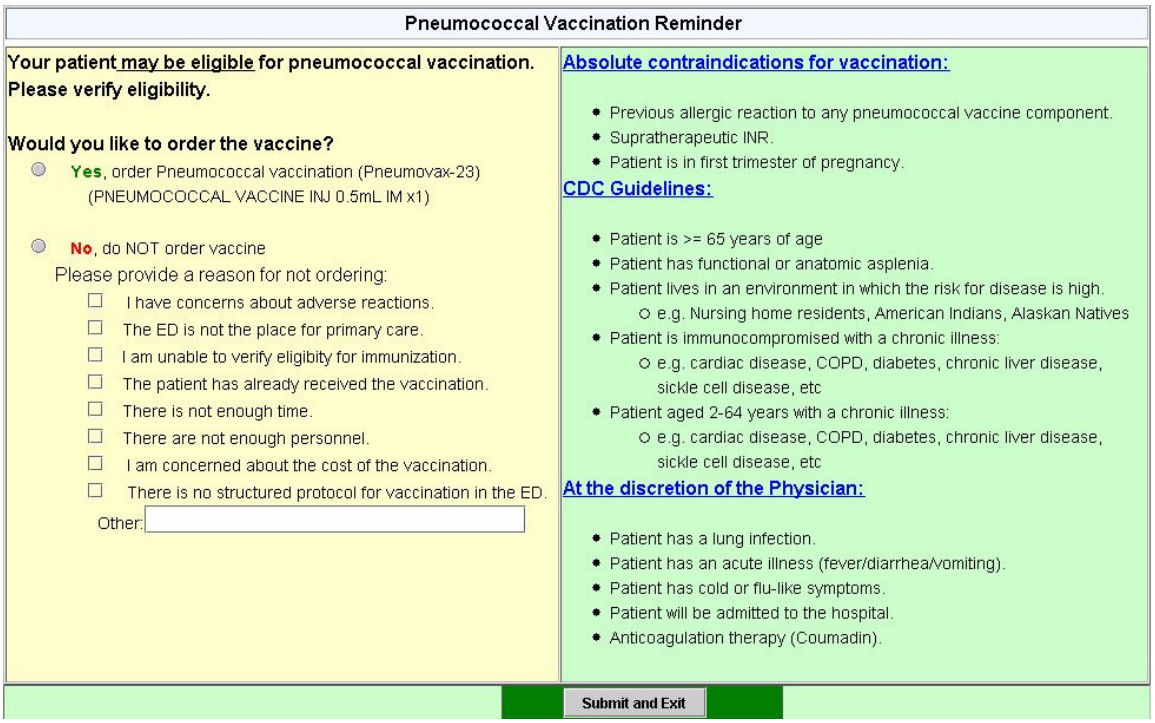

Figure 6: Pneumococcal vaccination prompt in the CPOE system.

Order Tracker System

The order tracker system was implemented in the ED together with the CPOE system. Order tracker is a work list of orders and allows ED nurses to electronically document ED orders, eliminating the need for paper printouts. Order tracker documentation is sent to the EMR as an ED order summary. The nurse documents the administration of the pneumococcal vaccine order in order tracker, including the lot number. If a patient refuses the vaccine at this time, the nurse can document the refusal in the system. A successful order administration is appended to the order summary and the health

maintenance section on the EMR's problem list.

Applied Technology

The information technology infrastructure to connect the various information systems for the pneumococcal vaccination application used the Perl and Java programming languages, and Oracle® and MySQL® databases.

Status Report

Readiness assessment

Before implementing the reminder system, we addressed educational and organizational issues. The system was planned, developed, and implemented with input from the end users. The weekly ED information system meetings, which include the director of the adult ED, the ED administrative director, the ED nurse manager, assistant manager, and nurse educators, as well as representatives from information system support, registration and the development team were used as the primary user discussion forum. The nurse manager and educator took responsibility for informing and educating the nursing staff. Information was presented and discussed at the ED faculty meetings and during resident conferences. The ED leadership added the pneumococcal vaccination program to its evaluation parameters. To increase awareness, we provided patient leaflets, posters, and vaccine information.

System implementation

The system has been in continuous operation in the adult ED since 01/30/2006. In general the informatics approach was favorably received by the ED nurses and physicians. Vaccination reminders that did not result in a successful vaccine administration included valid refusal reasons relating to the patient's status (23).

Lessons learned

The institution was affected by vaccinating patients in the ED and we initially underestimated this organizational aspect. Many providers and patients believe the ED is an inappropriate setting for pneumococcal vaccination. Primary care providers, in particular, may be concerned that the ED is overstepping its boundaries and that ED vaccination is an indication of the failure of primary care.

In our institution approximately 30% of admitted patients were initially cared for in the ED. The inpatient provider teams may agree that the most appropriate time for pneumococcal vaccination is hospital discharge rather than during the ED encounter. However, from an ED perspective, it is frequently not known whether the patient will be admitted to the hospital or discharged. The ED personnel embraced the idea that the ED encounter should not be a missed opportunity. In addition, pneumococcal vaccination has a very low adverse event rate (135). The Medical Center Medical Board, which includes all department chairmen, approved the ED vaccination practice.

As the ED was assuming its new vaccination responsibility, a strong educational and

information sharing initiative was needed. Despite our efforts, we noticed during informal observations that nursing staff were screening all ED patients. Some triage nurses felt that triage was an inappropriate time for vaccination screening, particularly if patient education about vaccination was needed.

Prospective evaluation

The system's impact on ED vaccination rate is currently being examined in a prospective interventional study (23). All patients presenting to the adult ED 65 years of age and older were included in the study. Patients were excluded if they had an Emergency Severity Index of 1 or did not undergo computerized triage documentation. During an initial 6-week study period, the system screened more than 600 patients for vaccination eligibility.

Discussion

In this paper, we described the design, development, and implementation of a computerized pneumococcal vaccination reminder system that used available information systems to create a closed-loop informatics solution in a challenging environment. The system is integrated into the ED workflow and is able to manage information at the point of decision making. We believe that the initially described design objectives of integration with clinical workflow, closed-loop approach, and managing information at the right time, in the right format, and involving the right individuals, were met.

The system demonstrates that it is possible to leverage different information technology

applications to create an integrated and closed-loop approach for a reminder or decision support system. Having access to such an infrastructure allows the design of systems that are "simple" and "do not stop clinicians," but rather change a clinician's direction (136). In addition, the user-driven development created a workflow-suitable approach that supported the acceptance among the busy ED clinicians.

Reminder systems have been effective in the inpatient setting with similar CPOE adoption issues from providers (11). We wanted to examine user acceptance and behavior, and evaluate the system prior to targeting all eligible patients. One of the system's limitations is that it only targets an elderly population. Previous work and early experiences from our ED suggest that this includes about 49% of eligible patients (137). Because the ED did not have a pneumococcal vaccination policy, the current system represents a feasibility study for the closed-loop approach. Furthermore, an automated approach to determine eligibility for patients <65 years old ideally would have coded co-morbidities electronically available. The problem list in our EMR is currently semi-structured making the integration of past medical history information more challenging. Asking the triage nurse to collect this information would not fit into the current workflow and we should investigate a computerized solution. An additional limitation of the system includes the determination of previous pneumococcal vaccination from the unstructured representation of the health maintenance record. We have developed an approach to identify pneumococcal vaccination from the health maintenance section and free text reports (16); however, determining the date of administration remains a challenge. Our system can easily scale to other types of vaccinations, preventive care measures, or

screening programs in our institution.

In summary, we believe this to be the first study targeting pneumococcal vaccination in the ED using computerized tools. It is currently being evaluated in a prospective study. Our system is scalable to other vaccinations and preventive care procedures. We believe the system can be successfully applied at other institutions to improve preventive care practices.

CHAPTER VI

PROSPECTIVE EVALUATION

Introduction

Pneumococcal vaccination is recommended for patients ≥65 years old and patients <65 years with co-morbid illnesses. However, current vaccination rates remain far below the Healthy People 2010 target of greater than 90%. The Emergency Department (ED) has been recommended as a suitable environment for vaccine administration as it represents the primary access point to health care for a large number of eligible patients which creates unique opportunities to offer preventive care measures. Despite demonstrating the opportunity and feasibility of an ED based pneumococcal vaccination program, experiences with ED based pneumococcal vaccination initiatives remain scarce.

Computerized reminders have been successful at increasing vaccination rates in primary care and inpatient settings; they have not, however, been applied in an ED environment. We developed a "closed-loop," informatics-based reminder system infrastructure that was embedded in the clinical workflow and included four different patient care information systems. The goal of this study was to assess the effectiveness of a computerized reminder system on pneumococcal vaccination rates in ED environment.

Pneumococcal infections are a considerable cause of morbidity and mortality, including 3,000 cases of meningitis, 50,000 cases of bacteremia, 500,000 cases of pneumonia, and

40,000 deaths annually in the United States (12). Pneumococcal vaccination is safe, cost-effective and reduces the rates of invasive infections (13, 14, 107-109). Despite widespread recommendations, pneumococcal vaccination rates for high-risk individuals remain below the 90% vaccination goal of Healthy People 2010 (1). High-risk patients are defined by the Centers for Disease Control and Prevention (CDC) as patients older than 65 years of age and patients younger than 65 with a chronic illness (12). Only 46-55% of high-risk patients are currently vaccinated with pneumococcal vaccination (1, 113).

The Emergency Department (ED) setting has been recommended as a suitable environment for vaccination and presents a challenging environment for offering vaccinations that are unrelated to the patient's primary reason for visit. The ED is providing episodic care and frequently lacks pertinent patient information that would support a quick determination of a patient's vaccination eligibility. Due to additional challenges such as frequent overcrowding (113, 127, 138, 139), or the shortages of nurses (140) and hospital beds (125), the ED setting may not be perceived as an optimal setting for offering pneumococcal vaccination. However, many patients at high risk for pneumococcal disease frequently seek care in the ED representing a unique opportunity to offer the vaccine (127). The American College of Emergency Physicians endorse ED-based vaccination initiatives (21). The feasibility of an ED-based vaccination program has been demonstrated (18, 19, 105) and the implementation of a vaccination program in the ED increased vaccination rates (17, 118, 128). However, experiences in the ED setting remain scarce (105, 129).

With the increased implementation of clinical information systems, it is conceivable that information technology in the ED may provide the infrastructure to facilitate recommended vaccination initiatives. We prospectively evaluated a "closed-loop," informatics-based reminder system on vaccination rates in the ED. The system was embedded in the clinical workflow and included 4 different information systems: the electronic patient record (EMR), the computerized triage application, the computerized provider order entry (CPOE), and the order tracker application.

The goal of this project was to assess the effectiveness of a computerized reminder targeting pneumococcal vaccination in the adult ED.

Methods

Study Setting and Population

The adult ED at Vanderbilt University Medical Center in Nashville, Tennessee, is an academic, urban, Level 1 Trauma Center. The ED staff includes 37 attending physicians, 34 resident physicians, and 93 full-time nurses who provide care for more than 50,000 patients annually.

The ED information infrastructure includes a computerized whiteboard which provides the point of entry for the four information systems that were the basis for the computerized vaccination reminder infrastructure (Figure 1). The information systems

include the electronic medical record (EMR) (27, 28), the computerized triage application (25), the computerized provider order entry system (CPOE) (26), and the order tracking application.

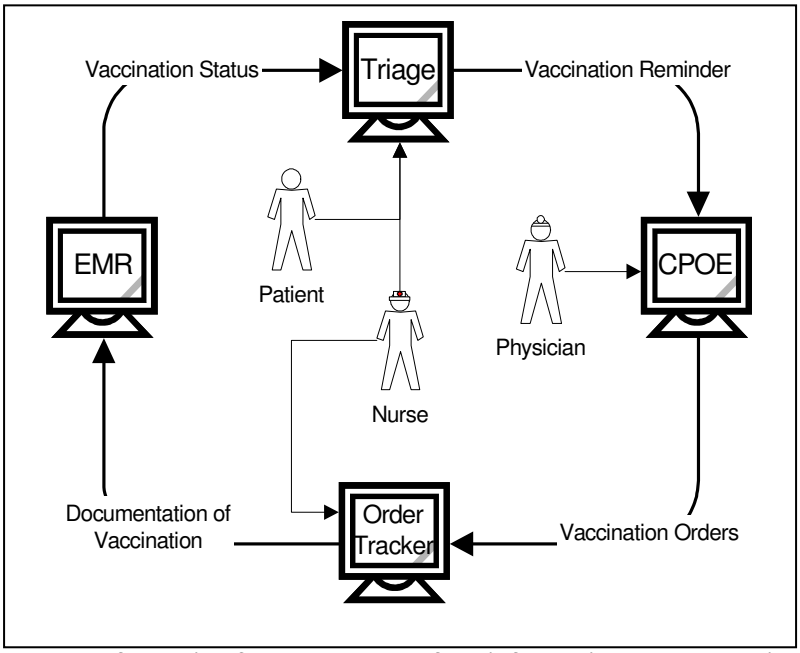

Figure 7: Information flow through the four informatics system used in the ED.

In the EMR the patient's problem list is semi-structured and includes sections for current problems and medications, past medical history, major procedures, and preventive care measures. The free-text preventive care section includes completed screening exams and the patient's current vaccination status.

The computerized triage application captures patient data in mostly coded format. As part of the computerized triage documentation, the nurse completes an initial assessment of

the patient's vaccination status while having access to the patient's health maintenance record in the EMR. After completing the documentation a triage summary page reminds the nurse for recommended tasks that are a result of the triage assessment.

Providers enter the patients' orders into the CPOE system. Physicians were prompted at the end of an order-entry session regarding pneumococcal vaccination.

Order tracker documentation is sent to the EMR as an ED order summary. The nurse documents the administration of the pneumococcal vaccine order in order tracker, including the lot number. If a patient refuses the vaccine at this time, the nurse can document the refusal in the system. A successful order administration is appended to the order summary and the health maintenance section on the EMR's problem list.

The study included patients 65 years old and older presenting to the adult ED during a two-month period (January 30, 2006 to March 30, 2006). We excluded patients with the highest acuity level based on the Emergency Severity Index (141, 142), patients without physician-entered orders in the CPOE system, and patients without computerized triage documentation, such as patients who left without being seen or were referred to another clinic prior to the triage process.

The study was approved by the Vanderbilt University Medical Center Institutional Review Board.

Intervention

All patients 65 years and older were included in the study. A patient's vaccination status was retrieved from the EMR and displayed in the computerized triage application. During the triage process the nurse verified the patient's vaccination with the patient. The pneumococcal vaccination status assessment was mandatory for the targeted population. The triage nurse documented current pneumococcal vaccination status reconciling information from the patient and the EMR problem list (Figure 1). Following the CDC pneumococcal vaccination guidelines, the system determined eligibility based on the patient's age, current vaccination status, and year of prior vaccination.

If a patient met the CDC guidelines for vaccination, the triage summary page displayed a nurse reminder prompting the nurse to inform the patient about being eligible for the recommended vaccination. After the opportunity to provide educational information, the nurse inquired whether the patient would like to receive the vaccine during the ED visit. If the patient declined, the system captured the refusal reason. If the patient consented, the triage application notified the CPOE system.

The CPOE system prompted physicians who consented to participate in the study to order the vaccine once at the end of a physician's first ordering session. We chose to display the vaccination reminder during the first order session of a physician in case the CPOE system was used only once during an ED encounter. The end of the first session was chosen to lessen interference with the orders that were related to the patient's primary reason for the ED visit. The physician reminder provided information that the patient may

be eligible for pneumococcal vaccination and has agreed to receive it during the current visit, the CDC guideline criteria including contraindications. One mouse click was necessary to accept the vaccination order; if the physician decided not to order the vaccine, the prompt captured a refusal reason from a pre-populated list. The placed order was sent to the order tracking system, which allowed the nurse to document the vaccine administration. Vaccine administration documentation was finally sent to the health maintenance section on the patient's problem list.

Outcome Measures

Our primary outcome measure was the increase of vaccination rates for patients 65 years and older. The secondary outcome measures included refusal reasons for both physicians and patients.

Statistical Analyses

Descriptive statistics were calculated for all patients available in the data set. A Fisher's exact statistic was used to calculate nominal variables. All reported *p* values are 2-tailed. Data analysis was performed using STATA software (version 9.1, Stata Corp., College Station, TX).

Results

Demographics

From 8676 total ED visits, 834 (9.6%) patients were 65 years old and older, with 727 unique visits. Patients were included as intent-to-treat. Of the target population, 433 (51.9%) were up-to-date and 401 (mean age 76.4 ± 7.8 years, mean acuity level: 2.5 ± 0.64) were eligible to receive the vaccine. 264 patients refused vaccination. Demographics are shown in table 1.

Table 14: Patient Demographics

Patients > 65	(n=834)	stdev
Gender (female)	58.6%	
Mean age (years)	77.06	7.49
Mean acuity	2.42	0.60
Ethnicity		
White	63.1%	
Black	19.4%	
Unknown	17.5%	
Disposition		
Admit	60.7%	
LWSD	28.3%	
LA	7.4%	
Other	3.6%	
Average LOS (days)	0.43	0.44
Chief Complaint		
PCP	75.9%	

Table 15: Physician Demographics

Prompted physicians	(n = 47)
Gender (% male)	60
Mean prompts	2.9
Mean orders	0.94

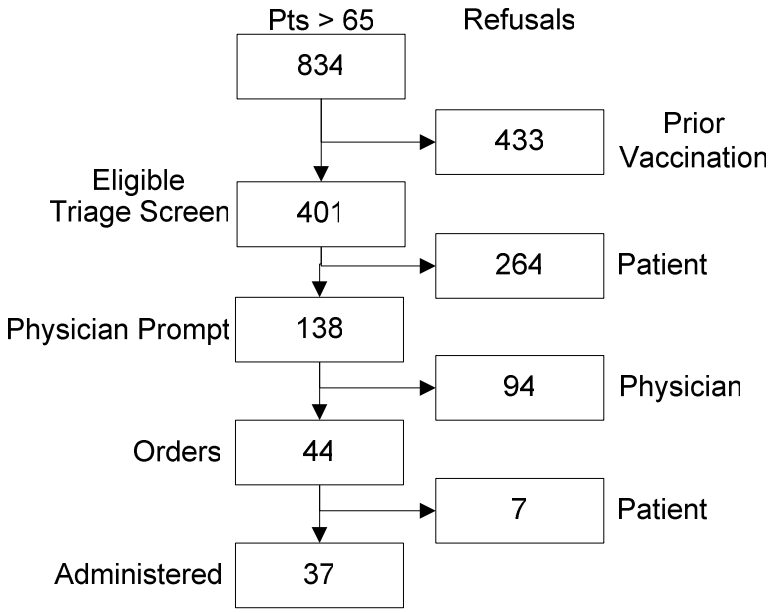

Figure 8: Patient 65 and older.

As compared to the ED baseline vaccination rate, the computerized reminder system increased ED vaccination rates from 51.9% to 56.4 % ($p < 0.01$). There were 122 unique ICD-9 coded chief complaints from the eligible patients, the most common chief complaints were chest pain (9.0%), shortness of breath (10.1%), trauma multiple (7.1%), and weakness, general (6.9%).

Refusal Reasons

The most frequent patient refusal reasons are shown in figure 3. Other refusal reasons documented in the free text box included: patient has had one, patient is unable to answer questions, language barriers, and the patient does not want one.

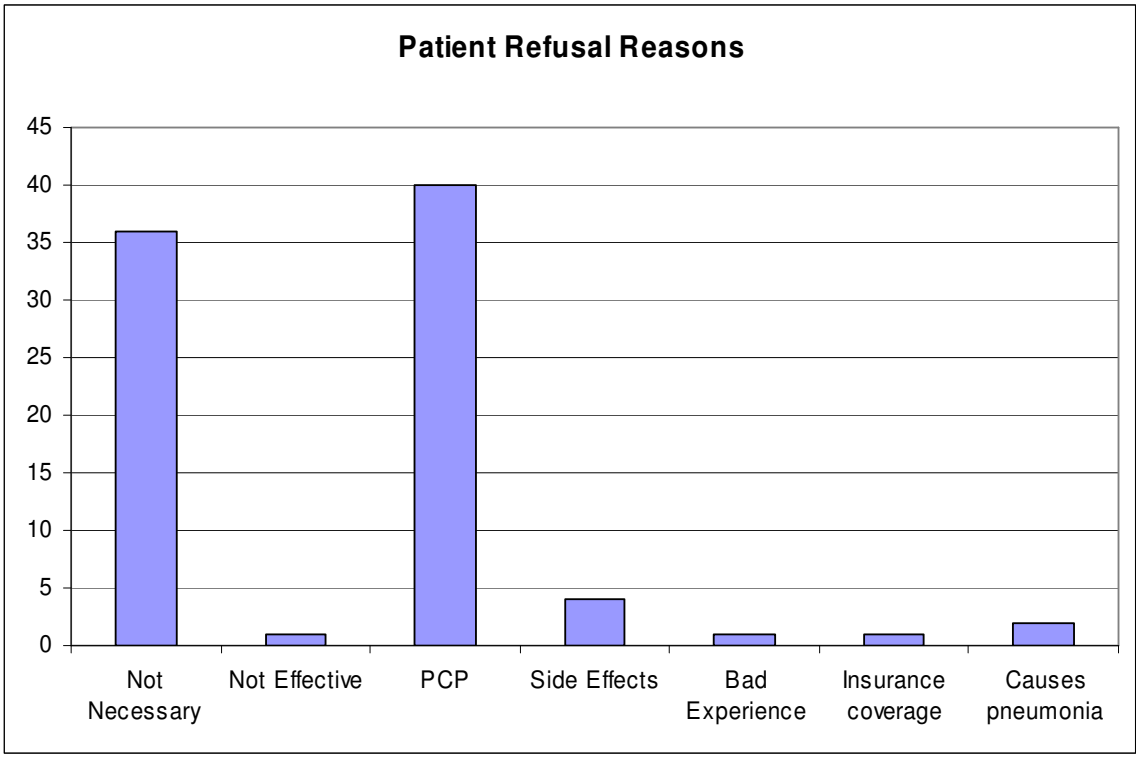

Figure 9: Patient Refusal Reasons in Triage.

Ninety-four physicians chose not to order the vaccination when presented with the vaccination reminder. The physician refusal reasons are shown in figure 4. Other refusal reasons typed into the free text box included: caretaker refuses, not the primary concern, patient is critically ill, patient has already had vaccination, and unable to access medical history.

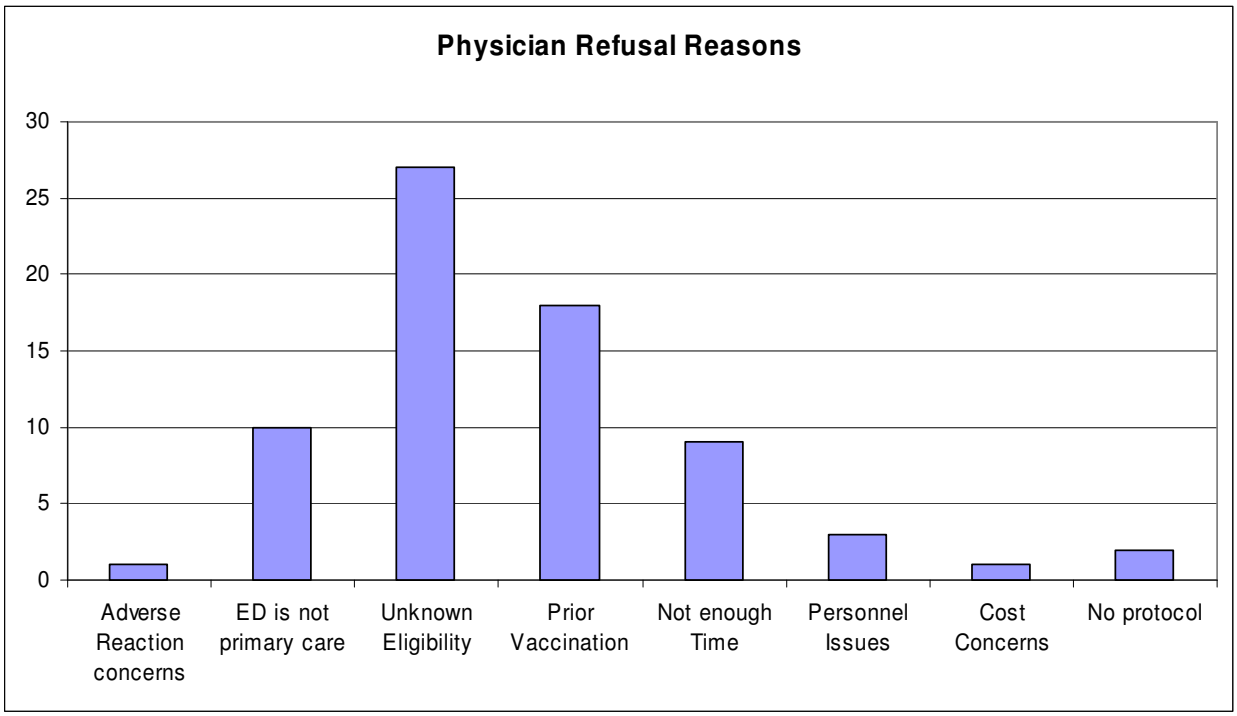

Figure 10: Physician refusal reasons

Seven patients refused the vaccination after it was ordered with reasons recorded such as a reported prior vaccination and no longer interested in receiving the vaccine. Four patients consented to be vaccinated during their visit, but there was no physician prompt.

Discussion

The closed-loop, informatics-based reminder system increased vaccination rates in the adult ED and created a sustainable, workflow-embedded, point-of-care infrastructure for a pneumococcal vaccination program in a challenging environment.

Many patients refused vaccination when asked during triage, suggesting increased patient education for the need for the vaccine. Most of the patients, 79% reported having a

primary care physician, but only 50% reported pneumococcal vaccination. Although the nurses were able to check the EMR for vaccination status, patient reporting was taken as the "gold standard" for determining eligibility.

One of the system's limitations is that it only targets an elderly population. Previous work and early experiences from our ED suggest that this includes about 49% of eligible patients (137). Because the ED did not have a pneumococcal vaccination policy, the current system represents a feasibility study for the closed-loop approach. Furthermore, an automated method to determine eligibility for patients younger than 65 years old ideally would have coded co-morbidities electronically available. The problem list in our EMR is currently semi-structured making the integration of past medical history information more challenging. Asking the triage nurse to collect this information would not fit into the current workflow and we should investigate a computerized solution. An additional limitation of the system includes the determination of previous pneumococcal vaccination from the unstructured representation of the health maintenance record. We have developed an approach to identify pneumococcal vaccination from the health maintenance section and free text reports (16); however, determining the date of administration remains a challenge. Our system can easily scale to other types of vaccinations, preventive care measures, or screening programs in our institution.

In summary, we believe this to be the first study targeting pneumococcal vaccination in the ED using computerized tools. Our system is scalable to other vaccinations and preventive care procedures. We believe the system can be successfully applied at other

institutions to improve preventive care practices. Many patients refused vaccination when prompted in triage, a patient education program could help to decrease these refusals.

CHAPTER VII

CONCLUSION

This thesis described the design, development, and prospective evaluation of a pneumococcal vaccination reminder system in the adult ED. A systematic literature review summarizing data from 66 randomized controlled trials (1966-2004) examined reminder system implementations and their success rate. The literature review differentiated between paper-based, computer-generated, and fully computerized reminders systems for prompting clinician for preventive care procedures in the inpatient and outpatient settings. The review found that paper-based reminder systems remain the most common implementation approach, while computerized methods have increased in recent years.

A feasibility study for creating a pneumococcal vaccination immunization registry studied if a simple keyword search that examined a patient's electronic medical record was able to identify patients with prior pneumococcal vaccination in the primary care clinics. A total of 4,768 patients matched at least one keyword in the search and were added to the immunization registry. This acted as a feasibility study of vaccination rates in the Vanderbilt primary care clinics. An immunization registry can help to bring the hospital up to meet the goals of Healthy People 2010.

Prior to implementing a computerized pneumococcal reminder system in the ED, we completed a readiness assessment through a survey among nurses and physicians in the adult ED. The survey examined clinicians' attitudes and beliefs on pneumococcal vaccination in the ED and the preferred way to implement a reminder system. Physicians and nurses favored a nurse order combined with physician intervention prior to administration for pneumococcal vaccination.

The development of the computerized reminder system in the adult ED focused on strong clinical workflow integration by taking advantage of the various clinical information system components. The reminder system utilized the electronic medical record to retrieve vaccination status, the computerized triage application to support the determination of a patient's eligibility criteria, the provider order entry system to remind physicians to order the vaccine for eligible and consenting patients, the order tracker system to notify the nurses about the vaccine order, and finally the electronic medical record which was sent the vaccination update documentation for administered vaccines.

This infrastructure created a "closed-loop" informatics approach, which was evaluated in a two-month prospective study that screened 834 patients aged 65 years and older and evaluated the effect of prompting physicians for offering the pneumococcal vaccinations to ED patients. During the study period 433 (51.9%) patients 65 years and older were up-to-date with pneumococcal vaccination, 260 (31.7%) declined to receive the vaccine during their ED visit. From the physician prompts, 94 (11.3%) the declined to order

vaccination, and 37 (4.4%) patients received the vaccine, the computerized reminder system increased vaccination rate from 51.9% to 56.4 % ($p < 0.01$).

Offering pneumococcal vaccination in the adult ED may help to boost overall vaccination rates. A previous ED survey reported common reasons for not offering preventive care included the ED being an inappropriate place for preventive care measures, lack of time or personnel, and concerns about adverse reactions (19). In contrast, a survey among ED patients showed that 89% of eligible patients were willing to receive the pneumococcal vaccination while in the ED (22). The results of the survey in this study indicated that physicians are willing to vaccinate patients in the ED, but may not have enough time, may be too busy, or may not remember to offer the vaccination during the visit. Overall, ED staff had favorable attitudes and beliefs for offering patients pneumococcal vaccinations. Our ED staff preferred a combined approach that would share responsibilities in the pneumococcal vaccination process and this was implemented using the available information systems.

We designed and developed a computerized pneumococcal vaccination reminder system using available information systems to create a closed-loop informatics solution in a challenging environment. The system was integrated into the ED workflow and was able to manage information at the point of decision making. The system demonstrated that it was possible to leverage different information technology applications to create an integrated and closed-loop approach for a reminder or decision support system. In addition, the user-driven development created a workflow-suitable approach that

supported the acceptance among the busy ED clinicians.

One of the reminder system's limitations is that it only targeted the elderly population. Previous work and early experiences from our ED suggested that patients 65 years and older include about 49% of eligible patients (137). Because the ED did not have a pneumococcal vaccination policy, the current system represents a feasibility study for a closed-loop informatics approach. An automated approach to determine eligibility for patients younger than 65 years old would require the availability of co-morbidities.. The problem list in our EMR currently represents free-text co-morbidities only in free-text format making the integration of past medical history information more challenging. Asking the triage nurse to collect detailed information would fit less into the current workflow. A possible computerized solution would involve a concept indexing of free-text terms on the problem list or the application of natural language processing methods. An additional limitation of the system included the determination of a patient's previous pneumococcal vaccination from the unstructured representation of the health maintenance record. We have developed an approach to identify pneumococcal vaccination from the health maintenance section and free text reports (16); however, determining the date of administration remained a challenge.

The informatics approach evaluated in this study may be scalable to other vaccinations and preventive care procedures, as additional data capture by busy ED clinicians was limited and relevant data were presented at the time of decision making. We believe the approach can be successfully applied at other institutions to improve preventive care

practices, given that an appropriate information system infrastructure is available.

In summary, we believe this to be the first study targeting pneumococcal vaccination in the ED using computerized tools. Four information systems were successfully integrated to increased vaccination rates in the adult ED. The prospective evaluation demonstrated an increase in vaccination rates among ED patients 65 years and older. The closed-loop, informatics-based reminder system increased vaccination rates in the ED and created a sustainable, workflow-embedded, point-of-care infra-structure for a pneumococcal vaccination program in a challenging environment.

APPENDIX

PHYSICIAN SURVEY

The ED*Pneumococcal Vaccination Profile ©

****

The purpose of this survey is to assess your beliefs, attitudes, and behaviors about vaccination practices in a general emergency department environment.

Information:

- This survey is **anonymous**.
- The information provided in this survey will only be used in **aggregate** form.
- The expected time to complete the survey is about **5 - 10 minutes**.
- Prior to data abstraction and analysis **the numbered envelope will be separated** from the survey guaranteeing your anonymity.
- The number on the envelope will allow the investigators to send out **reminders** for completing the survey.

Instructions:

- Answer **each** question in the survey.
- Return the **completed survey** in the provided envelope to **Pam Chunn**.

☺ **We appreciate your participation!** ☺

Corey Slovis, MD	Keith Wrenn, MD	Ian Jones, MD	Judith Dexheimer	Dominik Aronsky, MD, PhD
Professor & Chair	Professor & Vice-Chair	Director of Adult ED	Biomedical Informatics	Biomedical Informatics
Emergency Medicine	Director, Residency Prg	Emergency Medicine		Emergency Medicine
	Emergency Medicine			

If you have any concerns or questions related to this survey, you can contact:

Ian Jones, MD	Ian.Jones@vanderbilt.edu	936-0084
Dominik Aronsky, MD, PhD	Dominik.Aronsky@vanderbilt.edu	936-1739
Judith Dexheimer	Judith.Dexheimer@vanderbilt.edu	936-3573
The IRB office:		322-2918

Dept. of Biomedical Informatics
Dept. of Emergency Medicine

ED*PVP Instrument©
Judith Dexheimer/Dominik Aronsky

The purpose of this survey is to understand the attitudes, beliefs, practices and knowledge among physicians for immunization practices in an Emergency Department setting.

Demographics & Personal Information

1. Your age: _____ years
2. Gender: ☐ Female ☐ Male
3. Level of training: ☐ Attending Physician
   Year of board-certification: _____
   ☐ Fellow
   Year of board-certification: _____
   ☐ Resident - PGY-4 ☐ Resident - PGY-3
   ☐ Resident - PGY-2 ☐ Resident - PGY-1 ☐ Other: _____
4. Specialty training (current or completed): ☐ Emergency Medicine ☐ Internal Medicine ☐ Surgery ☐ Anesthesiology ☐ OB/GYN ☐ Psychiatry ☐ Other: _____

	Yes	No
5. Did you receive the **influenza** vaccination (or FluMist) **this** season (**2005 / 2006**) ?	☐	☐
6. Did you receive the **influenza** vaccination (or FluMist) **last** season (**2004 / 2005**) ?	☐	☐

During a patient's visit in the ED, how often do you **recommend**:	Always	Usually	Sometimes	Rarely	Never
7. the **influenza** vaccination to a patient (to receive **outside the ED**) ?	☐	☐	☐	☐	☐
8. the **pneumococcal** vaccination to a patient (to receive **outside the ED**) ?	☐	☐	☐	☐	☐

During a patient's visit in the ED, how often do you **order** (e.g. in WizOrder):	Always	Usually	Sometimes	Rarely	Never
9. the **influenza** vaccination for a patient (to receive during the ED visit) ?	☐	☐	☐	☐	☐
10. the **pneumococcal** vaccination during a patient's visit in the ED?	☐	☐	☐	☐	☐

	Always	Usually	Sometimes	Rarely	Never
11. How often do you view patient-specific information **before** you see/exam the patient? (e.g., in StarPanel)	☐	☐	☐	☐	☐
12. How often do you use the computer **in the exam room** (e.g., view patient-specific information in StarPanel, enter orders in Wiz, etc.) ?	☐	☐	☐	☐	☐
13. How often do you view an ED patient's **problem list** in StarPanel while a patient is in your care in the ED?	☐	☐	☐	☐	☐
14. How often do you view the **"Health Maintenance" section** in StarPanel's problem list while a patient is in your care in the ED?	☐	☐	☐	☐	☐
15. How often do you view the **"Immunizations" section** in StarPanel's problem list while a patient is in your care in the ED?	☐	☐	☐	☐	☐

In a general ED population I believe that it is important for adult patients to be up-to-date with the following immunizations:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
16. Tetanus prevention (patient is up-to-date **without** an open injury)	☐	☐	☐	☐	☐
17. Influenza vaccination	☐	☐	☐	☐	☐
18. Pneumococcal vaccination (eligible patients)	☐	☐	☐	☐	☐
Other (please explain): _____					

I believe offering the pneumococcal vaccination to eligible **ED patients** is:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
19. Cost-effective	☐	☐	☐	☐	☐
20. Important	☐	☐	☐	☐	☐
Other (please explain): _____					

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December 12, 2005

In a general ED setting, I believe that successful strategies for the implementation of pneumococcal vaccinations are:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
21. Nurse standing order with no physician involvement	☐	☐	☐	☐	☐
22. Nurse order with physician notification prior to administration (e.g., paper-based or computerized notification)	☐	☐	☐	☐	☐
23. A physician order	☐	☐	☐	☐	☐
Other (please explain): _____					

In a general ED setting, which methods do you believe are likely to help increase pneumococcal vaccination rates in eligible patients?	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
24. A paper-based reminder system (e.g., form, sticker on chart)	☐	☐	☐	☐	☐
25. A computerized reminder system (e.g., order entry system)	☐	☐	☐	☐	☐
26. Improved documentation in the patient's computerized patient record	☐	☐	☐	☐	☐
27. Feedback on individual physicians' vaccination rates	☐	☐	☐	☐	☐
28. Patient education (e.g., handouts, instruction material)	☐	☐	☐	☐	☐
29. More ED staff to help vaccinate	☐	☐	☐	☐	☐
30. Physician education conferences	☐	☐	☐	☐	☐
Other (please explain): _____					

I believe that the following factors are important to consider when offering the pneumococcal vaccination to ED patients:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
31. Vaccine effectiveness	☐	☐	☐	☐	☐
32. Patient's risk for illness	☐	☐	☐	☐	☐
33. Vaccination adverse effects	☐	☐	☐	☐	☐
34. Antimicrobial resistance of organism	☐	☐	☐	☐	☐
35. Recommendation from experts (e.g., local experts, national committees)	☐	☐	☐	☐	☐
36. Patient's request or interest for vaccination	☐	☐	☐	☐	☐
37. Determining the patient's vaccine status directly obtained from the patient	☐	☐	☐	☐	☐
38. Determining the patient's vaccine status in the clinical information system	☐	☐	☐	☐	☐
Other (please explain): _____					

I believe that important barriers to offering the pneumococcal vaccination to ED patients include:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
39. Remembering to offer vaccine	☐	☐	☐	☐	☐
40. Difficulty of identifying high-risk patients	☐	☐	☐	☐	☐
41. Insufficient time to counsel the patient in the ED	☐	☐	☐	☐	☐
42. Too busy with other tasks during an ED shift	☐	☐	☐	☐	☐
43. ED is an inappropriate setting for vaccination / preventive care measures	☐	☐	☐	☐	☐
44. Cost / reimbursement levels	☐	☐	☐	☐	☐
45. Inadequate ED personnel for administration	☐	☐	☐	☐	☐
46. Medico-legal liability issues	☐	☐	☐	☐	☐
Other: _____					

What would be helpful measures or strategies to increase overall vaccination rate?

_____

_____

For questions: Judith Dexheimer 936-3573 (Judith.Dexheimer@vanderbilt.edu) or Dominik Aronsky 936-1739 (Dominik.Aronsky@vanderbilt.edu)

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Dept. of Emergency Medicine

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Judith Dexheimer/Dominik Aronsky
December 12, 2005

NURSE SURVEY

The ED*Pneumococcal Vaccination Profile ©

****

The purpose of this survey is to assess your beliefs, attitudes, and behaviors about vaccination practices in a general emergency department environment.

Information:

- This survey is **anonymous**.
- The information provided in this survey will only be used in **aggregate** form.
- The expected time to complete the survey is about **5 - 10 minutes**.
- Prior to data abstraction and analysis **the numbered envelope will be separated** from the survey guaranteeing your anonymity.
- The number on the envelope will allow the investigators to send out **reminders** for completing the survey.

Instructions:

- Answer **each** question in the survey.
- Return the **completed survey** in the provided envelope to **Donna Mason**.

☺ **We appreciate your participation!** ☺

Corey Slovis, MD	Keith Wrenn, MD	Ian Jones, MD	Judith Dexheimer	Dominik Aronsky, MD, PhD
Professor & Chair	Professor & Vice-Chair	Director of Adult ED	Biomedical Informatics	Biomedical Informatics
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	Emergency Medicine			

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The IRB office:		322-2918

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The purpose of this survey is to understand the attitudes, beliefs, practices and knowledge among nurses for immunization practices in an Emergency Department setting.

Demographics & Personal Information

1. Your age: ..... _____ years
2. Gender: ..... ☐ Female ☐ Male
3. Level of training: ..... ☐ Associate Degree ☐ BSN (Bachelor in Nursing) ☐ MSN (Masters in Nursing) ☐ Diploma in Nursing ☐ Other: _____ ☐ Other: _____
4. Year of last degree obtained (certification): _____
4. Specialty training (current or completed): ..... ☐ CEN ☐ CCRN ☐ LifeFlight certification ☐ Other: _____

	Yes	No
5. Did you receive the **influenza** vaccination (or FluMist) **this** season (**2005 / 2006**) ?	☐	☐
6. Did you receive the **influenza** vaccination (or FluMist) **last** season (**2004 / 2005**) ?	☐	☐

During a patient's visit in the ED, how often do you **recommend**:	Always	Usually	Sometimes	Rarely	Never
7. the **influenza** vaccination to a patient (to receive **outside the ED**) ?	☐	☐	☐	☐	☐
8. the **pneumococcal** vaccination to a patient (to receive **outside the ED**) ?	☐	☐	☐	☐	☐

During a patient's visit in the ED, how often do you **remind** the **MD** to **order**:	Always	Usually	Sometimes	Rarely	Never
9. the **influenza** vaccination for a patient (to receive during the ED visit) ?	☐	☐	☐	☐	☐
10. the **pneumococcal** vaccination during a patient's visit in the ED?	☐	☐	☐	☐	☐

	Always	Usually	Sometimes	Rarely	Never
11. How often do you view patient-specific information **before** you see/exam the patient? (e.g., in StarPanel)	☐	☐	☐	☐	☐
12. How often do you use the computer **in the exam room** (e.g., view patient-specific information in StarPanel, enter orders in Wiz, etc.) ?	☐	☐	☐	☐	☐
13. How often do you view an ED patient's **problem list** in StarPanel while a patient is in your care in the ED?	☐	☐	☐	☐	☐
14. How often do you view the **"Health Maintenance" section** in StarPanel's problem list while a patient is in your care in the ED?	☐	☐	☐	☐	☐
15. How often do you view the **"Immunizations" section** in StarPanel's problem list while a patient is in your care in the ED?	☐	☐	☐	☐	☐

In a general ED population I believe that it is important for adult patients to be up-to-date with the following immunizations:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
16. Tetanus prevention (patient is up-to-date **without** an open injury)	☐	☐	☐	☐	☐
17. Influenza vaccination	☐	☐	☐	☐	☐
18. Pneumococcal vaccination (eligible patients).....	☐	☐	☐	☐	☐
Other (please explain): _____					

I believe offering the pneumococcal vaccination to eligible **ED patients** is:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
19. Cost-effective.....	☐	☐	☐	☐	☐
20. Important	☐	☐	☐	☐	☐
Other (please explain): _____					

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December 12, 2005

In a general ED setting, I believe that successful strategies for the implementation of pneumococcal vaccinations are:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
21. Nurse standing order with no physician involvement	☐	☐	☐	☐	☐
22. Nurse order with physician notification prior to administration (e.g., paper-based or computerized notification)	☐	☐	☐	☐	☐
23. A physician order	☐	☐	☐	☐	☐
Other (please explain): _____					

In a general ED setting, which methods do you believe are likely to help increase pneumococcal vaccination rates in eligible patients?	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
24. A paper-based reminder system (e.g., form, sticker on chart)	☐	☐	☐	☐	☐
25. A computerized reminder system (e.g., order entry system)	☐	☐	☐	☐	☐
26. Improved documentation in the patient's computerized patient record	☐	☐	☐	☐	☐
27. Feedback on individual nurses' vaccination rates	☐	☐	☐	☐	☐
28. Patient education (e.g., handouts, instruction material)	☐	☐	☐	☐	☐
29. More ED staff to help vaccinate	☐	☐	☐	☐	☐
30. Nurse education conferences, e.g., nurse grand rounds	☐	☐	☐	☐	☐
Other (please explain): _____					

I believe that the following factors are important to consider when offering the pneumococcal vaccination to ED patients:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
31. Vaccine effectiveness	☐	☐	☐	☐	☐
32. Patient's risk for illness	☐	☐	☐	☐	☐
33. Vaccination adverse effects	☐	☐	☐	☐	☐
34. Developing resistance of organism	☐	☐	☐	☐	☐
35. Recommendation from experts (e.g., local experts, national committees)	☐	☐	☐	☐	☐
36. Patient's request or interest for vaccination	☐	☐	☐	☐	☐
37. Determining the patient's vaccine status directly obtained from the patient	☐	☐	☐	☐	☐
38. Determining the patient's vaccine status in the clinical information system	☐	☐	☐	☐	☐
Other (please explain): _____					

I believe that important barriers to offering the pneumococcal vaccination to ED patients include:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
39. Remembering to offer vaccine	☐	☐	☐	☐	☐
40. Difficulty of identifying high-risk patients	☐	☐	☐	☐	☐
41. Insufficient time to counsel the patient in the ED	☐	☐	☐	☐	☐
42. Too busy with other tasks during an ED shift	☐	☐	☐	☐	☐
43. ED is an inappropriate setting for vaccination / preventive care measures	☐	☐	☐	☐	☐
44. Cost / reimbursement levels	☐	☐	☐	☐	☐
45. Inadequate ED personnel for administration	☐	☐	☐	☐	☐
46. Medico-legal liability issues	☐	☐	☐	☐	☐
Other: _____					

What would be helpful measures or strategies to increase overall vaccination rate?

_____

_____

For questions: Judith Dexheimer 936-3573 (Judith.Dexheimer@vanderbilt.edu) or Dominik Aronsky 936-1739 (Dominik.Aronsky@vanderbilt.edu)

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December 12, 2005

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