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Evaluation of the use of an integrated drug information system by primary care physicians for vulnerable population

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ABSTRACT

Objective: To investigate whether an electronic prescribing and integrated drug information system was more likely to be used by primary care physicians for patients of low socioeconomic (SES) patients.

Methods: Prospective 9 months follow-up study was conducted in Montreal, Canada from March to November 2003. The study included 28 primary care physicians and their 4096 respective patients with provincial drug insurance. Utilization rate was defined as the number of times the electronic medication history (EMH) and electronic prescribing system (E-rx) were accessed divided by the total number of medical visits made by those patients. System audit trails (utilization), provincial health insurance databases (visits) were used to measure system utilization rate. For each patient neighborhood-based measures of household income, derived from Statistics Canada, were used to measure socioeconomic status.

Results: The EMH was used 14.5 times per 100 visits. In comparison to high SES patients, there was a significant 70% increase (RR: 1.70; 95%CI: 1.15–2.47) in the EMH utilization for low SES patients. The electronic prescribing system was used 38.5 times per 100 visits and did not vary by patient SES. The EMH utilization rate for low SES patients with multiple emergency room (ER) visits was 2.4 times higher than for high SES patients with <1 ER visit (RR: 2.38; 95%CI: 1.36–4.14). The utilization rate for low SES patients, who took, at least six drugs per day, was four times higher compared to high SES patients with less complex drug management (RR: 4.00; 95%CI: 2.22–7.17).

Conclusions: Primary care physicians were more likely to access electronic information on current drug use for patients of low SES taking multiple medications and with fragmented care.

1. Introduction

Adverse drug-related events are the sixth leading cause of mortality [1]. In ambulatory care where the majority of medication prescriptions are generated, 58% of adverse drug events are associated with potentially avoidable prescribing errors. The rapid increase in the number of drugs used per patient [2–4] as well as the existence of multiple prescribing physicians contribute to these avoidable prescribing errors [5,6]. Indeed, there is evidence that neither community-based

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physicians nor emergency room staff have access to complete information regarding a patient's current medication profile. A recent study indicates that 27–48% of medications being used by community-based patients are not known or documented at the time of hospital admission or by the primary care physician [7]. Incomplete medication history is estimated to account for approximately 30% of all prescribing errors [8].

The implementation of computerized electronic prescribing and integrated drug management systems has been identified as one potential solution to reduce this source of avoidable prescribing errors [3,9–11]. Considerable investment has been made in developing integrated drug information management systems to facilitate safety in drug treatment [2,12–14]. However, the actual benefits of implementing an integrated drug information system in primary care, particularly for vulnerable subpopulations such as patients of low SES, are unknown.

Patients of lower socioeconomic status (SES) have a higher rate of morbidity and hospitalization [15–18]. Underutilization of recommended medical treatment for low SES patients appears to be in part responsible for the reported greater morbidity [19]. Such sub-optimal therapy may be related to greater fragmentation of care in lower SES patients [18,20] as evidenced by the use of more primary care services, [21–24] provided by different physicians [20,24] and a greater likelihood of using the emergency room (ER) as a regular source of care for their disease management [18,25–28]. In low SES patients, the problem may be compounded by the greater number of medications prescribed [29] and the consequent increased likelihood of experiencing preventable adverse drug-related events [6].

If incomplete drug information represents a significant problem in providing care for patients, we would expect physicians to use a computerized drug management system to review the current drug profile of patients of low SES more frequently than for other patients. By contrast, various other aspects of electronic prescribing such as the generation of typed prescriptions would not be expected to vary by socioeconomic status.

We had an opportunity to evaluate the utilization of a computerized electronic prescribing and integrated drug management system for community-based patients of primary care physicians. Using a combination of data retrieved from the computerized drug management system and comprehensive health care utilization information from the universal health insurance program, we tested the hypothesis that information on current drug use would be more likely to be accessed during clinical encounters for patients of low SES, with fragmented care and with a greater number of medications.

2. Methods

2.1. The Quebec prototype

The Medical Office of the Twenty First Century (MOXXI) is an electronic prescription and drug management system for primary care physicians, community-based pharmacists and their respective patients. In the MOXXI system, physicians are able to write prescriptions electronically and retrieve information on dispensed prescriptions and medical visits from the health insurance program and community pharmacy network (Fig. 1a). Information on dispensed medications and their costs are displayed in an electronic medication history (EMH) that provides a graphic representation of the list of medications based on start and end dates of prescriptions, color-coded by prescribing physician. The EMH also provides information on ER visits and hospitalizations based on medical visit information from the health insurance program (Fig. 1b).

2.2. Study design

A prospective follow-up study was conducted to assess the utilization of the electronic medication history (EMH) and electronic prescribing system (E-rx) over a 9-month period (March–November 2003) after the implementation of the MOXXI system. The study population was comprised of 28 primary care physicians who were in full time, fee-for-service private practice in the suburbs of Montreal, a metropolitan area of 3.9 million people. The population of patients studied was restricted to those covered by the provincial health insurance agency (RAMQ) which provides drug insurance for approximately half the population, including the elderly, welfare recipients, and persons without employer provided drug insurance [30].

2.3. Data sources

2.3.1. Health care administrative data

The provincial health insurance agency (RAMQ) provides first dollar coverage for all medical and hospital care for all Quebec residents. Three databases administered by RAMQ were used to measure beneficiary characteristics and utilization rate. The health beneficiary demographic database provided data on age, sex, and postal code. The medical services claims database provided information on the beneficiary, date, type, provider, and location of service delivery (e.g. inpatient, emergency, clinic) for all medical services remunerated on a fee-for-service basis (approximately 86% of all services) [31]. The prescription claims database provided information on each drug dispensed including the drug name, quantity, date and duration for each prescription, the prescribing physician, and the dispensing pharmacy.

2.3.2. Clinical data from the MOXXI system

The clinical data captured by the MOXXI system includes electronic prescriptions, a problem and allergy list, and an audit trail information on physician activity. In addition, records of all dispensed prescriptions and medical services from community pharmacies and the RAMQ are updated daily to the central server tables through a batch download. A copy of the clinical data is made daily to a research server, where patient and physician names are replaced with a study identification number to protect confidentiality.

The audit trail records a physician's utilization of different features of the MOXXI system. Each time the physician accesses the electronic medication history, or writes electronic prescriptions, the audit trail records the date and time, the patient's Medicare number, the physician identification number, and the drug prescribed. The audit trail logs of the

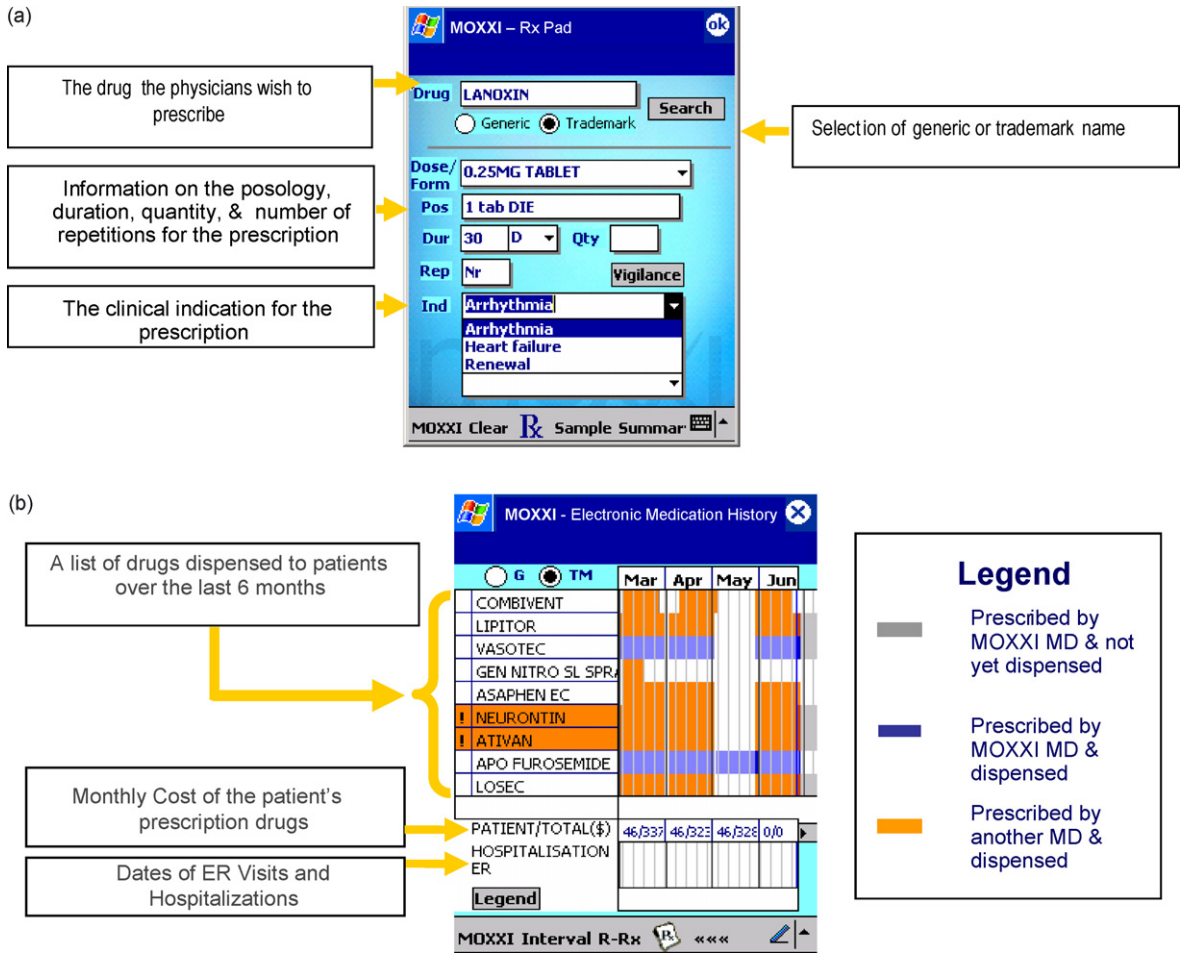

Fig. 1 – (a) Electronic prescribing system screen shot and (b) electronic medication history screen shot.

system were used to assess electronic medication history and electronic prescription use. Data from all sources were linked by Medicare number, a unique identifier for each Quebec resident.

2.4. *Outcome assessment*

2.4.1. *Electronic medication history (EMH) utilization*

The EMH utilization rate was defined as the number of individual patient visits during which the EMH was accessed divided by the total number of medical visits made by eligible patients to the study physicians during the follow-up period. The numerator, defined as the number of times the EMH was accessed, was determined by inspecting daily EMH access audit trails for patients who had made a visit to the study physicians. The denominator of medical visits was obtained from the medical services claims database, using the date of service, physician and beneficiary identifiers, and location service code.

2.4.2. *Electronic prescribing (E-rx) utilization*

The E-rx utilization rate was defined as the number of individual patient visits during which the E-rx system was used divided by the number of medical visits made by patients to their study physicians. The number of visits in which an E-rx was written for these patients was determined from the audit trails of the E-rx system.

2.5. *Predictors Assessment*

2.5.1. *Socioeconomic status (SES)*

Statistics Canada census information on mean household income by enumeration area was used to provide a proxy measure of patient socioeconomic status (SES) [32]. Mean household income in each enumeration area was first mapped to six-digit postal codes. In the province of Quebec there are 187,025 postal codes. Since postal codes do not respect census geographic boundaries, some six-digit postal codes match several enumeration areas [33]. When this was the case, mean household income of the particular six-digit postal code was calculated as the weighted average of mean household income of the enumeration areas represented in the six-digit postal code, where the weight represented the number of households in the enumeration area. The six-digit postal code of the residential address recorded for each eligible patient was used to assign household income to each patient.

Individuals were allocated to one of three categories of SES based on average household income of residents in their postal code. Low SES was defined as an average household income under the poverty line for a family of three in a

metropolitan area (CA$ 31,753 in 1995). High SES was defined as an average household income of CA$ 80,001 or more. This is the highest income category used in the 1996/1997 National Population Health Survey and is based on observed combinations of household income and size of household [34]. Middle SES was defined as average household income between defined lower SES and higher SES (CA$ 31,754–80,000).

2.5.2. *Fragmentation of care*

Three indices were used to measure fragmentation of care. The "number of emergency room visits" was defined as the number of distinct days that a patient received medical services in the ER during the follow-up period. The service location code and date in the RAMQ medical service claims was used to produce a count for each patient. The "number of prescribing physicians" was defined as the number of different physicians who prescribed drugs for each patient during the follow-up period. The prescriber identification number in the RAMQ prescription claims database was used to produce a count for each patient.

The "proportion of visits to study physicians" was defined as the number of visits that patients made either to the study physician or to another physician to which the study physician referred the patient, as a proportion of all visits made to any physician by an individual patient in the baseline year prior to implementation of the MOXXI system [35]. The date of service and the identification of the physician who provided the service or referred the patient in the medical services claims database was used to calculate a value for each patient.

2.5.3. *Complexity of drug management*

"Complexity of drug management" was defined as the average number of drugs dispensed per day during the follow-up period. For each day in the follow-up period, the drug identification number and the prescription start and end date in the prescription claims files were used to create a drug by day matrix. The average number of drugs per day was determined for each patient by dividing the sum of the number of drugs per day by the total number of days in the follow-up period.

2.6. *Statistical analysis*

Descriptive statistics were used to characterize the study population and determine utilization rates of the EMH and E-rx system by SES, degree of care fragmentation and complexity of drug treatment. Poisson regression within a generalized estimated equation (GEE) framework was used to test the study hypothesis. Physician was identified as a clustering variable in the GEE model, and an exchangeable correlation structure was used to account for correlation among residuals. Each model

Table 1 – Characteristics of patients who visited the study physicians from March to November 2003 by socioeconomic status ($n = 4096$)

	Socioeconomic Status Low SES ($n = 349$)	Middle SES ($n = 3304$)	Higher SES ($n = 443$)
Patient demographics			
Age			
≥65 years old	254 (72.8%)	2265 (68.6%)	265 (59.8%)
Mean [S.D., range]	67.1 [17.1, 2–99]	66.1 [15.6, 1–97]	62.1 [19.3, 1–93]
Gender (%)			
Female	233 (66.8%)	1961 (60.0%)	266 (60.1%)
Fragmentation of care			
Number of emergency room visits			
0–1	299 (85.7%)	2961 (89.6%)	415 (93.6%)
>1	50 (14.3%)	343 (10.4%)	28 (6.3%)
Mean [S.D., range]	0.6 [1.4, 0–13]	0.4 [1.3, 0–20]	0.4 [1.1, 0–11]
Number of prescribing physicians			
0–1	137 (39.3%)	1326 (40.1%)	216 (40.1%)
>1	212 (60.7%)	1978 (59.9%)	227 (59.9%)
Mean [S.D., range]	2.2 [1.7, 0–8]	2.2 [1.7, 0–14]	1.9 [1.7, 0–11]
Proportion of visits to study physicians			
>65% of visits	165 (37.3%)	1105 (33.4%)	123 (35.2%)
41–65% of visits	154 (34.8%)	1098 (33.2%)	112 (32.1%)
0–40% of visits	124 (28.0%)	1101 (33.3%)	114 (32.7%)
Mean [S.D.]	0.61 [0.29]	0.61 [0.28]	0.64 [0.29]
Complexity of drug management			
≤3.0 drugs/day	166 (47.6%)	1889 (57.2%)	310 (70.0%)
3.0–6.0/day	124 (35.5%)	938 (28.4%)	99 (22.4%)
>6.0 drugs/day	59 (16.9%)	477 (14.4%)	34 (7.7%)
Mean [S.D., range]	3.50 [3.13, 0–15.4]	3.01 [2.42, 0–20.4]	2.23 [1.64, 0–13.2]

included dummy variables for SES using high SES as the reference category. The unit of analysis was the patient. Each model was adjusted for age and gender. Combined effects of patient SES, fragmented care, and complex drug therapy were estimated by adding regression coefficients from the GEE Poisson regression model. Ninety-five percent confidence intervals (CI) for combined effects were estimated using equations proposed by Schlesselman [36].

3. Results

In the 9 months after the MOXXI system implementation, 4096 patients (47.9%) in the RAMQ drug insurance plan made at least one visit to a study physician. Of these, 343 (8.4%) were categorized as low SES, 443 (10.8%) were high SES, and the remainder were middle SES (Table 1). Patients of low SES were more likely to be female and 65 years of age or older. Low SES patients tended to have greater fragmentation of care and greater complexity of drug management compared to patients of middle and high SES. The proportion of patients having at least one ER visit and having been dispensed more than three drugs per day was highest in the lower SES patients. By contrast, the number of prescribing physicians and the proportion of visits to study physicians were similar across the three SES groups.

The overall EMH utilization rate was 14.5 per 100 visits. In comparison to high SES patients, there was a significant 55% increase (RR: 1.55; 95%CI: 1.15–2.08) in the EMH utilization for middle SES patients and a 70% increase (RR: 1.70; 95%CI: 1.15–2.47) for low SES patients (Fig. 2). The overall E-rx system utilization rate was 38.5 per 100 visits and did not vary by SES. Adjustment for age and gender in relationship to E-rx was not possible due to the high intra-cluster correlation among patients prescribed medications by the same physicians ($r = 0.6$).

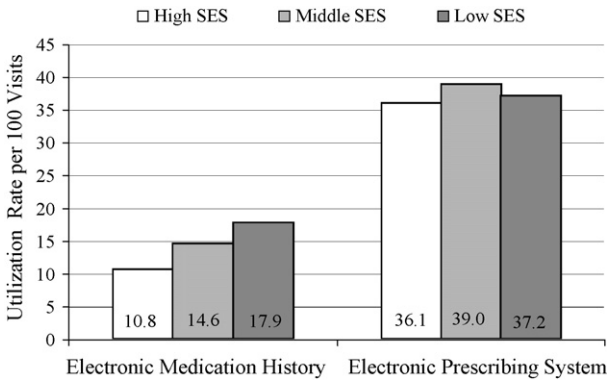

Fig. 2 – Physicians' differential utilization rate of electronic medication history and electronic prescribing (E-rx) system by patient socioeconomic status. (1) Compared to high SES group, increase in electronic medication history utilization rate for low SES group (rate ratio: 1.70; 95%CI: 1.15–2.47) and for middle SES group (rate ratio: 1.55; 95%CI: 1.15–2.08) was statistically significant. (2) Adjusted GEE analysis for age and gender in relationship to E-rx was not possible due to high intra-cluster correlation among patients prescribed medications by the same physicians ($r = 0.6$).

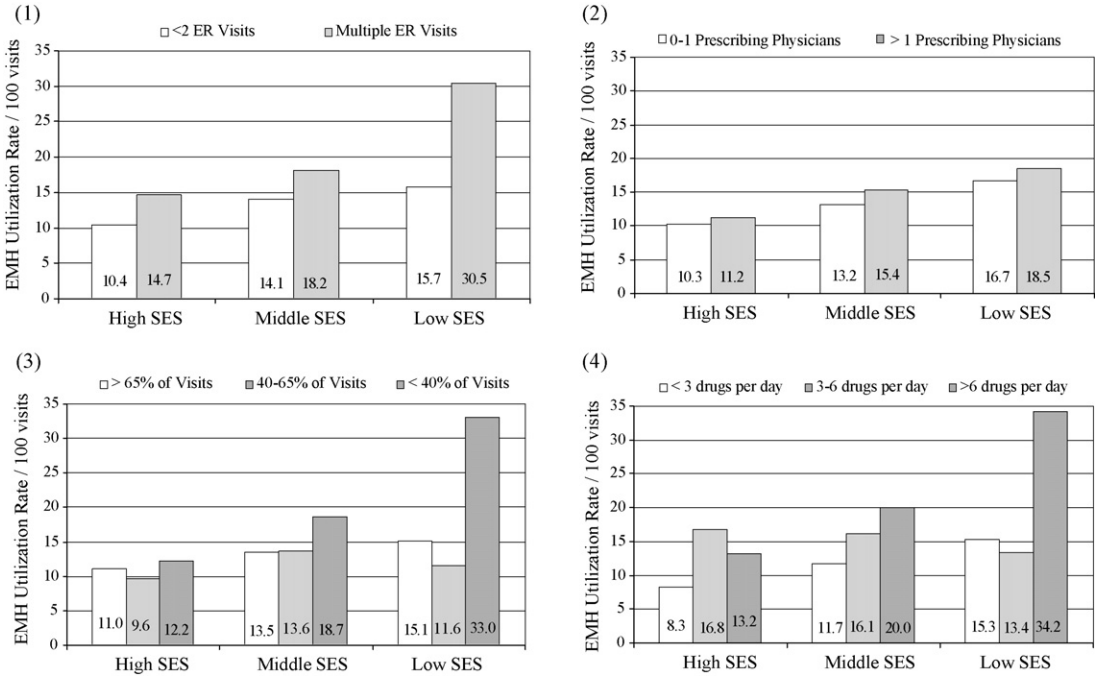

Fig. 3 – Physicians' utilization rate of electronic medication history (EMH) by patient socioeconomic status and fragmented care, and complexity of drug management. (1) EMH utilization rate by patient socioeconomic status and number of emergency room visits; (2) EMH utilization rate by patient socioeconomic status and number of prescribing physicians; (3) EMH utilization rate by patient socioeconomic status and proportion of visits to study physicians; (4) EMH utilization rate by patient socioeconomic status and average number of medications dispensed per day.

Table 2 – Electronic medication history utilization rate ratio by patient socioeconomic status, fragmented care , and complexity of drug management (*n* = 4096)

	Electronic medication history utilization rate ratio[a] (95%CI)[b] Socioeconomic Status (SES)		
	Low SES (*n* = 343)	Middle SES (*n* = 3304)	High SES (*n* = 443)
1. Fragmentation of care			
Number of emergency room (ER) visits			
0–1 ER visits	1.70 (1.17–2.48)	1.56 (1.16–2.10)	Reference[c]
>1 ER visits	2.38 (1.36–4.14)	2.18 (1.32–3.61)	1.49 (0.48–4.64)
Number of prescribing physicians			
0–1 prescribing physicians	1.71 (1.16–2.54)	1.55 (1.15–2.08)	Reference[c]
>1 prescribing physicians	2.25 (1.47–3.46)	2.03 (1.39–2.97)	1.10 (0.67–1.83)
Proportion of visits to study physicians			
>65% of total visits	1.69 (1.18–2.40)	1.55 (1.17–2.05)	Reference[c]
40–65% of total visits	2.06 (1.46–2.92)	1.54 (1.14–2.08)	0.99 (0.86–1.15)
<40% of total visits	2.24 (1.06–4.74)	1.67 (1.14–2.46)	1.33 (1.12–1.58)
2. Complexity of Drug Management Average number of drugs dispensed per day			
<3 drugs/day	1.64 (1.01–2.66)	1.50 (1.05–2.15)	Reference[c]
3.0–6.0 drugs/day	2.79 (1.43–4.28)	2.69 (1.44–5.04)	1.65 (1.13–2.38)
>6.0 drugs/day	4.00 (2.22–7.17)	3.67 (2.29–5.87)	2.44 (1.87–3.18)

[a] Generalized estimates equation (GEE) rate ratio adjusted for patient age and gender.
[b] CI indicates confidence interval.
[c] Reference group.

Overall, the EMH utilization rates for patients who had a greater degree of fragmented care and more complex drug treatment were consistently higher across the three SES groups. The increase in the EMH utilization rates among patients with lower SES was more pronounced for those patients who also had evidence of fragmented care and more complex drug therapy (Fig. 3).

Multivariate analysis showed that all the indices of fragmented care were positively associated with EMH utilization, and the magnitude of EMH utilization increased inversely by patient SES. A similar trend of EMH utilization was shown by the complexity of drug therapy and patient SES (Table 2).

4. Discussion

Many countries are making a considerable investment in the development of integrated drug information management systems to facilitate electronic prescribing and improved safety in drug treatment [2,12–14]. However, there has been extremely limited evaluation of these systems even though implementation of these systems in ambulatory care is expected to provide enhancements for detecting adverse drug-related events. This is particularly true for primary care physicians as they provide front-line health care to patients with a wide range of types and numbers of comorbidities, a common reason for adverse drug-related events.

Improving health outcomes in patients of low SES has been recognized as one of the major priorities in the health care system. This study demonstrated that electronic information regarding current drug use was more likely to be accessed by physicians for patients who have a high risk of adverse drug events: a group characterized as low SES patients using multiple medications, and with fragmented care. The selective use of the electronic medication history, but not the electronic prescribing system, for low SES patients with risk factors for adverse events suggests that there may be some immediate clinical benefits of having complete drug information available through an information infrastructure including ensuring safety for those patients.

There are likely multiple reasons why physicians were more likely to use an electronic medication history for low SES patients, and there are major challenges ahead for primary care physicians in obtaining a complete medication history from patients of low SES [14,37–39]. Low SES patients are more likely to use the emergency room for medical care and to be hospitalized. They are also more likely to use a greater number of medications, and have many prescribing physicians providing care [18,20]. Low SES patients in this study exhibited these characteristics; the proportion of patients having multiple emergency room visits were three times greater in low SES patients and twice as many low SES patients are prescribed at least six drugs per day. Access to computerized information would allow better management of patients with increased risk of adverse events associated with multiple medications use and fragmented care. Use of the electronic medication history may also be efficient for patients with many medications, reducing time for completing medication history [40].

Although each of the factors above are inter-related, the involvement of multiple health care providers [6] and number of medications [14,37,38,41] may not be the only explanation for the greater use of the electronic medication history for lower SES patients. Even after adjusting for these factors, physicians were still more likely to use the electronic medication history for lower SES patients, compared to higher SES

patients. There are several plausible explanations to suggest the use of electronic medication history may have provided greater benefits and efficiency in the provision of care for this group [42].

A recent systematic review identified differences in physicians' communication styles by patients' socioeconomic status. Patients of lower SES were more likely to receive a more directive and a less participatory consulting style, characterized by the number of questions asked by the physician. Physicians are more likely to ask a greater number of questions for lower SES patients, including those about medications, compared to higher SES patients [43]. This difference could be reflected by patients' communication style as patients of lower social class are less likely to play an active role in clinical information exchange between physician and patient during their consultations.

A particular type of nonadherence to medical regimen that is more prevalent among patient of lower SES may also have influenced the greater use of medication history by primary care physicians. According to Lowry et al. [44], patients of lower SES are more likely to have unintentional nonadherence, a passive process to properly adhering to the treatment regimen, to antihypertensive medication, compared to intentional nonadherence which is characterized by an active process in which the patient chooses to deviate from the treatment regimen in order to suit their own needs [45].

A lack of financial resources to allow for appropriate adherence to a medical regimen determined by their health providers may be one of the major potential reasons for unintentional non-adherence among patients of low SES. Several studies identified that monthly out-of-pocket cost was associated with cost-related underuse of treatments [46–49]. Our study population of patients is restricted to those who were covered by the provincial health insurance agency drug insurance. Even though these insured patients pay only a portion of the cost of the drug purchase [30], out-of-pocket costs to purchase the prescription may be a significant burden for low SES patients [32,47]. As patients often fail to alert their physicians about this cost-related medication underuse and the cost issue itself [48], access to both pieces of information regarding current treatment information via the medication history would be an exceptional opportunity for physicians to identify nonadherence behavior and assist low SES patients to improve health outcomes.

This study has several limitations. No information was available regarding the reasons why physicians used the electronic prescribing system and the electronic medication history. It is plausible that study physicians did not need to use the E-rx system during a visit for patients who did not need a prescription; whereas the electronic medication history could have been used during any visit to obtain information on prescriptions written by other physicians, to examine compliance or information on emergency room visits/hospitalization. Because we used a common denominator for calculating the utilization rate of the two systems, the E-rx system utilization rate is likely to have been underestimated. Similarly, in the electronic medication history there are several types of drug information available to assist primary care physicians in the care for their patients. Future research should include reasons for access within the audit log file, at least for a random subset of patients to elucidate the rationale for access to identify potential sources of benefit.

The clinical impact of a computerized system depends on the extent to which the system is used in care delivery. A prior study by Eccles et al. [49] concluded that a computerized decision support system had no significant effect on quality of care, likely because the system was rarely used by study physicians. A future study should explore whether higher rates of utilization of the electronic medication history by primary care

Summary points

Previous scientific knowledge before conducting our study:

- The majority of adverse drug events are potentially avoidable. The number of drugs used per patient and multiple prescribing physicians are some of the contributing factors to these avoidable prescribing errors.
- Patients of lower socioeconomic status (SES) have a higher rate of morbidity and hospitalization. Number of drugs used per patient and fragmented care are some of contributing factors of the reported suboptimal medical treatment among patients of lower SES.
- Implementation of the integrated drug information system in the primary care setting has a great potential for ensuring patient safety by detecting potentially avoidable prescribing errors.
- In order to assess such success, an evaluation of actual utilization of such a system by primary care physicians is a prerequisite.
- Previous studies failed to evaluate the degree of actual utilization of the system among primary care physicians during patients' visits.
- There is little evidence with respect to the degree of actual utilization of the integrated drug information systems among primary care physicians for populations which are likely to have the most benefit by the utilization of such information systems, such as patients of lower SES.

The authors believe our original scientific contributions are:

- Evaluation methodology of integrated drug information management systems in the primary care setting.
- To illustrate the finding that primary care physicians are more likely to access comprehensive drug histories, compared to electronic prescription systems.
- To illustrate the finding that greater access to a comprehensive drug history was found for populations at greater risk of adverse drug-related events, including low SES patients, those using a greater number of medications, multiple prescribing physicians, ER visits, and poorer continuity of care.

physicians leads to greater improvements in the quality of care and health outcomes in higher risk populations for adverse drug events.

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REFERENCES

[1] J. Lazarou, B.H. Pomeranz, P.N. Corey, Incidence of adverse drug reactions in hospitalized patients: a meta-analysis of prospective studies, JAMA (1998) 1200–1205.
[2] eHealth Initiative, Electronic Prescribing: Toward Maximum Value and Rapid Adoption, Washington, DC, 2004.
[3] G.D. Schiff, D. Rucker, Computerized prescribing: building the electronic infrastructure for better medication usage, J. Am. Med. Assoc. (1998) 1024–1029.
[4] T.S. Lesar, L. Briceland, D.S. Stein, Factors related to errors in medication prescribing, JAMA (1997) 312–317.
[5] N.J. MacKinnon, C.D. Helper, Indicators of preventable drug-related morbidity in older adults. Use within a managed care organization, J. Manage. Care Pharm. (2003) 134–141.
[6] R.M. Tamblyn, P.J. McLeod, M. Abrahamowicz, R. Laprise, Do too many cooks spoil the broth? Multiple physician involvement in medical management of elderly patients and potentially inappropriate drug combinations, CMAJ (1996) 1177–1184.
[7] V.C. Tam, S.R. Knowles, P.L. Cornish, N. Fine, R. Marchesano, E.E. Etchells, Frequency, type and clinical importance of medication history errors at admission to hospital: a systematic review, CMAJ (2005) 510–515.
[8] S. Dobrzanski, I. Hammond, G. Khan, H. Holdsworth, The nature of hospital prescribing errors, Br. J. Clin. Gov. (2002) 187–193.
[9] E.P. Armstrong, E.A. Chrischilles, Electronic prescribing and monitoring are needed to improve drug use, Arch. Intern. Med. (2000) 2713–2714.
[10] R.F. Moulds, Good prescribing: where to next? Med. J. Aust. (2003) 196–197.
[11] B. Honigman, P. Light, R.M. Pulling, D.W. Bates, A computerized method for identifying incidents associated with adverse drug events in outpatients, Int. J. Med. Inform. (2001) 21–32.
[12] H.L. Lipton, R.H. Miller, J.J. Wimbush, Electronic prescribing: ready for prime time? J. Health. Inform. Manage. 17 (4) (2003) 72–79.
[13] Canada Health Infoway Inc., Presentation of Business Plan, 2002, http://www.canadahealthinfoway.ca.
[14] Institutes of Medicine, To Err is Human, National Academy of Sciences Press, Washington, DC, 2001.
[15] B.T. Chan, P.C. Austin, Patient, physician, and community factors affecting referrals to specialists in Ontario, Canada: a population-based, multi-level modeling approach, Med. Care (2003) 500–511.
[16] Y. Chen, M. Tang, D. Krewski, R. Dales, Relationship between asthma prevalence and income among Canadians, JAMA (2001) 919–920.
[17] D. Erzen, K.C. Carriere, C. Mustard, L.L. Roos, J. Manfreda, N.R. Anthonisen, Income level and asthma prevalence and care patterns, Am. J. Respir. Crit. Care Med. (1997) 1060–1065.
[18] I. Brown, B. Shaw, Routine child health care in the emergency department, Can. J. Public Health (1999) 424–425.
[19] M.K. Kapral, H. Wang, M. Mamdani, J.V. Tu, Effect of socioeconomic status on treatment and mortality after stroke, Stroke (2002) 268–273.
[20] C.A. Mustard, T. Mayer, C. Black, B. Postl, Continuity of pediatric ambulatory care in a universally insured population, Pediatrics (1996) 1028–1034.
[21] P.J. Veugelers, A.M. Yip, Socioeconomic disparities in health care use: does universal coverage reduce inequalities in health? J. Epidemiol. Community Health (2003) 424–428.
[22] N.P. Roos, C.A. Mustard, Variation in health and health care use by socioeconomic status in Winnipeg, Canada: does the system work well? Yes and no, Milbank Q. (1997) 89–111.
[23] W. McIsaac, V. Goel, D. Naylor, Socio-economic status and visits to physicians by adults in Ontario, Canada, J. Health Serv. Res. Policy (1997) 94–102.
[24] M. Castro, K.B. Schechtman, J. Halstead, G. Bloomberg, Risk factors for asthma morbidity and mortality in a large metropolitan city, J. Asthma (2001) 625–635.
[25] C.A. Mustard, A.L. Kozyrskyj, M.L. Barer, S. Sheps, Emergency department use as a component of total ambulatory care: a population perspective, CMAJ (1998) 49–55.
[26] J. Bohland, Neighborhood variations in the use of hospital emergency rooms for primary care, Soc. Sci. Med. (1984) 1217–1226.
[27] D.D. Sin, L.W. Svenson, R.L. Cowie, S.F. Man, Can universal access to health care eliminate health inequities between children of poor and nonpoor families?: a case study of childhood asthma in Alberta, Chest (2003) 51–56.
[28] L.P. Boulet, K.R. Chapman, Asthma education: the Canadian experience [Review] [23 refs], Chest (1994), Suppl-210S.
[29] C. Metge, C. Black, S. Peterson, A.L. Kozyrskyj, The population's use of pharmaceuticals, Med. Care (1999) JS42–JS59.
[30] Regie de l'assurance-maladie du Quebec, Prescription Drug Insurance, Important Information about the Public Plan, 2003.
[31] Regie de l'assurance-maladie du Quebec, Statistiques Annuelles, Quebec, Quebec, Regie de l'assurance-maladie du Quebec, 2000, pp. 46–48, ISBN 2-550-30856-5.
[32] R. Tamblyn, R. Laprise, J.A. Hanley, M. Abrahamowicz, S. Scott, N. Mayo, J. Hurley, R. Grad, E. Latimer, R. Perreault, P. McLeod, A. Huang, P. Larochelle, L. Mallet, Adverse events associated with prescription drug cost-sharing among poor and elderly persons, JAMA (2001) 421–429.
[33] R. Wilkins, Use of postal codes and addresses in the analysis of health data, Health Rep. (1993) 157–177.
[34] The Atlas of Canada, Income Measures: Methodological Notes, 2004.
[35] R. Tamblyn, M. Abrahamowicz, W.D. Dauphinee, J.A. Hanley, J. Norcini, N. Girard, P. Grand'Maison, C. Brailovsky, Association between licensure examination scores and practice in primary care, JAMA (2002) 3019–3026.
[36] J. Schlesselman, Case–Control Studies, 1982.
[37] R.A. Cochrane, A.R. Mandal, M. Ledger-Scott, R. Walker, Changes in drug treatment after discharge from hospital in geriatric patients, BMJ (1992) 694–696.
[38] L.G. Miller, C.C. Matson, J.C. Rogers, Improving prescription documentation in the ambulatory setting, Fam. Pract. Res. J. (1992) 421–429.

[39] W.J. van der Kam, D.J. Meyboom, T.F. Tromp, P.W. Moorman, L.J. van der, Effects of electronic communication between the GP and the pharmacist. The quality of medication data on admission and after discharge, Fam. Pract. (2001) 605–609.
[40] J.M. Schectman, J.B. Schorling, M.M. Nadkarni, J.D. Voss, Determinants of physician use of an ambulatory prescription expert system, Int. J. Med. Inform. (2005) 711–717.
[41] C.F. Green, D.R. Mottram, M. Pirmohamed, R. Horner, P.H. Rowe, Communication regarding adverse drug reactions between secondary and primary care: a postal questionnaire survey of general practitioners, J. Clin. Pharm. Therap. (1999) 133–139.
[42] M.V. Williams, T. Davis, R.M. Parker, B.D. Weiss, The role of health literacy in patient–physician communication, Fam. Med. (2002) 383–389.
[43] B. Sleath, D. Roter, B. Chewning, B. Svarstad, Asking questions about medication: analysis of physician–patient interactions and physician perceptions, Med. Care (1999) 1169–1173.
[44] K.P. Lowry, T.K. Dudley, E.Z. Oddone, H.B. Bosworth, Intentional and unintentional nonadherence to antihypertensive medication, Ann. Pharmacother. (2005) 1198–1203.
[45] A.L. Wroe, Intentional and unintentional nonadherence: a study of decision making, J. Behav. Med. (2002) 355–372.
[46] J.D. Piette, M. Heisler, T.H. Wagner, Cost-related medication underuse among chronically III adults: the treatments people forgo, how often, and who is at risk, Am. J. Public Health (2004) 1782–1787.
[47] M.A. Steinman, L.P. Sands, K.E. Covinsky, Self-restriction of medications due to cost in seniors without prescription coverage, J. Gen. Intern. Med. (2001) 793–799.
[48] J.D. Piette, M. Heisler, T.H. Wagner, Cost-related medication underuse: do patients with chronic illnesses tell their doctors? Arch. Intern. Med. (2004) 1749–1755.
[49] M. Eccles, E. McColl, N. Steen, N. Rousseau, J. Grimshaw, D. Parkin, I. Purves, Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial, BMJ (2002) 941.