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A Clinical Decision Support System for Prevention of Venous Thromboembolism

Effect on Physician Behavior

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COMPUTER-BASED CLINICAL decision support systems (CDSSs) are defined as “any software designed to directly aid in clinical decision making in which characteristics of individual patients are matched to a computerized knowledge base for the purpose of generating patient-specific assessments or recommendations that are then presented to clinicians for consideration.”¹ Clinical decision support systems have been promoted for their potential to improve the quality of health care by supporting clinical decision making. In particular, it has been suggested that physicians have difficulties processing complex information² and will improve their prescription practices in response to electronically delivered recommendations.³ However, given their rapid rate of development and the limited range of clinical settings in which they have been tested to date, it has been stressed that CDSSs should be rigorously evaluated before widespread introduction into clinical practice.^{1,4}

In clinical hospital practice, venous thromboembolism remains a serious problem and pulmonary embolism is a major cause of death.⁵ Fatal pulmo-

Context Computer-based clinical decision support systems (CDSSs) have been promoted for their potential to improve quality of health care. However, given the limited range of clinical settings in which they have been tested, such systems must be evaluated rigorously before widespread introduction into clinical practice.

Objective To determine whether presentation of venous thromboembolism prophylaxis guidelines using a CDSS increases the proportion of appropriate clinical practice decisions made.

Design Time-series study conducted between December 1997 and July 1999.

Setting Orthopedic surgery department of a teaching hospital in Paris, France.

Participants A total of 1971 patients who underwent orthopedic surgery.

Intervention A CDSS designed to provide immediate information pertaining to venous thromboembolism prevention among surgical patients was integrated into daily medical practice during three 10-week intervention periods, alternated with four 10-week control periods, with a 4-week washout between each period.

Main Outcome Measure Proportion of appropriate prescriptions ordered for anticoagulation, according to preestablished clinical guidelines, during intervention vs control periods.

Results Physicians complied with guidelines in 82.8% (95% confidence interval [CI], 77.6%-87.1%) of cases during control periods and in 94.9% (95% CI, 92.5%-96.6%) of cases during intervention periods. During each intervention period, the appropriateness of prescription increased significantly ($P < .001$). Each time the CDSS was removed, physician practice reverted to that observed before initiation of the intervention. The relative risk of inappropriate practice decisions during control periods vs intervention periods was 3.8 (95% CI, 2.7-5.4).

Conclusions In our study, implementation of clinical guidelines for venous thromboembolism prophylaxis through a CDSS used routinely in an orthopedic surgery department and integrated into the hospital information system changed physician behavior and improved compliance with guidelines.

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nary embolism may occur in up to 1% of general surgery patients and 3% of orthopedic surgical patients who do not

receive prophylaxis.⁶ The most efficient way to prevent both fatal and non-fatal venous thromboembolism is to use

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routine prophylaxis for moderate- to high-risk patients. Despite the publication of several clinical guidelines for venous thromboembolism prophylaxis in both Europe and North America⁶⁻⁹ as well as studies suggesting that prophylaxis remains underused, few studies aimed at improving prophylaxis practices have been performed.^{10,11} One probable reason is that optimal decisions about the use of anticoagulants in prevention of venous thromboembolism require access to a large amount of complex information to evaluate the degree of risk of hospitalized patients. We have developed a CDSS to implement clinical guidelines on venous thromboembolism prophylaxis in an orthopedic surgery department. In this study, we evaluated the effect of this system on physician behavior. We aimed to determine whether real-time presentation of venous thromboembolism prophylaxis guidelines through a CDSS increases the proportion of appropriate anticoagulant prescriptions ordered and whether this behavior change was extinguished after discontinuing use of the CDSS.

METHODS

Study Site and Population

The study was conducted in the orthopedic surgery department of Lariboisière Hospital, a 1000-acute-bed teaching hospital of the Assistance Publique-Hôpitaux de Paris group (the Paris, France, metropolitan area public hospital network). About 2400 patients are hospitalized annually in this department. All surgeons (7 full-time, 7 part-time) working in the orthopedic surgery department were involved in the study. All orthopedic patients who underwent surgery in the department (from December 1997 to July 1999) were included in the study.

The Assistance Publique-Hôpitaux de Paris Institutional Review Board determined that, according to French policy, the study was exempt from review requirement and could be conducted without informed consent from patients.

Table 1. Guidelines for Venous Thromboembolism Prophylaxis*

Surgical Risk Level	Patient Risk Level	Venous Thromboembolism Risk Level
1	1	Low (No treatment recommended)
	2	
	3	
2	1	Moderate (Low dosage of low-molecular-weight heparin recommended)
	2	
	3	
3	1	High (High dosage of low-molecular-weight heparin recommended)
	2	
	3	

*See "Methods" section of text for details. See Table 2 for explanation of patient and surgical risk levels.

Guideline and Software Development

Clinical guidelines for venous thromboembolism prophylaxis were developed at Assistance Publique-Hôpitaux de Paris.^{12,13} These local guidelines for general surgery, urologic surgery, gynecologic surgery, and orthopedic surgery were created by local hospital experts. In this study, assessment of guideline use with and without the CDSS was restricted to orthopedic surgery patients.

The risk of thromboembolism in a hospital patient depends on the planned surgical procedure (or the reason for admission) and on preexisting patient-related variables. Each of these factors has been classified in existing guidelines as low, moderate, or high risk.⁶⁻⁹ There is no published classification of risk that combines patient risk factors and surgical risk factors to obtain an overall risk of venous thromboembolism. However, taking into account both types of risk for a given patient is crucial in clinical practice. Thus, the local hospital expert group proposed a classification system in which, for each patient, the presence of patient risk factors and surgical risk factors are combined to classify patients as having a low, moderate, or high risk for venous thromboembolism. A prophylactic strategy is recommended for each level of risk. When the risk level is low, no medication is recommended; when the risk level is moderate, prescription of a low dosage of low-molecular-weight heparin is recommended; and when the risk level is high, prescription of a high

dosage of low-molecular-weight heparin is recommended (TABLE 1).

Our CDSS is an online computer application designed as a tool to provide clinicians with relevant, real-time information pertaining to venous thromboembolism prevention among surgical patients. This application is linked to the diagnosis related group-based information system that is implemented in all French hospitals. Patients' administrative and clinical data are collected by direct entry in admitting, operating room, and medical care units. These data are stored in a coded and integrated clinical patient database and are available for computer-assisted decision making.

The CDSS can be accessed through computer terminals available just outside each operating room. Following each surgical procedure, after entering an identification code, the physician enters data related to the clinical situation of the patient (age, sex, disease, surgical procedure, and preexisting patient and surgical risk factors of venous thromboembolism). The physician orders all treatments necessary for patient follow-up (eg, antibiotic therapy, pain management, immobilization), including venous thromboembolism prophylaxis, through the computer system. The computer system critiques the orders using data contained in the patient's database and guideline-based criteria stored in the system's knowledge base. If the computer detects a discrepancy between the prescription and the corresponding information in the database, the

physician is immediately notified via a message on the computer screen suggesting the appropriate prescription and explaining the reasons. The physician can choose to maintain or change his/her order. At the end of the process, the patient follow-up and prescription information, including

venous thromboembolism prophylaxis, is printed out and included in the patient's file.

Study Design

The study had an alternating time-series design, with three 10-week intervention periods, four 10-week con-

rol periods, and a 4-week washout between each period.

During intervention periods, physicians received a message from the CDSS if their prescriptions were not appropriate according to the guidelines. During control periods, physicians ordered all treatment related to thromboembolism prophylaxis through the computer system but received no critiquing messages from the CDSS.

Outcome Measures

To evaluate the effects of the CDSS, the proportion of venous prophylaxis prescriptions that was appropriate according to clinical guidelines was considered to be the main end point. This proportion was estimated based on the final prescription order for each patient compared with treatment designated by algorithms established prior to the study and derived from the guidelines. Each prescription could be classified as appropriate or not appropriate. A prescription was classified as not appropriate when no medication was ordered by the physician when the CDSS recommended prescription of low-molecular-weight heparin (type 1 error), when the wrong dosage of low-molecular-weight heparin was prescribed (type 2 error), or when a prescription of low-molecular-weight heparin was made when the CDSS proposed no medication (type 3 error).

The percentage of inappropriate initial prescriptions that were changed after advice was given by the CDSS during intervention periods was also calculated according to each level of risk of venous thromboembolism. We also recorded the number of pulmonary embolisms and deep vein thromboses diagnosed in the orthopedic department during the study period.

Statistical Analysis

Analysis included all eligible patients. Comparisons of clinical characteristics of patients during intervention and control periods were tested using the χ^2 test and the *t* test where appropriate. The nominal significance level for the end points was .05 (2-sided formulation).

Table 2. Characteristics of Patients Enrolled During Control and Intervention Periods

Characteristics	Control Periods	Intervention Periods
No. of patients	1112	859
Mean age, y	51.1	52.2
Length of intervention, min	77.2	80.4
Male, No. (%)	484 (47.1)	430 (50.8)
Patient Risk		
No. (%) of patients		
Level 1 (no risk factors)	411 (37.0)	270 (31.4)
Level 2	658 (59.2)	551 (64.1)
Age >40 y	654 (58.8)	559 (65.1)
Combined oral contraceptive	15 (1.3)	19 (2.2)
Heart failure	13 (1.2)	14 (1.6)
Preoperative bed rest >4 d	34 (3.1)	39 (4.5)
Venous insufficiency	24 (2.2)	29 (3.4)
Presurgery acute infection	15 (1.3)	9 (1.1)
Postpartum (1 mo)	81 (7.3)	74 (8.7)
Obesity	18 (1.6)	21 (2.4)
Level 3	43 (3.9)	38 (4.4)
Recent or metastatic malignancy	23 (2.1)	23 (2.7)
Previous deep vein thrombosis or pulmonary embolism	3 (0.3)	0 (0)
Lower limb paralysis	8 (0.7)	6 (0.7)
Myeloproliferative disease	9 (0.8)	8 (0.9)
Thrombophilia	2 (0.2)	6 (0.7)
Surgical Risk		
No. (%) of patients		
Level 1	402 (36.1)	302 (35.2)
Upper limb surgery	363 (32.7)	286 (33.3)
Diagnostic arthroscopy	3 (0.2)	6 (0.7)
Foot surgery	35 (3.1)	22 (2.6)
Device removal	16 (1.4)	9 (1.1)
Herniated disk surgery	2 (0.2)	0 (0)
Level 2	53 (4.8)	40 (4.6)
Lower limb immobilization	2 (0.2)	3 (0.4)
Spine surgery (without neurological impairment)	36 (3.2)	26 (3.0)
Therapeutic arthroscopy	20 (1.8)	13 (1.5)
Level 3	657 (59.1)	517 (60.2)
Spine surgery (with neurological impairment)	4 (0.4)	9 (1.1)
Hip surgery and surgery of the pelvis	633 (56.9)	509 (59.3)
Lower limb trauma	22 (2.0)	0 (0)
Multiple trauma	0 (0)	0 (0)
Venous Thromboembolism Risk		
No. (%) of patients		
Low risk	397 (35.7)	299 (34.8)
Moderate risk	58 (5.2)	40 (4.6)
High risk	657 (59.1)	520 (60.6)

To evaluate the effect of the decision-making application on appropriateness of prescription, we first chose the patient as the unit of analysis because the patient experiences the care and generates the original data. Then we took into account as a unit of analysis the physician (eg, the sequence of prescriptions of 1 physician). We accounted for the potential nonindependence of patient observations of a physician resulting from clustering by using a logistic regression model for binary data with random effect. We assumed that only the intercept, not the decision-making application effect, varies among physicians. The decision-making application effect was tested using the logit of the probability of appropriateness as response, while the period (control vs intervention) was considered the explicative covariate. The intercept was regarded as a random effect and the period as a fixed effect. Model parameters were estimated using the iteratively reweighted restricted likelihood method and fixed effects were tested with the Fisher exact test (SAS GLIMIX macro).¹⁴ Mean probability of appropriateness of prescription according to study period was then generated by taking the exponential transformation of the logit.

All statistical analyses were performed using SAS version 6.12 computer software (SAS Institute Inc, Cary, NC).

RESULTS

A total of 1971 patients were included in the study; 1112 during control periods and 859 during intervention periods. The computer system was used in 100% of patients who underwent surgery during the study period. Patient characteristics were comparable in the intervention and control periods, except for patient risk factors. There were more patients with no preexisting risk factors during the control periods than in the intervention periods (36.9% vs 31.5%; $P = .04$). However, distribution of venous thromboembolism risks were comparable in the 2 groups (TABLE 2). A total of 696 patients (35.3%) were at low risk of venous thromboembolism,

98 patients (5.0%) were at moderate risk, and 1177 patients (59.7%) were at high risk. During the study period, the mean number of patients per surgeon was 141 (range, 4-370). Five surgeons operated on fewer than 40 patients each and 8 surgeons operated on more than 100 patients.

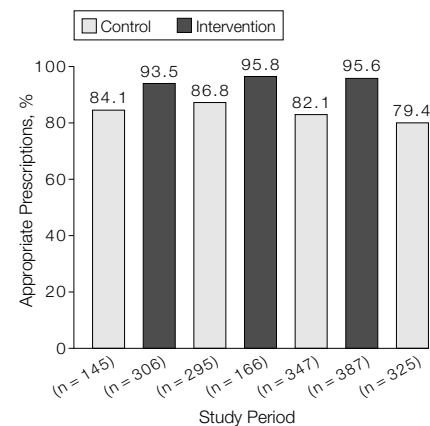
Physicians complied with guidelines in 82.8% (95% confidence interval [CI], 77.6%-87.1%) of cases during control periods and in 94.9% (95% CI, 92.5%-96.6%) of cases during intervention periods. Logistic regression analysis, performed using the physician as the unit of analysis, demonstrated a significant physician effect ($P < .001$) and a significant difference between the 2 study periods on appropriateness of prescription ($P < .001$). The relative risk of inappropriateness was 3.8 (95% CI, 2.7-5.4) for control periods vs intervention periods, equivalent to a 73% reduction in risk of inappropriate prescription.

Results according to period are shown in the FIGURE. During each intervention period, the proportion of appropriate prescriptions ordered increased significantly. Each time the CDSS was removed, physician compliance with guidelines reverted to that observed before initiation of the intervention.

Results according to venous thromboembolism risk are shown in TABLE 3. A total of 191 prescriptions (17.2%) were judged inappropriate by the CDSS during control periods and 113 prescriptions (13.2%) were judged inappropriate during intervention periods. Among these 113 prescriptions, 69 (61.1%) were modified by the physician according to the recommendation of the CDSS and 44 (38.9%) remained unchanged. Overall, the effect of the CDSS was greatest for patients at moderate risk of venous thromboembolism. In this group, 18 (81.8%) of 22 inappropriate prescriptions were changed after advice given by the CDSS. The CDSS appeared to have less effect for patients at high risk of venous thromboembolism. In this group, 24 (51.1%) of 47 inappropriate prescriptions were changed.

TABLE 4 presents the number of errors by type for the 191 inappropriate

Figure. Appropriateness of Prescription by Study Period



For intervention periods, data are percentages of appropriate prescriptions ordered after opportunity to correct initial decision. See "Study Design" for a description of the study periods.

prescriptions ordered during the control periods and the 44 inappropriate prescriptions that were not changed during the intervention periods. The system did not allow for analysis of the 69 initial prescriptions that were changed according to the recommendation. During intervention periods, the error rate decreased by 86% for type 1 errors, by 59% for type 2 errors, and by 66% for type 3 errors.

The CDSS improved the clinical practice of all physicians except 1 whose proportion of appropriate prescriptions was close to 100% during control periods. The greatest improvement was observed among the 5 surgeons who operated on fewer than 40 patients.

One pulmonary embolism and 2 deep vein thromboses were diagnosed during control periods. No pulmonary embolisms and 2 deep vein thromboses were diagnosed during intervention periods.

COMMENT

Our study showed that implementation of clinical guidelines for venous thromboembolism prophylaxis through a CDSS in an orthopedic surgery department significantly changed physician behavior and improved compliance with guidelines. The improvement was

Table 3. Appropriate and Inappropriate Prescriptions According to Venous Thromboembolism Risk During Intervention and Control Periods*

	Venous Thromboembolism Risk							
	Low		Moderate		High		Total	
	C (n = 397)	I (n = 299)	C (n = 58)	I (n = 40)	C (n = 657)	I (n = 520)	C (n = 1112)	I (n = 859)
Initial prescription was appropriate	344 (86.7)	255 (85.3)	3 (5.7)	18 (45.0)	574 (87.4)	473 (91)	921 (82.8)	746 (86.8)
Initial prescription was not appropriate	53 (13.3)	44 (14.7)	55 (94.3)	22 (55.0)	83 (12.6)	47 (9.0)	191 (17.2)	113 (13.2)
And was changed after advice given by the CDSS	...	27 (9.0)	...	18 (45.0)	...	24 (4.6)	...	69 (8.0)
And remained inappropriate after advice given by the CDSS	...	17 (5.7)	...	4 (10.0)	...	23 (4.4)	...	44 (5.1)
Total appropriate prescriptions	344 (86.7)	282 (94.3)	3 (5.7)	36 (90)	574 (87.4)	497 (95.6)	921 (82.8)	815 (94.9)

*Data are number (percentage) of prescriptions. C indicates control period; I, intervention period; CDSS, clinical decision support system; and ellipses, data not applicable.

Table 4. Inappropriate Prescriptions by Type of Error*

	Control Periods (n = 1112)	Intervention Periods (n = 859)†
Total No. of errors	191 (17.2)	44 (5.1)
Error type		
1	65 (5.8)	7 (0.8)
2	73 (6.6)	23 (2.7)
3	53 (4.8)	14 (1.6)

*Data are number (percentage of total prescriptions). Type 1 errors indicate no medication was ordered by the physician when prophylaxis was recommended; type 2 errors, wrong dosage of medication was prescribed; and type 3 errors, medication was ordered by the physician when prophylaxis was not recommended.

†Data are not available for prescriptions changed according to the guidelines.

greater for patients at moderate risk of venous thromboembolism than for patients at high risk of venous thromboembolism where practices were already appropriate for more than 90% of patients before any intervention. In patients with elective hip surgery and hip fractures, drug regimens including subcutaneous heparin and low-molecular-weight heparin have been proven effective in prevention of deep vein thrombosis⁶⁻⁸ and this strategy is well accepted by French surgeons. However, the moderate risk constitutes a gray zone of uncertainties and is more difficult to define. Physicians may also have difficulty remembering the guidelines for this category involving relatively few patients (5% of the total). This explains the dramatic effect of the CDSS on physician behavior concerning this subgroup of patients during intervention periods. For the same group, the percentage of appropriate initial prescriptions (before advice was given by the CDSS) was much more important

during intervention periods (45%) than during control periods (5.7%). Due to a Hawthorne effect, the physicians involved in the study were probably more watchful when the CDSS was in use than when it was not in use. This was an indirect effect of the CDSS.

The CDSS reduced all types of errors but its input seemed to be particularly important for type 1 errors (failure to order a medication when prophylaxis was recommended).

Our study contributes several important considerations to the understanding of the potential role of CDSSs in clinical guideline implementation. First, this study confirms that use of a CDSS at the time of prescription constitutes an effective guideline implementation strategy.¹⁵⁻¹⁸ A significant effect on physician behavior was observed despite a high baseline compliance to guidelines (84.1%) before intervention. In 2 recent studies performed in surgical and medical-surgical patients, 86% and 85%, respectively, received venous thromboembolism prophylaxis before any intervention.^{10,19}

The CDSS was able to maintain a sustained effect of guidelines for a relatively long period. Failure to do so constitutes a major weakness of most guideline implementation strategies, including paper reminders.^{20,21} The guidelines can also be easily updated on the CDSS, which facilitates the implementation over time of up-to-date guidelines.^{15,16}

The CDSS was integrated into the daily practice of physicians. Thus, all consecutive patients who underwent

surgery during the study period were included in the study. Since the computer system was used as a data collection tool, it was easy to evaluate the effect of the system.

Second, when we designed the CDSS, we chose to establish a critiquing system rather than a reminding system. Such critiquing systems, which advise clinicians about what should be done after a prescription contrary to guidelines has been ordered, have been commonly applied.²² A simple reminder system that notifies clinicians before prescription of tasks that should be done probably can be disregarded more easily by the clinician. A critiquing system can also be used on a routine basis to calculate physician deviation rates before intervention, thus facilitating efforts toward continuous quality improvement.²³

Third, some investigators have considered that reminding or alerting clinicians about what constitutes appropriate practice is a continuing medical education strategy.²⁴ The rate of reversion of compliance to guidelines to baseline values during each control period, even after 15 months, showed that a CDSS cannot be considered an educational tool or that education alone is unable to sustain substantial changes in physician practice as has been suggested previously.^{25,26}

Our study had several limitations. The clinical guidelines, particularly the combination of patient- and surgery-related risk factors used to generate venous thromboembolism risk, were developed locally and may not be acceptable to other groups of physi-

cians. The CDSS was implemented in 1 department of 1 hospital and, therefore, the applicability of our results to other settings is unknown. Another limitation is that we evaluated the effect of implementing a CDSS on process, not on patient outcomes. The number of pulmonary embolisms and deep vein thromboses diagnosed among patients during their hospital stay is insufficient to evaluate patient outcomes since a thromboembolism event can occur after discharge. However, the aim of the CDSS was to increase the appropriateness of prophylaxis, not to demonstrate a relationship between prophylaxis and thromboembolism. In addition, there is no noninvasive, accurate, and inexpensive diagnostic test to identify patients with deep vein thrombosis.²⁷ The difficulties in interpreting outcomes are widely recognized.²⁸ Numerous authors now consider it better to evaluate process rather than outcomes when assessing quality of

care.²⁹⁻³¹ Outcomes have multiple determinants and it is impossible to know what proportion of a given health outcome is determined by quality factors (ie, processes and structure of care) and what proportion is due to patient-related risk factors.³² Interpretation of health outcomes is hampered by the problem of case-mix.²⁸ Statistical analyses require an adequate number of outcomes for the results to be meaningful.^{29,32} Conversely, the use of process measures can identify specific shortcomings (eg, proportion of inappropriate prescriptions) and point toward what needs to be changed.²⁸

Clinical decision support systems have been successfully implemented for preventive care, drug dosing, and management of diseases.¹ Our study shows that implementation of clinical guidelines for venous thromboembolism prophylaxis through a CDSS used routinely in an orthopedic surgery ward and integrated into a computerized hos-

pital information system significantly changed physician behavior and improved compliance with guidelines. This system, integrated in the daily practice of physicians, appeared to constitute a way to obtain a sustained effect of clinical guidelines. Given the limited range of clinical settings and health systems in which CDSSs have been tested, it is important to evaluate such systems on physician behavior.

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REFERENCES

- Hunt DL, Haynes RB, Hanna SE, Smith K. Effects of computer-based clinical decision support systems on physician performance and patient outcome: a systematic review. *JAMA*. 1998;280:1339-1346.
- Weed LL, Weed L. Opening the black box of clinical judgment—an overview. *BMJ*. 1999;319:1279.
- Schiff GD, Rucker D. Computerized prescribing: building the electronic infrastructure for better medication usage. *JAMA*. 1998;279:1024-1029.
- Evans RS, Pestotnik SL, Classen DC, et al. A computer-assisted management program for antibiotics and other anti-infective agents. *N Engl J Med*. 1998;338:232-238.
- Anderson FA, Wheeler HB, Goldberg RJ, et al. A population-based perspective of the hospital incidence and case-fatality rates of deep vein thrombosis and pulmonary embolism. *Arch Intern Med*. 1991;151:933-938.
- Clagett GP, Anderson FA, Heit J, Levine MN. Prevention of thromboembolism. *Chest*. 1995;108:312S-334S.
- Prophylaxie des thromboses veineuses profondes et des embolies pulmonaires post-opératoires (chirurgie générale, gynécologique et orthopédique). *Ann Fr Anesth Reanim*. 1991;10:417-421.
- Nicolaides AN, Arcelus J, Belcaro G, et al. Prevention of venous thromboembolism: European Consensus Statement. *Int Angiol*. 1992;1:151-159.
- Thromboembolic Risk Factors (THRIFT) Consensus Group. Risk of and prophylaxis for venous thromboembolism in hospital patients. *BMJ*. 1992;305:567-574.
- Anderson FA, Wheeler HB, Goldberg RJ, Hosmer DW, Forcier A, Patwardhan NA. Changing clinical practice: prospective study of the impact of continuing medical education and quality assurance programs on use of prophylaxis for venous thromboembolism. *Arch Intern Med*. 1994;154:669-677.
- Patterson R. A computerized reminder for prophylaxis of deep vein thrombosis in surgical patients. *Proc AMIA Symp*. 1998:573-576.
- Durieux P, Ravaud P. From clinical guidelines to quality assurance: the experience of Assistance Publique-Hôpitaux de Paris. *Int J Qual Health Care*. 1997;9:215-219.
- Ravaud P, Durieux P, Fourcade A, and the Comité Scientifique Thrombose AP-HP. Prophylaxie des thromboses veineuses post-opératoires: recommandations de l'Assistance Publique-Hôpitaux de Paris. *Sang Thromb Vaisseaux*. 1995;7:119-129.
- Wolfiger R, O'Connell M. Generalized linear mixed models: a pseudo-likelihood approach. *J Stat Comput Simulation*. 1993;48:233-243.
- NHS Centre for Reviews and Dissemination. Implementing clinical practice guidelines: can guidelines be used to improve medical practice? *Effective Health Care*. 1994;8:1-12.
- Oxman AD, Thomson MA, Davis DA, Haynes RB. No magic bullets: a systematic review of 102 trials of interventions to improve professional practice. *CMAJ*. 1995;153:1423-1431.
- Shea S, DuMouchel W, Bahamonde L. A meta-analysis of 16 randomized controlled trials to evaluate computer-based clinical reminder systems for preventive care in the ambulatory setting. *J Am Med Assoc*. 1996;3:399-409.
- Balas EA, Austin SM, Mitchell JA, Ewigman BG, Bopp KD, Brown GD. The clinical value of computerized information services: a review of 98 randomized clinical trials. *Arch Fam Med*. 1996;5:271-278.
- Ryskamp RP, Trotter SJ. Utilization of venous thromboembolism prophylaxis in a medical-surgical ICU. *Chest*. 1998;113:162-164.
- McNally E, de Lacey G, Lowell P, Welch T. Posters for accident departments: simple method of sustaining reduction in x-ray examinations. *BMJ*. 1995;310:640-642.
- Auleley G-R, Ravaud P, Giraudeau B, et al. Implementation of the Ottawa ankle rules in France. *JAMA*. 1997;277:1935-1939.
- Randolph AG, Haynes RB, Wyatt JC, Cook DJ, Guyatt GH. Users' guides to the medical literature, XVIII: how to use an article evaluating the clinical impact of a computer-based clinical decision support system. *JAMA*. 1999;282:67-74.
- 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;278:1585-1590.
- Davis DA, Thomson MA, Oxman AD, Haynes B. Changing physician performance: a systematic review of the effect of continuing medical education strategies. *JAMA*. 1995;274:700-705.
- Soumerai SB, McLaughlin TJ, Avorn J. Improving drug prescribing in primary care: a critical analysis of the experimental literature. *Milbank Q*. 1989;67:268-317.
- Weingarten SR, Riedinger MS, Conner L, et al. Practice guidelines and reminders to reduce duration of hospital stay for patients with chest pain. *Ann Intern Med*. 1994;120:257-263.
- Goldhaber SZ, Morpurgo M, for the WHO/International Society and Federation of Cardiology Task Force. Diagnosis, treatment, and prevention of pulmonary embolism. *JAMA*. 1992;268:1727-1733.
- Davies HT, Crombie IK. Assessing the quality of care. *BMJ*. 1995;311:766.
- Mant J, Hicks N. Detecting differences in quality of care: the sensitivity of measures of process and outcomes in treating acute myocardial infarction. *BMJ*. 1995;311:793-796.
- Brook RH, McGlynn EA, Cleary PD. Quality of health care: measuring quality of care. *N Engl J Med*. 1996;335:966-970.
- McKee M. Indicators of clinical performance: problematic, but poor standards of care must be tackled. *BMJ*. 1997;315:142.
- Hammermeister KE. Participatory continuous improvement. *Ann Thorac Surg*. 1994;58:1815-1821.