

EFFECT OF EDUCATIONAL AND POLICY INTERVENTIONS ON INSTITUTIONAL UTILIZATION OF WET NEBULIZATION RESPIRATORY DRUGS AND PORTABLE INHALERS

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ABSTRACT

Background

Asthma and chronic obstructive pulmonary disease treatment guidelines support the preferential use of portable inhalers (PIs) over wet nebulization (WN) respiratory therapy. Hospital- and community-based educational initiatives and a community-based provincial drug program policy change were previously implemented to promote the conversion of WN therapy to PI and spacer device use in Nova Scotia.

Objective

To examine the effect of these interventions on salbutamol, ipratropium bromide, and spacer device (Aerochamber[®]) use at the Queen Elizabeth II Health Sciences Centre (QEII HSC).

Methods

We conducted a time-series analysis of drug utilization data from August 1998 to July 2005. We used two intervention phases compared to the pre-intervention phase to determine whether the educational and policy interventions were associated with significant changes in monthly drug and spacer device utilization rates at the QEII HSC (1000-bed teaching hospital; Halifax, Nova Scotia).

Results

Salbutamol and ipratropium bromide PI use significantly increased in both intervention phases, compared to the pre-intervention phase. Mean (SD) defined daily doses/100 bed-days for salbutamol PI increased from 30.4 (0.4) in the pre-intervention phase to 34.6 (0.9) and 37.0 (0.4) in intervention phases I and II respectively ($p < 0.001$ for both), and ipratropium bromide PI increased from 27.3 (3.5) to 32.8 (2.5) in intervention phase I ($p = 0.004$) and 35.6 (3.5) in intervention phase II ($p < 0.001$). However, a significant corresponding decrease was observed with salbutamol WN only. Mean (SD) Aerochamber[®] units/100 bed-days significantly increased.

Conclusions

Educational and policy interventions had limited effects on converting WN to PI use at the QEII HSC.

Key Words: *Respiratory drug therapy; wet nebulization; portable inhaler; drug utilization; educational intervention; time-series analysis*

Asthma and chronic obstructive pulmonary disease (COPD) are common chronic lower respiratory diseases and are among the leading causes of morbidity and mortality worldwide.¹⁻³ In 2002, more than 2.9 million deaths globally were

attributable to asthma and COPD. The direct medical treatment costs and the indirect costs from loss of work and productivity represent a substantial economic and social burden. Total costs for all respiratory diseases exceeded \$8

billion in Canada in 1998, of which prescription drugs accounted for \$1.1 billion.⁴

Inhaled bronchodilator medications such as salbutamol and ipratropium bromide are central to symptom management in asthma and COPD patients. They may be delivered via wet nebulization (WN) or portable inhalers (PIs) (e.g., metered-dose inhalers, dry powder inhalers) with or without a spacer device. Spacer devices facilitate the use of metered-dose inhalers and enhance the pulmonary deposition of the medication. Asthma and COPD treatment guidelines support the preferential use of PIs over WN^{2, 5-8} because PIs are as effective as WN,⁹⁻¹² more efficient, portable, convenient, less costly,^{9,13-15} and associated with less bacterial contamination.^{9,16}

In the province of Nova Scotia, retail prescription purchases for nebulization solutions accounted for \$2.4 of the \$3.2 million (Canadian)

spent on bronchodilator medications in 1995 in the Nova Scotia Seniors' and Community Services' Pharmacare Program, a provincial drug insurance program providing coverage to residents aged 65 years and older and those receiving income assistance.^{17,18} Thus, in 2000, to encourage guideline adherence, conversion of WN to PI and spacer device use, and to realize cost savings, multifaceted educational initiatives and a Pharmacare policy change were implemented in the community setting (Table 1). The Pharmacare policy change consisted of moving WN respiratory drugs from regular benefit to exception drug ('limited use') status and adding a spacer device (Aerochamber[®], Trudell Medical International, London, Ontario, Canada) as a reimbursable benefit. The exception status benefit required a written physician's request for patients meeting selected reimbursement criteria (Table 1).

TABLE 1 Summary of Interventions Promoting the Conversion of Wet Nebulization Respiratory Therapy to Portable Inhaler Use in Nova Scotia

DATE	INTERVENTION	SYNOPSIS
Community-based interventions^a		
Dec. 1999 to Feb. 2000	Newsletters	Provincial newsletters sent to physicians and pharmacists announcing the upcoming Pharmacare policy change.
Feb. to Mar. 2000	Continuing education (CE) programs	Live CE programs (on comparative efficacy of wet nebulization (WN) and portable inhaler (PI) delivery methods, and patient teaching techniques on use of PIs with spacer devices); attended by 147 pharmacists across Nova Scotia.
Feb. 2000	Professional pharmacy fee	Professional fee for pharmacists implemented for initial and follow-up patient education on proper PI and spacer device technique.
Feb. 2000	Posters	The Lung Association of Nova Scotia distributed 3500 posters supporting the initiative to all pharmacies, physician offices, hospitals, asthma clinics and long-term care facilities.
Feb. 2000 to present	24-hour telephone support for patients	Provided by the Lung Association of Nova Scotia.
Aug. 1, 2000	Policy change became effective	Implementation of the Nova Scotia Seniors' and Community Services' Pharmacare Program policy change for reimbursement of respiratory drugs: 1) WN respiratory therapy changed to exception status ("limited use") benefit; requires written request from physician for patients meeting one of the following reimbursement criteria: <ul style="list-style-type: none"> • Adult patients with a vital capacity of 900 mL or less • Adult patients with a respiratory rate greater than 25 breaths per minute • Patients who have demonstrated they cannot follow instructions, cannot hold the spacer device or cannot hold the device long enough to actuate it • Other situations as deemed appropriate, upon written request from the physician 2) Spacer device added as a reimbursable formulary benefit
Hospital-based interventions by multidisciplinary team^b		
Apr. 2000	Hospital newsletter and drug use evaluation bulletin	Distributed to all medical staff, pharmacists, hospital managers and directors. Newsletter described the benefits of PIs and spacer devices over WN therapy, reviewed associated drug costs, and encouraged the assessment and conversion of WN to PI and spacer device use throughout the patient's hospital stay.

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DATE	INTERVENTION	SYNOPSIS
Apr. 2000	Posters	Posters (75) describing benefits of PIs over WN therapy and reviewing associated drug costs were put up on all nursing units, selected ambulatory care areas, pharmacy and respiratory therapy departments.
May 2000	Patient education materials	Patient education materials on inhaler technique and spacer device (Aerochamber [®]) use were updated. A nurse, pharmacist or respiratory therapist, depending on the nursing unit and staff availability, was available to perform patient teaching on proper PI and spacer device technique at any time.
May 2000	Memo and laminated pocket cards	Memo to active medical staff (420) and 4 th year medical students notifying them of the educational initiative. Patient education materials, a laminated pocket card with a guide for assessing patients for conversion and dose conversion chart were also enclosed.
May to June 2000	Educational inservices	10 educational inservices (on benefits of initiative, PI and spacer device patient teaching technique) attended by 37 general medicine nurses, 7 pharmacists, and 25 respiratory therapists.
Fall 2000	Portable inhaler and spacer device teaching	Provided to internal medicine residents and supplemented by monthly review of correct technique by general medicine pharmacists throughout the Fall of 2000.
Sept. 2000	Meeting	Respirologist discussed the initiative at meetings with the Division of General Medicine and Department of Medicine.
Sept. 2000	Standing orders	Department of Medicine physician standing orders for admission for COPD exacerbation came into effect. These orders placed the option of PI with spacer device first above WN therapy, and if the latter was used, therapy was required to be reassessed in 48 hours.
Aug. 2001	Drug use evaluation bulletin	Disseminated results of hospital-based initiative to date; distributed to all medical staff, pharmacists, hospital managers and directors.

^aThe community-based interventions are important inputs into the prescribing decisions in the hospital setting when patients are discharged from the hospital. All Nova Scotia physicians, regardless of their primary practice setting, received the community newsletters and posters, informing them about the Pharmacare policy change.

^bThe multidisciplinary team consisted of a drug utilization pharmacist (lead), respirologist, asthma educator (nurse), drug evaluation pharmacist, respiratory therapist and general medicine pharmacists.

In the year preceding the Pharmacare policy change, drug expenditures at the Queen Elizabeth II Health Sciences Centre (QEII HSC; Halifax, Nova Scotia) exceeded \$180,000 for salbutamol and ipratropium bromide therapy, of which WN therapy accounted for approximately \$115,000 (63% of total). Approximate treatment costs for 1-week of salbutamol and ipratropium bromide WN therapy (cost of drugs and supplies) were \$167, while the combined costs for equivalent doses of salbutamol and ipratropium bromide PI and spacer device (Aerochamber[®]) use were \$28. Therefore, to support the community-based initiative, enhance patient care, and realize drug cost savings in the hospital setting, multifaceted educational initiatives were implemented by a multidisciplinary team at the QEII HSC (Table 1).

A previous study reported on the effectiveness of the community-based educational initiatives and policy change on salbutamol and ipratropium bromide utilization in the community setting.¹⁹ However, the effectiveness of the hospital-based educational initiatives at the QEII

HSC is unknown. Furthermore, whether the community-based interventions influenced prescribing practices in the hospital setting in a universal health care system has not been studied. We examined the effect of the hospital- and community-based multifaceted educational initiatives and a community-based Pharmacare policy change on salbutamol, ipratropium bromide, and spacer device utilization at the QEII HSC.

METHODS

Setting and Design

We conducted a time-series analysis of drug utilization data to examine changes in salbutamol, ipratropium bromide, and spacer device use at the QEII HSC, from August 1, 1998 to July 31, 2005. The QEII HSC is the largest adult academic health sciences centre in Atlantic Canada with approximately 1000 beds, providing core services to 395,000 Halifax residents (40% of Nova Scotia's population) and tertiary and quaternary

services to the rest of Atlantic Canada.²⁰ These residents have universal access to hospital care. This research was approved by the Capital Health Research Ethics Board, Halifax.

Data Sources

We obtained drug and spacer device data from the QEII HSC's pharmacy computer system, which contains comprehensive records of drugs and spacer devices dispensed to all patients. Drug and spacer device data for all hospital inpatients and emergency department patients were included in our study. The number of bed-days (patient-days) at the QEII HSC and hospital admissions due to respiratory diagnoses (asthma, COPD and allied conditions; *International Classification of Diseases, Ninth Revision* [ICD-9] codes 490-493, 495-496; *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* [ICD-10-CA] codes J40-46) were obtained for each month of the 7-year study period from Capital Health Decision Support. All data were obtained in aggregate and no patient identifiers were involved.

Assessment of Salbutamol, Ipratropium Bromide and Spacer Device Use

Monthly salbutamol and ipratropium bromide utilization data were expressed in defined daily doses (DDD), using the World Health Organization's (WHO) Anatomical Therapeutic Chemical (ATC) classification system (WHO, version 2005).²¹ The DDD is a standardized unit of measure used widely in drug utilization research,^{22,23} and is defined as the assumed average maintenance dose per day for a drug used for its main indication in adults.²¹ Combination products (e.g. Combivent[®] containing salbutamol and ipratropium bromide) were analysed according to their separate components. Monthly salbutamol and ipratropium bromide utilization rates were standardized and expressed in DDD per 100 bed-days and DDD per respiratory admission, while spacer device use was standardized and expressed in number of units per 100 bed-days and number of units per respiratory admission. The Aerochamber[®] was the only spacer device supplied at the QEII HSC throughout the study period. The Aerochamber[®] spacer device was available both with and without the adult

facemask product, with the latter representing the majority of spacer device use at the QEII HSC.

We divided the 7-year study into 3 time periods: 1) August 1998 to December 1999, which we called the pre-intervention phase; 2) January 2000 to July 2000, which we called intervention phase I (in which we examined the effects of the educational initiatives before the policy change occurred); and 3) August 2000 to July 2005, which we called intervention phase II (in which we examined the effects of both the educational initiatives and policy change). We used two intervention phases in our analysis because the community-based policy change may have indirectly influenced drug prescribing in the hospital setting, particularly in the days prior to a patient's discharge from hospital. January 2000 was selected as the start of intervention phase I because it reflected the earliest expected changes in utilization, as newsletters on the initiative and policy change were first disseminated in December 1999. August 2000 was selected as the start of intervention phase II because the Pharmacare policy change became effective on August 1, 2000. All active hospital-based interventions were completed by 2001 (Table 1). We did not conduct a separate evaluation of each individual component (i.e., newsletters, posters, patient education materials, pocket cards, educational inservices, meetings, etc.) of the multifaceted intervention due to the short and overlapping time periods between the individual components.

Statistical Analysis

We used intervention time-series analysis models to determine whether the educational initiatives and policy change were associated with significant changes in the monthly utilization rates of salbutamol PI, salbutamol WN, ipratropium bromide PI, ipratropium bromide WN, and spacer device. Time-series analysis consists of several techniques for modeling autocorrelation in temporally sequenced data.²⁴

Descriptive statistics (mean (SD)) were used to summarize the drug and device utilization rates for each of the 3 time periods. We used autoregressive integrated moving average (ARIMA) / seasonal autoregressive integrated moving average (SARIMA) models²⁵ with the two

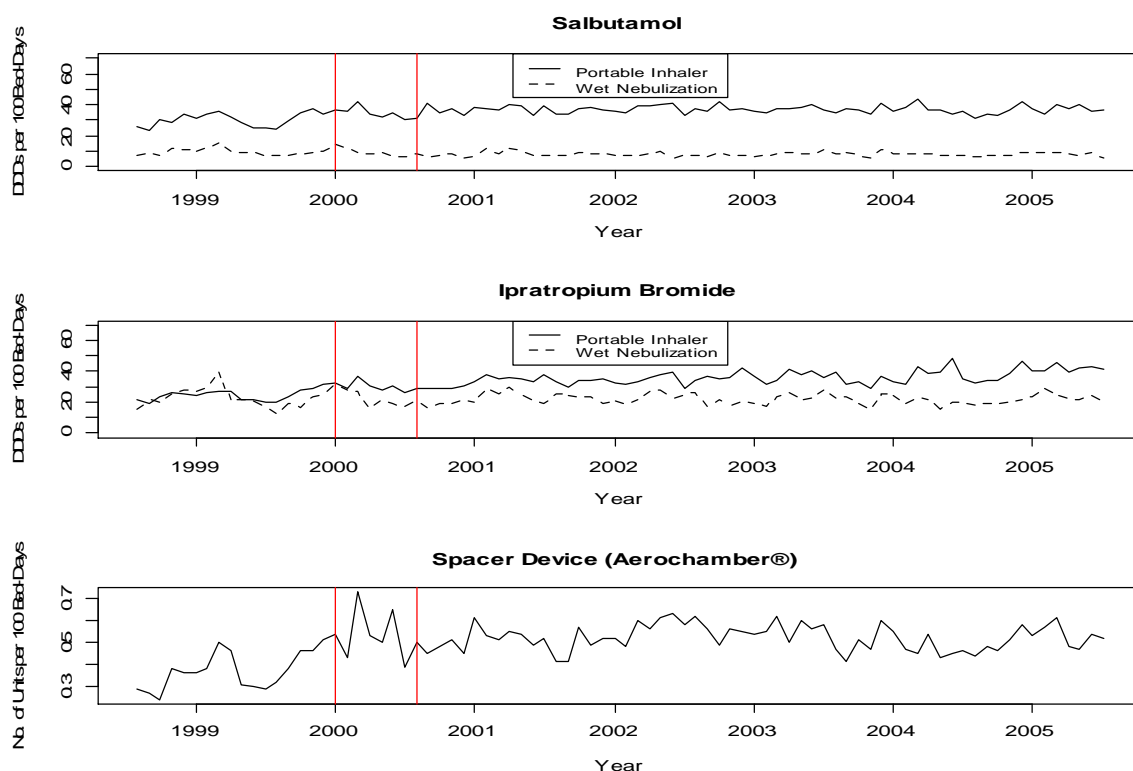
intervention phases compared to the pre-intervention phase. Seasonal trend and adjustment were determined using the Seasonal Mann-Kendall test²⁶ for the 5-year post intervention time-series, and using the sample autocorrelation plot for the entire time-series controlled by the intervention effect. All p values were two-sided, and analyses were conducted using R 2.3.1 (available from the Comprehensive R Archive Network at www.r-project.org, accessed April 9, 2008).

RESULTS

Standardized monthly utilization rates of salbutamol PI, salbutamol WN, ipratropium bromide PI, ipratropium bromide WN, and spacer device for each of the 3 time periods are shown in Figure 1 (graphs shown for DDD per 100 bed-

days data only; similar graphs for DDD per respiratory admission data not shown). The multifaceted educational initiatives and Pharmacare policy change were associated with increased salbutamol and ipratropium bromide PI utilization rates in both intervention phases I and II, as compared to the pre-intervention phase (Table 2). These increases were statistically significant ($p < 0.05$, and in most cases $p < 0.001$) for data standardized in DDD per 100 bed-days as well as DDD per respiratory admission, with the exception of salbutamol PI use in DDD per respiratory admission, which showed a nonsignificant rise from a mean (SD) of 245.0 (22.0) in the pre-intervention phase to 280.9 (35.8) in intervention phase I ($p = 0.32$) and 285.6 (24.1) in intervention phase II ($p = 0.09$).

FIG. 1 Monthly Utilization Rates of Salbutamol, Ipratropium Bromide, and Spacer Device (Aerochamber®) August 1998 to July 2005



The first vertical line denotes the beginning of intervention phase I (reflects the start of the educational initiatives). The second vertical line denotes the beginning of intervention phase II (reflects the change in Pharmacare policy, effective August 1, 2000).

DDD = defined daily doses

Increased PI use, however, corresponded to very modest and nonsignificant decreases in salbutamol and ipratropium bromide WN utilization rates in both intervention phases I and II, as compared to the pre-intervention phase (Table 2). The exception being salbutamol WN use in DDD per 100 bed-days, which significantly decreased from a mean (SD) of 9.6 (0.1) in the pre-intervention phase to 8.6 (0.4) in intervention phase I

($p=0.004$) and 7.9 (0.1) in intervention phase II ($p<0.001$).

Monthly spacer device utilization rates, expressed in the number of units per 100 bed-days and number of units per respiratory admission, significantly increased in both intervention phases I and II, as compared to the pre-intervention phase ($p<0.001$ for both) (Table 2).

TABLE 2 Effect of Interventions on Salbutamol, Ipratropium Bromide, and Spacer Device Utilization Rates at the Queen Elizabeth II Health Sciences Centre^a

Drug or Device	Pre-Intervention Phase	Intervention Phase I	p Value ^b	Intervention Phase II	p Value ^b
DDDs (or Units^c) per 100 Bed-Days					
Portable inhaler					
▪ Salbutamol	30.4 (0.4)	34.6 (0.9)	< 0.001	37.0 (0.4)	< 0.001
▪ Ipratropium bromide	27.3 (3.5)	32.8 (2.5)	< 0.001	35.6 (3.5)	< 0.001
Wet nebulization					
▪ Salbutamol	9.6 (0.1)	8.6 (0.4)	0.004	7.9 (0.1)	< 0.001
▪ Ipratropium bromide	23.1 (0.6)	20.8 (1.4)	0.12	22.0 (0.7)	0.11
Spacer device					
▪ Aerochamber [®]	0.37 (0.02)	0.52 (0.04)	< 0.001	0.52 (0.03)	< 0.001
DDDs (or Units^c) per Respiratory Admission					
Portable inhaler					
▪ Salbutamol	245.0 (22.0)	280.9 (35.8)	0.32	285.6 (24.1)	0.09
▪ Ipratropium bromide	183.4 (8.3)	261.6 (21.8)	< 0.001	276.6 (8.3)	< 0.001
Wet nebulization					
▪ Salbutamol	70.4 (5.4)	65.6 (8.8)	0.59	61.1 (6.1)	0.13
▪ Ipratropium bromide	171.9 (12.4)	167.3 (23.1)	0.84	170.2 (14.0)	0.90
Spacer device					
▪ Aerochamber [®]	2.67 (0.25)	4.28 (0.38)	< 0.001	3.97 (0.29)	< 0.001

^a Values given as mean (SD); DDDs = defined daily doses

^b p value compared to the pre-intervention phase

^c Spacer device (Aerochamber[®]) utilization expressed in number of units

DISCUSSION

Using standardized drug and device utilization data over a 7-year period, we found that hospital- and community-based multifaceted educational initiatives and a Pharmacare policy change were associated with increased PI and spacer device use at the QEII HSC. However, a significant corresponding decrease was observed with salbutamol WN therapy in DDD per 100 bed-days. These findings suggest that the multifaceted educational initiatives by the multidisciplinary team had limited effects on converting WN to PI use at the QEII HSC. The increased PI and spacer device use and lack of a corresponding decrease in WN therapy may reflect the increased conversion from WN to PI use in Pharmacare patients before they are discharged from hospital or may reflect the increased number of patients admitted to hospital already on PIs.

A previous study examined the effect of educational initiatives and policy change on the prescribing of WN therapy and PIs in the community setting in Nova Scotia.¹⁹ The interventions were associated with a sharp decrease in WN use and a corresponding increase in PI use. The success in the community setting is likely due to the policy change linked to reimbursement, with the community-based educational initiatives having a much lesser effect. In a recent report, Hendeles et al.²⁷ commented that their hospital-based educational efforts to convert WN to PI and spacer device use were ineffective. They subsequently implemented a hospital-wide conversion policy allowing respiratory therapists to automatically convert WN to PI and spacer device use, which was met with limited success. This report, however, did not use standardized drug and device utilization rates, nor include a statistical analysis.

Published guidelines and literature suggest that many hospitalized patients can use PIs, including those presenting to the emergency department and mechanically ventilated patients.^{2,5-12} Various patient, health care professional and organizational factors may explain the apparent lack of conversion from WN to PI use in our study. Patients who meet the exclusion criteria for the Pharmacare policy may be more likely to be admitted to hospital since they may have more

severe disease. Some patients may believe that WN therapy is more effective than PI, particularly if they are accustomed to receiving WN therapy in the hospital. Some health care professionals may also believe that WN therapy is more effective than PI,²⁸ or that many hospitalized patients are too sick or lack proper coordination to use PIs and spacer devices adequately. A lack of hospital staff awareness of published guidelines or a hospital initiative promoting conversion of WN to PI use may also explain the limited effects seen.

Other factors may include the stocking of WN therapy on most nursing units, WN therapy was not restricted in the hospital setting, the belief that use of PIs is more time consuming for hospital staff²⁹ and decreased compliance with guidelines if there is no financial incentive (i.e., patients do not pay out of pocket for medications administered in hospital). Finally, our findings may reflect habits or values that are difficult to change.

While some literature suggests that multifaceted interventions may be more effective than single intervention strategies in influencing prescribing behaviour,^{30,31} a recent systematic review on the effectiveness of guideline dissemination and implementation strategies found no relationship between the number of component interventions and the effects of multifaceted interventions.³² Furthermore, simple guideline implementation and educational strategies were found to be generally ineffective as compared to strategies that integrate education with other organizational approaches.³³ We also did not conduct an analysis of possible barriers prior to implementing the interventions, nor did we evaluate whether the educational interventions were successful in changing attitudes or beliefs. Ideally, possible barriers should be identified and analysed prior to developing the quality improvement intervention, in order to guide the selection of both the type and content of the intervention.³⁴ This may also partly explain our findings.

A recent qualitative study conducted at two teaching hospitals in Atlantic Canada reported on the perceived reasons for resistance to change in the emergency department use of portable inhalers and spacer devices in pediatric asthma patients.²⁹ This study identified several major themes

influencing the adoption of portable inhalers and spacer devices by health care professionals, including perceived increased workload and equipment costs with using portable inhalers and spacer devices, myths about the superiority of nebulization, and the need to better define health care professional roles including leadership. Examining whether similar or other possible barriers existed in our hospital setting, and implementing interventions to address them, may facilitate the conversion of WN therapy to PI and spacer device use at our hospital.

Furthermore, examining the influence of hospital staff and health care professional trainee turnover may be useful, particularly in a teaching hospital. Easily accessible, ongoing web-based educational seminars and other tools may be useful, if hospital staff and trainee turnover are identified as possible barriers.

Our study has several strengths. By standardizing the drug and device utilization rates (in terms of DDD, number of bed-days and respiratory admissions), we controlled for important differences in factors that may influence drug use and also ensured that changes were not due to differences in bed occupancy or patient population. Additionally, time-series designs are one of the strongest, quasi-experimental designs to estimate intervention effects in non-randomized settings.³⁵ Time-series modeling allowed us to accurately measure associations between interventions and changes in salbutamol, ipratropium bromide and spacer device use. Using comprehensive drug and device utilization data, we examined the effects of multifaceted educational initiatives and a community-based policy change on the hospital setting; previously, the effects of the latter were less well known. Moreover, we used two intervention phases in our analysis, which allowed us to examine the separate effects of the educational initiatives prior to the community-based policy change, as the policy change may have indirectly influenced drug prescribing in the hospital setting. Finally, the long follow-up period (5 years since implementation of the interventions) allowed us to examine the sustainability of the effect of the educational initiatives and policy change.

Several limitations of our study merit emphasis. Our data are population-based, and we thus examined monthly trends in utilization rates only. We were unable to examine individual-level information. In addition, we cannot exclude the possibility that simultaneously occurring interventions or changes in the environment, such as industry marketing or publication of respiratory diseases guidelines, were responsible for utilization changes. As well, we did not examine factors such as long-acting bronchodilator use or the use of patient's own medications (e.g., PIs) in hospital. Some patients may have been converted from WN therapy to a long-acting bronchodilator PI, such as salmeterol. However, if this occurred, this would have represented a minority of patients, particularly since some long-acting bronchodilators were not available on the Canadian market until the latter part of the study period and were infrequently prescribed. In the last year of our study, which represented the maximum usage of long-acting bronchodilators at the QEII HSC, total salmeterol, formoterol and tiotropium usage only accounted for 1.7%, 0.5%, and 4.7% of all PI use, respectively. The use of patient's own medications in the hospital setting also accounts for a minority of medication use in hospital, particularly in a universally funded health care system. Moreover, these 2 factors, the use of long-acting bronchodilator PIs and patient's own medications, would have underestimated the PI utilization rate observed in our study. Finally, we did not examine patient preferences, effectiveness of therapy or differences in the length of hospital stay for those patients who switched from WN to PI use.

CONCLUSION

We found that multifaceted interventions promoting the conversion of WN to PI use had limited effects in the hospital setting. Further work is required to explore the reasons for this; and to implement other approaches, as needed, to facilitate the uptake of evidence-based asthma and COPD guidelines into clinical practice, and to overcome health system, health care professional and patient barriers to change.

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Potential Conflicts of Interest

Unrestricted educational grants were received for printed educational materials, portable inhaler and spacer device (Aerochamber[®]) patient teaching devices, and refreshments at educational inservices at the Queen Elizabeth II Health Sciences Centre, from Trudell Medical, Glaxo Wellcome, Boehringer Ingelheim and Astra Zeneca.

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