Empirical Derivation of an Electronic Clinically Useful Problem Statement System

Steven H. Brown, MS, MD; Randolph A. Miller, MD; Henry N. Camp, BA; Dario A. Guise, DrIng; and H. Kenneth Walker, MD

Problem lists are tools to improve patient management. In the medical record, they connect diagnoses to therapy, prognosis, and psychosocial issues. Computer-based problem lists enhance paper-based approaches by enabling cost-containment and quality assurance applications, but they require clinically expressive controlled vocabularies. Because existing controlled vocabularies do not represent problem statements at a clinically useful level, we derived a new canonical problem statement vocabulary through semi-automated analysis and distillation of provider-entered problem lists collected over 6 years from 74 696 patients. We combined automated and manual methods to condense 891 770 problem statements entered by 1961 care providers at Grady Memorial Hospital in Atlanta, Georgia, to 15 534 Canonical Clinical Problem Statement System (CCPSS) terms. The nature and frequency of problem statements were characterized, interrelations among them were enumerated, and a database capturing the epidemiology of problems was created. The authors identified 23 503 problem relations (co-occurrences, sign–symptom complexes, and differential diagnoses) and 22 690 modifier words that further categorized "canonical" problems.

To assess completeness, CCPSS content was compared with that of the 1997 Unified Medical Language System Metathesaurus (containing terms from 44 clinical vocabularies). Unified Medical Language System terms expressed 25% of individual CCPSS terms exactly (71% of problems by frequency), 27% partially, and 48% poorly or not at all. Clinicians judged that CCPSS terms completely captured their clinical intent for 84% of 686 randomly selected free-text problem statements. The CCPSS represents clinical concepts at a level exceeding that of previous approaches. A similar national approach could create a standardized, useful, shared resource for clinical practice.

Problem lists represent a powerful method for organizing, clarifying, and communicating clinical data and reasoning (1–6). Computer-based problem lists offer improvements (including easier access and maintenance) over paper-based lists (2, 7, 8). Optimal implementation of computer-based problem lists requires a structured problem vocabulary that is both meaningful to clinicians and computationally tractable (9). No optimal problem list vocabulary currently exists, despite efforts to create one (10–12).

The value of quality-controlled clinical vocabularies has been recognized for several decades (9, 13–17). Institutions investing in structured electronic data can implement patient-specific decision support systems and deliver targeted education to providers and consumers of health care (18–20). Examples include clinical reminder systems (14, 21–24), semi-automated enumeration of treatment alternatives (18, 25), generation of case-specific literature citations (26, 27), and suggestions for drug dosage adjustments (19, 25). Structuring clinical data also enables implementation of automated clinical guidelines (28–31) and improved quality monitoring (2, 32–35), including prevention of adverse events (36–38). Researchers can use structured clinical data to identify relevant cases and expedite collection of patient information (39–46). Finally, structured clinical data facilitates clinically accurate billing (47) and may increase compliance with governmental and regulatory agency directives (48, 49). The major impediment to implementing such beneficial systems is that clinicians do not naturally or freely generate "structured" clinical records by using a fixed vocabulary of prespecified terms (50).

Weed defined a problem as anything, including social problems, that requires management or diagnostic work-up (1, 51). He further elaborated that "Each medical record should have a complete list of all the patient's problems, including clearly established diagnoses and all other unexplained findings

Ann Intern Med. 1999;131:117-126.

From Vanderbilt University and Veterans Affairs Medical Center, Nashville, Tennessee; Medical Systems Development Corp., Marietta, Georgia; and Emory University School of Medicine, Atlanta, Georgia. For current author addresses, see end of text.

See editorial comment on pp 146-147.

. . . [The problem list is] a dynamic table of contents of a patient's chart . . . a compact history of the patient" (2). In the early 1970s, Feinstein developed an extensive model of the diagnostic process (52–54). He described diagnoses as explanations for the patient's manifestations of illness (52) and indicated that intermediate diagnostic stations exist (53). Observations by Elstein and colleagues (55), Eddy and Clanton (56), and Kassirer and various associates (57–62) subsequently documented that expert physicians use clinical pattern recognition to refine intermediate diagnostic conclusions via serial inferences until a prognosis or therapeutic course can be defined.

A problem statement may consist of a manifestation, a diagnosis, or an intermediate clinical state. Problem lists may include factors that influence therapy selection or patient education, such as patient preferences, religious beliefs, social supports, literacy, and language barriers (4, 63, 64). Existing standardized vocabularies that predominantly include diagnoses or findings, such as the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) (65) and the Systematized Nomenclature of Human and Veterinary Medicine (SNOMED) (66), cannot encompass all categories of problem statements.

Weed organized and promoted use of the problem-oriented medical record (1). Subsequently, several institutions adopted this approach (1, 2, 4, 5, 67–71), although few used computers to do so (72–78). The use of problem lists per se has generated little criticism despite substantial controversy over dedicated implementation of comprehensive problem-oriented records (9, 79–81). Because full-scale problem-oriented medical record systems are cumbersome and are not universally accepted, most computerized medical record systems provide problem lists but are not "problem-oriented." The Joint Commission on Accreditation of Healthcare Organizations currently requires institutions to record problem lists for patients receiving ambulatory care services (48); as a result, most health care institutions have implemented some form of recorded problem lists.

Computerized problem-statement input techniques have varied across implementation sites because no ideal problem statement vocabulary exists. Three historical approaches to problem statement entry include dedicated use of locally or nationally derived controlled vocabularies (82), entry using free text only (83, 84), and, most commonly, a combination of both (15–17, 76, 85–88).

We describe a novel, empirical approach to derive an electronic, clinically useful, canonical problem list vocabulary. Various editions of Webster's Dictionary define *canonical* as "relating to various of the simplest and most significant forms or schemata to which general equations, statements, or expressions may be reduced without loss of generality" (89) and "conforming to a general rule or acceptable procedure" (90). We analyzed and distilled provider-entered problem lists for 74 696 patients to produce a core set of clinically useful problem statements. The analysis characterized the nature and frequency of problem statement modifiers and enumerated interrelations among problems. The resulting Canonical Clinical Problem Statement System (CCPSS) was evaluated by comparing it with the vocabularies that make up the 1997 National Library of Medicine (NLM) Unified Medical Language System (UMLS) Metathesaurus (91) and by assessing clinical user satisfaction with it.

Methods

Study Institutions

Grady Memorial Hospital in Atlanta, Georgia, is an 890-bed public hospital and clinic that had 36 844 admissions and 762 085 outpatient visits in 1995. Each year, approximately 240 medical students, 400 postgraduate trainees, and 1200 physicians from Emory University School of Medicine provide care in conjunction with 650 Grady Memorial Hospital nursing staff persons. Vanderbilt University Medical Center in Nashville, Tennessee, includes a 658-bed private academic hospital and affiliated clinics. These facilities had 28 641 admissions and 469 515 outpatient visits in 1996. The combined staff consists of 878 nurses, 982 full-time physicians, 866 part-time clinicians, and 105 medical students per class.

Paper-based problem lists have been widely used at Grady Memorial Hospital since 1970 (4, 92). Since 1989, electronically stored provider-entered problem lists have largely replaced paper-based ones (86, 93). Grady Memorial Hospital's problem list is a shared, continually updated document that follows the patient through all inpatient admissions and outpatient visits. To a much lesser extent, Vanderbilt University Medical Center has used electronic, free-text problem lists since 1997.

Source of Raw Problem Statement Data

Our study includes all problem lists entered by care providers into Grady Memorial Hospital's THERESA system through menu choices or as free text from July 1989 to May 1995. After encrypting patient identifiers to protect confidentiality, developers of the THERESA computerized medical record system provided the authors with 891 770 raw problem statements. The original THERESA menus

combined terms from existing standardized vocabularies with terms contributed by the nursing and medical services at Grady Memorial Hospital. Periodically, previously entered free-text entries were reviewed and made available as menu choices.

Derivation of the Canonical Clinical Problem Statement System

One of the authors, an internist with 7 years of postresidency clinical experience, transformed the raw data from Grady Memorial Hospital into the final CCPSS by performing 36 generations of computer-assisted processing. Automated techniques were sufficient for some processing (such as conversion to uppercase text), but accurate translation and expansion of many of the concepts required manual analysis. Evaluating terms in their original context helped to clarify misspellings and abbreviations (for example, "MI" might represent myocardial infarction, mitral insufficiency, or masticatory impairment). Literature review and consultations with clinical domain experts helped to determine the meanings of ambiguous or obscure problem statements.

Modifiers detailing problem severity, disease or finding laterality, temporal patterns (such as "history of . . ." or "intermittent . . ."), problem activity, and estimates of likelihood (such as "possible" or "rule out . . .") were cataloged and extracted. Manual review was essential because a valid modifier in one context could appear as an integral portion of another problem name. For example, the modifiers "left" and "right" distinguish the laterality of a femur fracture, but "left" heart failure and "right" heart failure are clinically distinct problems. Lines containing multiple problem statements ("allergy to penicillin and sulfa") were separated into individual problem statements. Closely related terms, such as "abdomen pain diffuse" and "abdomen pain generalized," were condensed into a single expression. Clinical utility guided this process (**Figure**).

During all iterations, audit trails were maintained to keep an accurate history of each evolving problem statement. One audit trail related modifiers to the terms from which they were extracted. Another audit trail characterized interrelations among problems, such as being the subproblem of a main problem or a member of a sign–symptom complex.

Evaluation of the Canonical Clinical Problem Statement System

The coverage of the CCPSS final problem vocabulary was evaluated by comparing it with the extensive set of 44 vocabularies in the NLM's UMLS Metathesaurus (eighth edition, 1997) and with clinician-generated free-text problem statements from Vanderbilt University Medical Center. All CCPSS final problem statements, excluding modifiers, were submitted to the NLM's knowledge source server (94) program on 10 February 1997. Output of the NLM server was classified as a failure to match (no term returned), an exact match, or a partial match (returned term more specific or more general than the submitted term).

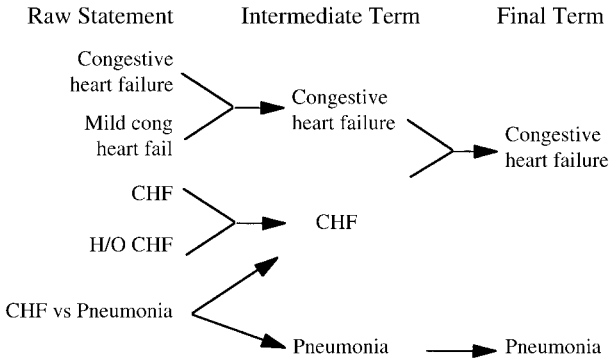

Figure. Simplified example of the problem statement distillation process. The final term "congestive heart failure" (*CHF*) would be assigned a frequency of 5 and would be linked to the modifiers "history of" (*H/O*) and "mild."

Using locally developed World Wide Web–based vocabulary browsing tools (95), one of the authors mapped all clinician-generated problems that had been transcribed into Vanderbilt University's Medical Archival and Retrieval System (MARS) (96) on 23 September 1997, an arbitrarily selected 24-hour period. The mapping translated, as closely as possible, transcribed problems into the final CCPSS. The physicians who had dictated the transcribed problem statements subsequently judged the clinical adequacy of each problem statement mapping as follows: 1) clinical meaning fully captured, 2) clinical meaning partially captured, or 3) misleading or potentially dangerous translation of meaning.

Results

Derivation of the Canonical Clinical Problem Statement System

The raw THERESA problem files yielded 891 770 problem statements. Longitudinal problem records from 74 696 patients entered by 1961 unique providers were included. All problems entered over 6 years, including subproblems, inactive problems, and reformulated intermediate states, were individually extracted. Individual problem statements were counted only once across multiple visits. Of the 891 770 problem statements, 695 696 were entered from the THERESA controlled vocabulary, 196 055 were entered as free text, and 19 were indeterminate. Problems were entered by medical students (n = 154 158), postgraduate trainees (n = 429 354), attending physician staff (n = 78 602), and others (n = 229 656).

The distillation process consumed approximately 2000 person-hours of effort over 2 years. Removing duplicates reduced vocabulary size from 891 770 to 64 036 elements. Subsequent automated processing reduced the data set by 30 000 elements. The first manual review pass eliminated 10 200 terms, the second eliminated 5000 terms, and the third eliminated 1500 terms. Simplification of multiconcept lines in the first phase of manual review led to a transient increase of 5200 unique entries. The entire distillation process reduced the initial data set by 98.3%.

The CCPSS comprises the overall set of canonical terminology, modifier lists, and frequency-weighted links. The 15 534 final CCPSS terms represent 927 261 original "raw" entries (more than 891 770 because of the overall frequency of split multiconcept problems). In the set of 64 036 nonduplicate elements, there were 18 907 problem co-occurrences, 20 535 main problem–subproblem relations, 22 690 modifier linkages, and 5406 expressions of differential diagnoses or sign–symptom complexes. The average number of unique ways that users originally expressed each CCPSS term was 4 (range, 1 to 555 unique expressions); 693 terms had more than 20 unique raw forms.

Correlations between CCPSS terms and raw data elements represent the "epidemiology" of individual canonical problem statements. The 10 highest-frequency canonical terms accounted for 25% of the original raw entries, the 100 most common terms (**Appendix Table**) covered 64% of the original raw entries, and the top 500 terms accounted for 85%. Of the 500 most prevalent canonical problem statements, 401 were symptoms, signs, laboratory or imaging results, procedures, or specific diagnoses and 90 were intermediate diagnoses or psychosocial problems (**Table 1**).

Table 1. Types of 500 Most Common Problems

Problem Category	Occurrence, *n* (%)
Symptoms	25 (5)
Signs	73 (15)
Laboratory or imaging result	86 (17)
Procedures	24 (5)
Specific diagnoses	193 (39)
Intermediate diagnoses	59 (12)
Psychosocial issues	31 (6)
Other	9 (2)

Evaluation of the Canonical Clinical Problem Statement System

Unified Medical Language System Coverage of the Canonical Clinical Problem Statement System

All CCPSS terms (excluding modifiers) were submitted to the UMLS server for matching (**Table 2**). "Exact matches" between terms differed only in word order, use of plurals, or addition of prepositions. Approximately 25% of matches were exact, 27% were partial, and 48% were poor or nonexistent. With respect to the partially redundant set of 891 770 original problem statements, UMLS exactly covered 71% by frequency.

Table 2. Unified Medical Language System Coverage of Canonical Clinical Problem Statement System Terms and the Original Entries They Represent*

Result of Comparison	UMLS Coverage of CCPSS Terms	UMLS Coverage of Original Problems
	n (%)	
Exact or nearly exact match	3954 (25.45)	662 360 (71.43)
Mismatch due to granularity (UMLS too specific or too general)	4171 (26.85)	109 355 (11.79)
Poor or no match	7409 (47.70)	155 546 (16.77)

* CCPSS = Canonical Clinical Problem Statement System; UMLS = United Medical Language System.

Testing the Canonical Clinical Problem Statement System by Using a 24-Hour Sample of Free-Text Vanderbilt University Problem Lists

On 23 September 1997, 36 clinicians from Vanderbilt University Medical Center generated 674 lines of problem statements on 234 patients. Multiconcept problem statements were separated to yield 742 individual problem statements for the test set. Nineteen of the 36 clinicians returned forms rating the quality of mapping for 686 of the 742 problem statements. Respondents were practitioners of general medicine ($n = 5$), medical subspecialties ($n = 4$), general surgery ($n = 2$), surgical subspecialties ($n = 5$), and neurology ($n = 3$).

The clinicians judged that the CCPSS mappings completely captured their clinical intent in 84% of instances (**Table 3**). Clinicians judged the mappings of 3% of Vanderbilt University Medical Center problem statements as misleading or clinically dangerous. Of those misleading or clinically dangerous ratings, only one third (1%) clearly represented failures of CCPSS mapping per se. For example, "luteal phase defect" was unmatched in CCPSS.

Discussion

There are two historical approaches to problem statement vocabulary analysis (97–103). The first approach compares clinically generated problem statements with existing controlled vocabularies to estimate coverage. Findings of previous studies, summarized in **Table 4**, indicate coverage rates between 37% and 73% for free-text clinical problem statements. Our study attained a preliminary coverage rate of 84%. Our results also agree with previous efforts indicating that UMLS does not cover all clinical problem statements (98, 100, 103, 104). The

Table 3. Clinicians' Assessment of Canonical Clinical Problem Statement System Mappings of Vanderbilt University Terms

Result of Comparison	Count (Percentage)
Clinical intent completely captured	306 (83.8)
Clinical intent partially captured	47 (12.9)
Misleading or possibly dangerous	12 (3.3)

lack of intermediate diagnostic states (an important form of problem description) in the vocabularies of the 1997 UMLS may explain this shortcoming. Twelve percent of the most frequent CCPSS terms were classified as intermediate diagnostic states (**Table 1**). Of note, UMLS covers commonly occurring problems better than less common ones. In addition, UMLS matched 71% of the 927 261 nonunique raw problem statements but only 25% of unique CCPSS terms. Our findings support Eagon's observation that terminology in the UMLS Metathesaurus tends to be too specific or too general (**Table 2**) with respect to clinician-generated problem statements (103).

The second approach to electronic problem capture creates new problem vocabularies through analysis and synthesis of a set of clinical problem statements (88, 105, 106). The Veterans Affairs Lexicon Utility was derived in 1993 from UMLS (88). Payne and Martin (105) also used UMLS to create a problem list vocabulary but concluded that supplementation of the terms with additional phrases was required. Wilton (83), Scherpbier and coworkers (84), and Yarnall and associates (87) created databases of human-reviewed clinical problem statements and linked them to ICD-9 codes. Yarnall and associates (87) showed that such a system results in more thorough and accurate billing coding than manual methods. As the first step in developing a new, clinically relevant controlled vocabulary, Chute and Elkin (106) processed 7953 commonly occurring problem statements (without duplicates). Their approach used less manual review than our study did and resulted in a 35% reduction of the data set compared with the 76% reduction of nonduplicate problems that we found.

Successful clinical informatics projects synergistically combine computational techniques with sound medical judgment. Our study represents a quasi-automated, labor-intensive effort to distill a clinically useful problem-statement vocabulary from a large corpus of clinician-entered problem lists.

The audit trails and epidemiologic term frequencies within CCPSS enable applications that are not possible with traditional problem vocabularies. The CCPSS captures, in clinically meaningful terms, the frequency of provider-entered problems and their interrelations for 74 696 patients at a single institution over the course of 6 years. One might use the current CCPSS to estimate the frequency of acute myocardial infarction in patients with endocarditis

Table 4. Studies Evaluating Problem Statement Coding Capabilities of Controlled Vocabularies*

Author, Year (Reference)	Source, Nature, and Number of Clinical Terms	Judged By	Target Controlled Vocabulary	Results
Payne et al., 1992 (97)	605 problems from outpatient problem lists and SOAP format progress notes	Clinician panel	ICD-9	41% had any translation; out of a subset of those, 42% were rated "satisfactory"
Campbell and Payne, 1994 (98)	359 unique problems from outpatient medicine and pediatrics clinics	Clinician panel	UMLS, 4th ed. SNOMED Read version 2.0 ICD-9-CM	65% "satisfactory" 60% "satisfactory" 38% "satisfactory" 37% "satisfactory"
Rosenberg and Coultas, 1994 (100)	447 (271 unique) diagnoses from outpatient general medicine clinic progress notes	Clinician panel	UMLS, 4th ed.	73% "satisfactory"
Zelingher et al., 1995 (101)	118 040 problems from outpatient general medicine clinic problem lists	Clinician generating problem statement	Local vocabulary	66% matched
Mullins et al., 1996 (104)	88 problems from outpatient family practice clinic progress notes containing problem lists	Medical student panel	Read version 3.1 SNOMED 3.1 UMLS, 6th ed.	49% "good" matches 61% "good" matches 61% "good" matches
Eagon et al., 1997 (103)	6355 unique problems from problem lists	Clinician panel	UMLS, 7th ed.	62% synonymous matches 26% of matched terms were more specific or more general
Current study	742 problems from outpatient problem lists	Clinician generating problem statement	CCPSS	In 84%, clinical intent fully captured; in 13%, clinical intent partially captured

* CCPSS = Canonical Clinical Problem Statement System; ICD-9 = International Classification of Diseases, Ninth Revision; ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; SNOMED = Systematized Nomenclature of Human and Veterinary Medicine; SOAP = subjective data, objective data, assessment, plan; UMLS = Unified Medical Language System.

Appendix Table. The Top 100 Problems at an Urban Hospital, 1989–1995

Rank	Frequency	Percentage	Problem Statement	Related Problem
1	50 294	5.6	DATA BASE [incomplete—e.g., Hx but no Pe]	
2	48 023	5.4	Pregnancy intrauterine	2, 22, 34, 45, 71
3	31 856	3.6	Hypertension [not otherwise specified]	3, 14
4	29 583	3.3	Anemia [not otherwise specified]	4, 93
5	15 983	1.8	Health maintenance	
6	15 681	1.8	Pneumonia [not otherwise specified]	
7	14 433	1.6	Alcohol abuse	7, 8, 30, 31, 71, 80
8	14 005	1.6	Tobacco abuse	7, 8, 30, 31, 71, 80
9	10 735	1.2	Abortion elective	9, 12
10	10 187	1.1	Urinary tract infection	10, 45, 65, 100
11	10 081	1.1	Congestive heart failure	
12	9501	1.1	Abortion spontaneous	9, 12
13	8405	0.9	Size dates [greater than/less than]	
14	7253	0.8	Hypertension essential	3, 14
15	7230	0.8	Prenatal care late	
16	6861	0.8	Asthma	16, 87
17	6567	0.7	Chest pain	17, 32, 35, 73, 94
18	6554	0.7	Diabetes mellitus noninsulin dependent	18, 20, 28, 37, 68
19	6531	0.7	Weight [increased/decreased]	19, 62
20	6482	0.7	Diabetes mellitus NOS	18, 20, 28, 37, 68
21	6198	0.7	Sterilization desired	
22	6178	0.7	LMP date unsure	2, 22, 34, 45, 71
23	6088	0.7	Gonorrhea	
24	6011	0.7	HIV test positive	24, 27
25	5489	0.6	COPD	
26	5469	0.6	Hypercholesterolemia	
27	5178	0.6	AIDS	24, 27
28	5010	0.6	Diabetes mellitus insulin-dependent	18, 20, 28, 37, 68
29	4997	0.6	Cervicitis chlamydial	
30	4696	0.5	Substance abuse	7, 8, 30, 31, 71, 83
31	4643	0.5	Cocaine abuse	7, 8, 30, 31, 71, 83
32	4617	0.5	Coronary atherosclerotic heart disease	17, 32, 35, 73, 94
33	4540	0.5	CVA [not otherwise specified]	
34	4530	0.5	Pregnancy adolescent	2, 22, 34, 45, 61, 71
35	4432	0.5	Angina unstable	17, 32, 35, 73, 94
36	4321	0.5	Arthritis osteoarthritis	
37	4245	0.5	Ketoacidosis diabetic	18, 20, 28, 37, 68
38	4189	0.5	Trichomoniasis	
39	4057	0.5	Fever	
40	3995	0.4	Gastrointestinal bleed	
41	3559	0.4	Tuberculosis	
42	3556	0.4	Syphilis	42, 92
43	3459	0.4	Language barrier English not spoken	
44	3382	0.4	Penicillin allergy	44, 51
45	3252	0.4	Urinary tract infection pregnancy	2, 10, 22, 34, 45, 65, 71, 100
46	3235	0.4	Cesarean section low transverse	46, 75
47	3216	0.4	Mental status altered	
48	3211	0.4	Renal insufficiency chronic	48, 56, 57, 70
49	3163	0.4	Infant preterm	49, 50
50	3102	0.3	Infant preterm low birth weight	49, 50
51	3073	0.3	Drug allergies none	44, 51
52	3052	0.3	PUD	
53	3050	0.3	Short stature	
54	3047	0.3	PCP	
55	3022	0.3	Chest x ray abnormal	
56	2962	0.3	Renal failure acute	48, 56, 57, 70
57	2940	0.3	Renal failure chronic	48, 56, 57, 70
58	2931	0.3	Syncope	
59	2894	0.3	Cervical dysplasia	59, 98
60	2871	0.3	Rubella immunity not present	60, 77
61	2864	0.3	Maternal age [advanced/value]	34, 61
62	2836	0.3	Obesity	19, 62
63	2701	0.3	Condyloma acuminata	
64	2694	0.3	Seizure disorder	64, 86
65	2622	0.3	Pyelonephritis	10, 45, 65, 100
66	2607	0.3	Cellulitis	
67	2600	0.3	Rh unsensitized	
68	2596	0.3	Hyperglycemia	18, 20, 28, 37, 68
69	2594	0.3	Stool heme positive	
70	2589	0.3	Renal insufficiency	48, 53, 54, 67
71	2580	0.3	Substance abuse pregnancy tobacco	2, 7, 8, 22, 30, 31, 34, 45, 71, 83
72	2570	0.3	Gout	
73	2502	0.3	Myocardial infarction [not otherwise specified]	17, 32, 35, 73, 94
74	2495	0.3	Discharge planning [incomplete]	
75	2450	0.3	Cesarean section scar type unknown	46, 75
76	2444	0.3	Hyponatremia	
77	2437	0.3	Rubella immunity [degree]	60, 77
78	2407	0.3	Heart disease [not otherwise specified]	78, 96

Continued on following page

Appendix Table—*Continued*

Rank	Frequency	Percentage	Problem Statement	Related Problem
79	2385	0.3	Hemoglobin [value]	
80	2305	0.3	Diarrhea	
81	2247	0.3	Sign symptom complex	
82	2208	0.2	Macrosomic infant	
83	2186	0.2	Drug abuse intravenous	7, 8, 30, 31, 71, 83
84	2112	0.2	Depressive disorder NOS	
85	2097	0.2	Abdomen pain	
86	2093	0.2	Seizure	61, 87
87	2093	0.2	Asthma exacerbation acute	16, 84
88	2058	0.2	Oral candidiasis	
89	2041	0.2	Atrial fibrillation	
90	2016	0.2	Headache	
91	1992	0.2	Hypokalemia	
92	1947	0.2	RPR reactive	42, 92
93	1942	0.2	Anemia microcytic	4, 93
94	1921	0.2	Myocardial infarction acute	17, 32, 35, 73, 94
95	1907	0.2	Cancer [not otherwise specified]	
96	1829	0.2	Organic heart disease [not otherwise specified]	78, 96
97	1800	0.2	Deep venous thrombosis	
98	1793	0.2	Pap smear result abnormal	59, 98
99	1743	0.2	Dehydration	
100	1742	0.2	Urosepsis	10, 45, 65, 100
Total		63.8		

* COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; Heme = hemoccult; Hx = history; LMP = last menstrual period; NOS = not otherwise specified; Pap = Papanicolaou; PCP = *Pneumocystis carinii* pneumonia; Pe = physical examination; PUD = peptic ulcer disease; RPR = rapid plasma reagin.

at Grady Memorial Hospital or the correlation of child abuse with inadequate prenatal care. Future use of a "standardized" CCPSS at other facilities could lead to intrainstitutional and interinstitutional epidemiologic study of patient problems. For example, one might compare the frequency of "poor social support" and "symptomatic hypoglycemia" for patients with "diabetes mellitus" among institutions.

Epidemiologic aspects of CCPSS can also facilitate computerized decision support. For example, a clinician entering "type II diabetes mellitus requiring insulin" in a patient's problem list could be interactively presented with the most common subproblems for demographically similar patients. Conversely, displaying main problems common to a set of unexplained signs and symptoms may prove helpful in the diagnostic process.

Although the data set from which the CCPSS is derived is large, it is not clinically complete. Mechanisms to add entries and update linkages from a large and diverse group of sites must be devised. Over time, this should help to address two major CCPSS deficiencies: single facility origin and unequal entry of raw problem statements by different Grady Memorial Hospital clinical services. The CCPSS lacks formal hierarchical structures, a feature common in many controlled vocabularies.

Fragmented, disparate medical records can contribute to suboptimal care for patients seen by multiple practitioners at different sites (107, 108). Transfer of information from electronic medical records across institutions could help relieve this problem. However, computer-based exchange of patient-specific data among institutions is not routinely possible because of incompatibilities in clinical vocabularies, varying networking protocols, and incompatible clinical application systems, despite important advances, such as the Health Level 7 clinical data interchange standard (109, 110). Because problem lists can provide a precise summary of a patient's condition, they represent a good starting point for interinstitutional data exchange. A standardized, clinically expressive electronic problem vocabulary could help ensure that electronically transferred problem lists would be useful across institutional boundaries.

Representing the medical necessity of services for an individual patient is an important issue for providers, institutions, and third-party payers. Necessity is currently reported to agencies and payers by linking a diagnostic code to a service code. The most common diagnostic coding scheme used is the ICD-9, which poorly describes patients' problems (97, 98). In addition, use of the ICD-9 forces providers to describe problems in unfamiliar terms and imposes the burdens of ICD-9 code memorization and look-up. The Health Care Financing Administration's evaluation and management codes (49) and proposed hospital ambulatory procedure codes (111) both rely on ICD-9 codes to represent patient problems. A clinically derived, useful, and accurate problem coding system, such as CCPSS, that could be used seamlessly during patient care activities, would improve acceptability of coding requirements for health care providers and could provide payers with better and more direct information.

Meaningful review of quality of care requires clinical understanding and analysis above and be-

yond documentation of medical necessity (7, 32). Appropriate quality audits cannot be conducted if the physician is "given some manual in which the criteria for several hundred diseases but not all the undiagnosed complaints in medical practice were cataloged with the unrealistic assumption that he [or she] would study these each time he [or she] saw a patient in a very busy practice" (32). A well-conceived, standardized problem list is a good framework to provide the clinical context that quality-of-care audits require.

The CCPSS audit trail mappings from raw end-user statements to final canonical form can help to encode future users' chart entries despite the presence of misspellings, abbreviations, synonyms, and drug trade names. For example, "guiac positive stool" maps to "heme positive stool" and "htpokalemia induced by lasix" maps to the co-occurring problems of "hypokalemia" and "furosemide adverse reaction." It is difficult for purely computational lexical methods to provide such conversions.

The applicability of comparative vocabulary studies (including ours) is time limited because many vocabularies change substantially from edition to edition. In the case of the UMLS Metathesaurus, entire new vocabularies or large portions of vocabularies are incorporated each year. Despite our efforts to the contrary, the knowledge server program may not have been set up to optimally estimate UMLS coverage. This effect is probably small, given the consistency of the current study results with others.

In 1863, Florence Nightingale stated "I am fain to sum up with an urgent appeal for adopting this or some uniform system of publishing the statistical records of hospitals" (112). More than a century later, the 1996 Health Insurance Portability and Accountability Act (113) required the establishment of standards for a range of electronic administrative health transactions, including the codes or vocabularies to be used in selected elements of these transactions. Although many administrative transactions do not involve detailed clinical information, claims attachments, for which a standard must be recommended in 1999, often contain such information. If implementation of the Health Insurance Portability and Accountability Act proceeds as expected, it will be an important first step in the establishment of clinical vocabulary standards in the United States.

Our current study provides a basis for continuing work on a clinically useful canonical problem vocabulary. Such a vocabulary will enable the construction of more thorough and accurate electronically accessible problem lists and will permit epidemiologic studies of problems across institutions. The authors believe that the CCPSS (or a similarly derived vocabulary), after additional refinement and testing, should form the basis for a nationwide approach to this issue. Mechanisms must be developed to share, use, and maintain the CCPSS and similar vocabularies across institutions. An excellent mechanism for vocabulary standardization and distribution is the ongoing NLM UMLS project. We intend to provide a copy of CCPSS to the NLM to be considered for inclusion in and distribution through future releases of UMLS. Much work remains to be done, and a coordinated effort is mandatory. Clinicians, informatics researchers, professional organizations, commercial enterprises, and government institutions must discuss these problematic issues and collaborate on solutions to resolve the problem of problems.

Acknowledgments: The authors thank Dr. William W. Stead of Vanderbilt University, Ms. Betsy Humphreys of the National Library of Medicine, and Mr. Karl E. Liliestedt of Medical Systems Development Corp. for their contributions.

Grant Support: By National Library of Medicine grants 1 F38 LM00021-01A1 (Dr. Brown), LM06226-02 (Dr. Miller), 5 G08 LM05443 (Dr. Miller), and 1 R55 LM05779-01 (Dr. Guise).

Requests for Reprints: Steven H. Brown, MS, MD, Division of Biomedical Informatics, Room 402, Eskind Biomedical Library, 2209 Garland Avenue, Nashville, TN 37232-8340; e-mail, steven.brown@med.va.gov.

Current Author Addresses: Dr. Brown: Division of Biomedical Informatics, Room 402, Eskind Biomedical Library, 2209 Garland Avenue, Nashville, TN 37232-8340.
Dr. Miller: Division of Biomedical Informatics, Room 436, Eskind Biomedical Library, 2209 Garland Avenue, Nashville, TN 37232-8340.
Mr. Camp: Medical Systems Development Corp., 620 Village Trace, Marietta, GA 30067.
Dr. Guise: Division of Biomedical Informatics, Room 410, Eskind Biomedical Library, 2209 Garland Avenue, Nashville, TN 37232-8340.
Dr. Walker: Emory University Department of Medicine, 69 Butler Street, Atlanta, GA 30303.

References

1. **Weed LL.** Medical records, patient care, and medical education. Ir J Med Sci. 1964;17:271-82.
2. **Weed LL.** Medical records that guide and teach. N Engl J Med. 1968;278: 593-600.
3. **Hurst JW.** Ten reasons why Lawrence Weed is right. N Engl J Med. 1971; 284:51-2.
4. **Hurst JW.** How to implement the Weed system. (In order to improve patient care, education, and research by improving medical records). Arch Intern Med. 1971;128:456-62.
5. **Mehigan JA.** Patient care and medical case notes. A plea for the wider use of the Weed system of problem orientated medical records. Ir Med J. 1975; 68:80-4.
6. **Lloyd BW, Barnett P.** Use of problem lists in letters between hospital doctors and general practitioners. BMJ. 1993;306:247.
7. **Weed LL.** Medical records that guide and teach. N Engl J Med. 1968;278: 652-7.
8. **Safran C, Rury C, Rind DM, Taylor WC.** Outpatient medical records for a teaching hospital: beginning the physician-computer dialogue. In: Frisse ME, ed. Computer Applications in Medical Care: Proceedings of the 16th AMIA Conference on Medical Informatics. New York: McGraw-Hill; 1992:114-8.
9. **Feinstein AR.** The problems of the "problem-oriented medical record." Ann Intern Med. 1973;78:751-62.
10. **Evans DA, Cimino JJ, Hersh WR, Huff SM, Bell DS.** Toward a medical-concept representation language. The Canon Group. J Am Med Inform Assoc. 1994;1:207-17.
11. **Cimino JJ.** Review paper: coding systems in health care. Methods Inf Med. 1996;35:273-84.
12. **Chute CG, Cohn SP, Campbell KE, Oliver DE, Campbell JR.** The content

coverage of clinical classifications. For The Computer-Based Patient Record Institute's Work Group on Codes & Structures. J Am Med Inform Assoc. 1996;3:224-33.
13. **Greenes RA, Barnett GO, Klein SW, Robbins A, Prior RE.** Recording, retrieval and review of medical data by physician-computer interaction. N Engl J Med. 1970;282:307-15.
14. **McDonald CJ.** Protocol-based computer reminders, the quality of care and the non-perfectibility of man. N Engl J Med. 1976;295:1351-5.
15. **Stead WW, Hammond WE, Straube MJ.** A chartless record—is it adequate? J Med Syst. 1983;7:103-9.
16. **Barnett GO.** The application of computer-based medical-record systems in ambulatory practice. N Engl J Med. 1984;310:1643-50.
17. **Whiting-O'Keefe QE, Whiting A, Henke J.** The STOR clinical information system. MD Comput. 1988;5:8-21.
18. **Tierney WM, Miller ME, Overhage JM, McDonald CJ.** Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. JAMA. 1993;269:379-83.
19. **Geissbuhler A, Miller RA.** A new approach to the implementation of direct care-provider order entry. In: Cimino JJ, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1996:689-93.
20. **Safran C, Gray J.** Teleumbilical cord extends newborn care beyond NICU. Telemedicine and Telehealth Networks. 1997;3:22-4, 52.
21. **McDonald CJ, Wilson GA, McCabe GP Jr.** Physician response to computer reminders. JAMA. 1980;244:1579-81.
22. **Barnett GO, Winickoff RN, Morgan MM, Zielstorff RD.** A computer-based monitoring system for follow-up of elevated blood pressure. Med Care. 1983;21:400-9.
23. **Winickoff RN, Coltin KL, Fleishman SJ, Barnett GO.** Semiautomated reminder system for improving syphilis management. J Gen Intern Med. 1986;1:78-84.
24. **McDonald CJ, Tierney WM, Overhage JM, Martin DK, Wilson GA.** The Regenstrief Medical Record System: 20 years of experience in hospitals, clinics, and neighborhood health centers. MD Comput. 1992;9:206-17.
25. **Evans RS, Pestotnik SL, Classen DC, Clemmer TP, Weaver LK, Orme JF Jr, et al.** A computer-assisted management program for antibiotics and other antiinfective agents. N Engl J Med. 1998;338:232-8.
26. **Powsner SM, Riely CA, Barwick KW, Morrow JS, Miller PL.** Automated bibliographic retrieval based on current topics in hepatology: hepatopix. Comput Biomed Res. 1989;22:552-64.
27. **Cimino JJ, Johnson SB, Aguirre A, Roderer N, Clayton PD.** The MEDLINE button. In: Frisse ME, ed. Computer Applications in Medical Care: Proceedings of the 16th AMIA Conference on Medical Informatics. New York: McGraw-Hill; 1992:81-5.
28. **Tierney WM, Overhage JM, Takesue BY, Harris LE, Murray MD, Vargo DL, et al.** Computerizing guidelines to improve care and patient outcomes: the example of heart failure. J Am Med Inform Assoc. 1995;2:316-22.
29. **Tierney WM, Overhage JM, McDonald CJ.** Computerizing guidelines: factors for success. In: Cimino JJ, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1996:459-62.
30. **Pestotnik SL, Classen DC, Evans RS, Burke JP.** Implementing antibiotic practice guidelines through computer-assisted decision support: clinical and financial outcomes. Ann Intern Med. 1996;124:884-90.
31. **Schriger DL, Baraff LJ, Rogers WH, Cretin S.** Implementation of clinical guidelines using a computer charting system. Effect on the initial care of health care workers exposed to body fluids. JAMA. 1997;278:1585-90.
32. **Weed LL.** Quality control and the medical record. Arch Intern Med. 1971;127:101-5.
33. **Pestotnik SL, Evans RS, Burke JP, Gardner RM, Classen DC.** Therapeutic antibiotic monitoring: surveillance using a computerized expert system. Am J Med. 1990;88:43-8.
34. **Grover FL, Hammermeister KE, Shroyer AL.** Quality initiatives and the power of the database: what they are and how they run. Ann Thorac Surg. 1995;60:1514-21.
35. **Spoeri RK, Ullman R.** Measuring and reporting managed care performance: lessons learned and new initiatives. Ann Intern Med. 1997;127(8 Pt 2):726-32.
36. **Classen DC, Pestotnik SL, Evans RS, Burke JP.** Computerized surveillance of adverse drug events in hospital patients. JAMA. 1991;266:2847-51.
37. **Evans RS, Classen DC, Stevens LE, Pestotnik SL, Gardner RM, Lloyd JF, et al.** Using a hospital information system to assess the effects of adverse drug events. In: Safran C, ed. Computer Applications in Medical Care: Proceedings of the 17th AMIA Conference on Medical Informatics. New York: McGraw-Hill; 1993:161-5.
38. **Bates DW, O'Neil AC, Boyle D, Teich J, Chertow GM, Komaroff AL, et al.** Potential identifiability and preventability of adverse events using information systems. J Am Med Inform Assoc. 1994;1:404-11.
39. **Safran C, Porter D, Lightfoot J, Rury CD, Underhill LH, Bleich HL, et al.** ClinQuery: a system for online searching of data in a teaching hospital. Ann Intern Med. 1989;111:751-6.
40. **Tierney WM, Harris LE, Copley JB, Luft FC.** Effect of hypertension and type II diabetes on renal function in an urban population. Am J Hypertens. 1990;3:69-75.
41. **Tierney WM, McDonald CJ.** Practice databases and their uses in clinical research. Stat Med. 1991;10:541-57.
42. **Kahn MG.** Clinical databases and critical care research. Crit Care Clin. 1994;10:37-51.
43. **Peleg II, Maibach HT, Brown SH, Wilcox CM.** Aspirin and nonsteroidal anti-inflammatory drug use and the risk of subsequent colorectal cancer. Arch Intern Med. 1994;154:394-9.
44. **Davis RB, Iezzoni LI, Phillips RS, Reiley P, Coffman GA, Safran C.** Predicting in-hospital mortality. The importance of functional status information. Med Care. 1995;33:906-21.
45. **McDonald CJ, Overhage JM, Dexter P, Takesue BY, Dwyer DM.** A framework for capturing clinical data sets from computerized sources. Ann Intern Med. 1997;127(8 Pt 2):675-82.
46. **Selby JV.** Linking automated databases for research in managed care settings. Ann Intern Med. 1997;127(8 Pt 2):719-24.
47. **Hohnloser JH, Puerner F, Soltanian H.** Improving clinician's coded data entry through the use of an electronic patient record system: 3.5 years experience with a semiautomatic browsing and encoding tool in clinical routine. Comput Biomed Res. 1996;29:41-7.
48. Comprehensive Accreditation Manual for Hospitals. Oakbrook Terrace, IL: The Joint Commission on Accreditation of Healthcare Organizations; 1996.
49. **American Medical Association, Health Care Financing Administration.** Documentation guidelines for evaluation and management services. Available at http://www.hcfa.gov/medicare/master1.pdf. 1997:1-52.
50. **McDonald CJ, Tierney WM.** Computer-stored medical records. Their future role in medical practice. JAMA. 1988;259:3433-40.
51. **Weed LL.** The problem-oriented record. In: Hurst JW, Walker HK, eds. The Problem Oriented System. New York: Medcom Pr; 1972:23-4.
52. **Feinstein AR.** An analysis of diagnostic reasoning. I. The domains and disorders of clinical macrobiology. Yale J Biol Med. 1973;46:212-32.
53. **Feinstein AR.** An analysis of diagnostic reasoning. II. The strategy of intermediate decisions. Yale J Biol Med. 1973;46:264-83.
54. **Feinstein AR.** An analysis of diagnostic reasoning. III. The construction of clinical algorithms. Yale J Biol Med. 1974;47:5-32.
55. **Elstein AS, Shulman LS, Sprafka SA.** Medical Problem Solving: An Analysis of Clinical Reasoning. Cambridge, MA: Harvard Univ Pr; 1978.
56. **Eddy DM, Clanton CH.** The art of diagnosis: solving the clinicopathological exercise. N Engl J Med. 1982;306:1263-8.
57. **Kassirer JP, Gorry GA.** Clinical problem solving: a behavioral analysis. Ann Intern Med. 1978;89:245-55.
58. **Kassirer JP, Kopelman RI.** Intuitive and inspirational, or inductive and incremental? Hosp Pract (Off Ed). 1988;23:21-4, 26-7.
59. **Kassirer JP, Kopelman RI.** Strategies of information gathering: Part II. Hosp Pract (Off Ed). 1988;23:26-8.
60. **Kassirer JP, Kopelman RI.** Strategies of information gathering: Part I. Hosp Pract (Off Ed). 1988;23:37, 41, 44, 51-2, 55.
61. **Kassirer JP.** Diagnostic reasoning. Ann Intern Med. 1989;110:893-900.
62. **Kassirer JP, Kopelman RI.** Cognitive errors in diagnosis: instantiation, classification, and consequences. Am J Med. 1989;86:433-41.
63. **Freidin RB, Goldman L, Cecil RR.** Patient-physician concordance in problem identification in the primary care setting. Ann Intern Med. 1980;93:490-3.
64. **Longabaugh R, Fowler DR, Stout R, Kriebel G Jr.** Validation of a problem-focused nomenclature. Arch Gen Psychiatry. 1983;40:453-61.
65. International Classification of Diseases. Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death. Geneva: World Health Organization; 1977.
66. **Cote RA, Rothwell DJ, Palotay JL, Beckett RS, Brochu L, eds.** The Systematized Nomenclature of Human and Veterinary Medicine: SNOMED International. Northfield IL: Coll of American Pathologists; 1993.
67. **Ingber JS, Rose LF.** The problem-oriented record: clinical application in a teaching hospital. J Dent Educ. 1975;39:472-82.
68. **Lambert RP, Mackay IR.** A problem-orientated outpatient record. Med J Aust. 1976;2:368-72.
69. **Fernow LC, McColl I, Mackie C, Rendall M.** An analysis of the use of problem oriented medical records (POMR) by medical and surgical house officers: factors affecting use of this format in a teaching hospital. Med Educ. 1977;11:341-6.
70. **Reinstein L.** Problem-oriented medical record: experience in 238 rehabilitation institutions. Arch Phys Med Rehabil. 1977;58:398-401.
71. **Deisher JB.** The problem-oriented unit record in residency management. J Fam Pract. 1978;7:1059-60.
72. **Gledhill VX, Mackay IR, Mathews JD, Strickland RG, Stevens DP, Thompson CD.** The problem-oriented medical synopsis. Applications to patient care, education, and research. Ann Intern Med. 1973;78:685-91.
73. **Schmidt EC, Schall DW, Morrison CC.** Computerized problem-oriented medical record for ambulatory practice. Med Care. 1974;12:316-27.
74. **Mellner C, Selander H, Wolodarski J.** The computerized problem-oriented medical record at Karolinska Hospital—format and function, users' acceptance and patient attitude to questionnaire. Methods Inf Med. 1976;15:11-20.
75. **Slamecka V, Camp HN, Badre AN, Hall WD.** MARIS: a knowledge system for internal medicine. Information processing and management. 1977;13:273-6.
76. **Schultz JR, Davis L.** The technology of PROMIS. In: Proceedings, Sixth Conference on Computer Applications in Radiology & Computer Aided Analysis of Radiological Images. 1979;67:1237-44.
77. **Lloyd SC.** Computer-generated progress notes in an automated POMR. J Med Syst. 1984;8:35-42.
78. **Stitt FW.** The Problem-Oriented Medical Synopsis: a patient-centered clinical information system. In: Safran C, ed. Computer Applications in Medical Care: Proceedings of the 17th AMIA Conference on Medical Informatics. New York: McGraw-Hill; 1993:88-92.
79. **Goldfinger SE.** The problem-oriented record: a critique from a believer. N Engl J Med. 1973;288:606-8.

80. **Stratmann WC.** Assessing the problem-oriented approach to care delivery. Med Care. 1980;18:456-64.
81. **Donnelly WJ, Brauner DJ.** Why SOAP is bad for the medical record. Arch Intern Med. 1992;152:481-4.
82. **Pryor TA, Gardner RM, Clayton PD, Warner HR.** The HELP system. J Med Syst. 1983;7:87-102.
83. **Wilton R.** Non-categorical problem lists in a primary-care information system. In: Clayton PD, ed. Computer Applications in Medical Care: Proceedings of the 15th AMIA Conference on Medical Informatics. New York: McGraw-Hill; 1991:823-7.
84. **Scherpbier HJ, Abrams RS, Roth DH, Hail JJ.** A simple approach to physician entry of patient problem list. In: Ozbolt JG, ed. Computer Applications in Medical Care: Proceedings of the 17th AMIA Conference on Medical Informatics. Philadelphia: Hanley & Belfus; 1994:206-10.
85. **Safran C, Rury C, Rind DM, Taylor WC.** A computer-based outpatient medical record for a teaching hospital. MD Comput. 1991;8:291-9.
86. **Camp HN.** Technical Challenges, Past and Future, in Implementing THERESA—A One Million Patient, One Billion Item Computer Based Patient Record and Decision Support System. Health Care Information Infrastructure. Philadelphia: Society of Photo-Optical Instrumentation Engineers; 1995:83-6.
87. **Yarnall KS, Michener JL, Broadhead WE, Hammond WE, Tse CK.** Computer-prompted diagnostic codes. J Fam Pract. 1995;40:257-62.
88. **Lincoln MJ.** Developing and implementing the problem list. In: Kolodner RM, ed. Computerizing Large Integrated Health Networks: The VA Success. New York: Springer; 1997:349-81.
89. Webster's Third New International Dictionary of the English Language, Unabridged. Springfield, MA: Merriam; 1986.
90. Webster's Ninth New Collegiate Dictionary. Springfield, MA: Merriam; 1983.
91. **Lindberg DA, Humphreys BL, McCray AT.** The Unified Medical Language System. Methods Inf Med. 1993;32:281-91.
92. **Hurst JW, Walker HK, eds.** The Problem-Oriented System. New York: Medcom Pr; 1972.
93. **Walker HK.** Grady Memorial's integrated database improves speed, accuracy, and cost containment. Comput Healthc. 1989;10:36-7, 40, 42.
94. **McCray AT, Razi AM, Bangalore AK, Browne AC, Stavri PZ.** The UMLS Knowledge Source Server: a versatile Internet-based research tool. In: Cimino JJ, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1996:164-8.
95. **Brown SH, Giuse DA.** Cross institutional reuse of a problem statement knowledge base. In: Masys DR, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1997:151-5.
96. **Giuse DA, Mickish A.** Increasing the availability of the computerized patient record. In: Cimino JJ, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1996:633-7.
97. **Payne TH, Murphy GR, Salazar AA.** How well does ICD9 represent phrases used in the medical record problem list? In: Frisse ME, ed. Computer Applications in Medical Care: Proceedings of the 16th AMIA Conference on Medical Informatics. New York:McGraw-Hill; 1992:654-7.
98. **Campbell JR, Payne TH.** A comparison of four schemes for codification of problem lists. In: Ozbolt JG, ed. Computer Applications in Medical Care: Proceedings of the 18th AMIA Conference on Medical Informatics. Philadelphia: Hanley & Belfus; 1994:201-5.
99. **Barrows RC Jr**, **Cimino JJ, Clayton PD.** Mapping clinically useful terminology to a controlled medical vocabulary. In: Ozbolt JG, ed. Computer Applications in Medical Care: Proceedings of the 18th AMIA Conference on Medical Informatics. Philadelphia: Hanley & Belfus; 1994:211-5.
100. **Rosenberg KM, Coultas DB.** Acceptability of Unified Medical Language System terms as substitute for natural language general medicine clinic diagnoses. In: Ozbolt JG, ed. Computer Applications in Medical Care: Proceedings of the 18th AMIA Conference on Medical Informatics. Philadelphia: Hanley & Belfus; 1994:193-7.
101. **Zelingher J, Rind DM, Caraballo E, Tuttle MS, Olson NE, Safran C.** Categorization of free-text problem lists: an effective method of capturing clinical data. In: Gardner RM, ed. Computer Applications in Medical Care: Proceedings of the 19th AMIA Conference on Medical Informatics. Philadelphia: Hanley & Belfus; 1995:416-20.
102. **Eagon JC, Hurdle JF, Lincoln MJ.** Inter-rater reliability and review of the VA unresolved narratives. In: Cimino JJ, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1996:130-4.
103. **Eagon J, Ortiz E, Zollo K, Hurdle J, Lincoln M.** Department of Veterans Affairs, University of Utah consortium participation in the NLM/AHCPR Large Scale Vocabulary Test. In: Masys DR, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1997:565-9.
104. **Mullins HC, Scanland PM, Collins D, Treece L, Petruzzi P Jr**, **Goodson A, et al.** The efficacy of SNOMED, Read Codes, and UMLS in coding ambulatory family practice clinical records. In: Cimino JJ, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1996:135-9.
105. **Payne TH, Martin DR.** How useful is the UMLS metathesaurus in developing a controlled vocabulary for an automated problem list? In: Safran C, ed. Computer Applications in Medical Care: Proceedings of the 17th AMIA Conference on Medical Informatics. New York: McGraw-Hill; 1993:705-9.
106. **Chute CG, Elkin PL.** A clinically derived terminology: qualification to reduction. In: Masys DR, ed. Proceedings: A Conference of the American Medical Informatics Association. AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1997:570-3.
107. **Munday A, Kelly B, Forrester JW, Timoney A, McGovern E.** Do general practitioners and community pharmacists want information on the reasons for drug therapy changes implemented by secondary care? Br J Gen Pract. 1997;47:563-6.
108. **Phillips-Harris C, Fanale JE.** The acute and long-term care interface. Integrating the continuum. Clin Geriatr Med. 1995;11:481-501.
109. **McDonald CJ, Overhage JM, Dexter P, Takesue B, Suico JG.** What is done, what is needed and what is realistic to expect from medical informatics standards. Int J Med Inf. 1998;48:5-12.
110. **Hammond WE.** The status of healthcare standards in the United States. Int J Biomed Comput. 1995;39:87-92.
111. **Health Care Financing Administration.** Hospital outpatient prospective payment system. Available at http://www.hcfa.gov/medicare/hopsmain.htm. 1999.
112. **Nightingale F.** Notes on Hospitals [microform]. 3d ed. London: Longman, Green, Longman, Roberts, and Green; 1863.
113. **Kennedy EM, Kassebaum NL.** Health Insurance Portability and Accountability Act. Public Law 104-191. 1996.