The Electronic Asthma Management System (eAMS) Improves Primary Care Asthma Management

Online Data Supplement

METHODS

Study Design, Setting, Population

Included clinics were academic family health teams (primary health teams including family physicians, nurses, and allied health members) which used the OSCAR electronic medical record (EMR) system (http://oscarcanada.org), were under a capitated funding model, and did not have asthma educators or respiratory therapists on site. Site principal investigators (GA, DC, SGo) sent invitations to all physicians and nurse practitioners (NPs) at each site. We identified asthma patients in the practices of all consented clinicians through a validated EMR search algorithm,[1] including: "asthma" in the cumulative patient profile (a standardized chart component which includes active and past medical history), use of the diagnostic billing code for asthma/allergic bronchitis (493) within the last 3 years [excluding patients in whom a COPD-related diagnostic billing code (491, 492, 496) had been used in the last 3 years]; and presence of "asthma" in any of the typed chart notes (algorithm-generated lists were vetted/modified by clinicians). We included asthma patients who were $\geq$ 16 years old, understood English, and had been on asthma medication in the prior 12 months (excluding patients who had been on a COPD medication in the prior year).[1] Asthma medications included: beclomethasone; budesonide; budesonide/formoterol; ciclesonide; fluticasone; fluticasone/salmeterol; formoterol; mometasone; mometasone/formoterol; salbutamol; salmeterol; and terbutaline sulfate (including all drug formulations, where applicable). COPD medications included medications used predominantly for COPD: tiotropium bromide and ipratropium bromide. [1] Note that 19 included patients were prescribed a long-acting muscarinic antagonist (tiotropium bromide) between the time they were identified as study candidates and the time they appeared for their first study visit, and were thus on a long-acting muscarinic antagonist at baseline (Table S1). Eligible patient lists were updated periodically throughout the study, to capture patients entering and leaving the included practices. Were excluded patients who were pregnant (due to lack of evidence for the most effective and safest therapeutic intensification regimen as part of an asthma action plan), or whom the physician deemed to have cognitive limitations (due to inability to use an asthma action plan) or a life expectancy of < 1 year (due to inability to capture adequate follow-up data). We excluded visits exclusively for administration of injection medication(s) (e.g. the flu shot). The study took place between August 1st, 2012 and July 31st, 2014.

Intervention

During the baseline period, all included clinicians were sent an email with access to the MacHealth/Ontario Lung Association AAP module (an accredited online educational module designed to teach primary care physicians how to complete an AAP, available at: https://machealth.ca/programs/asthma-action-plan/). We also provided clinicians with paper and .pdf copies of a blank AAP. This AAP was built through systematic evaluation of existing AAPs,[2] multiple stakeholder wiki-based collaborative editing, and usability optimization.[3, 4]

Intervention Implementation

The intervention user interface was developed with serial testing and feedback from the lead physicians at each of the three included sites. Study staff presented the eAMS to prescribers at the 3 sites in 3-4 presentations (at clinic rounds/meetings) held around the time of eAMS launch and 2-3 presentations delivered between 6-12 months after launch, at each site. All prescribers also received a pamphlet detailing eAMS features and were emailed a reminder to visit the study site, which included an online user guide, FAQs, a downloadable/printable brochure, site-specific educational videos, and a link to the online AAP module (see below).

Patient Questionnaire

All included patients were provided with the tablet questionnaire by a clinic staff member (e.g. receptionist) upon arrival for their appointment (i.e. before interacting with the clinician). Clinic staff used a database query or an automated patient tag in the registration system to identify the eligible patients. Patients who had completed the questionnaire within the prior month were not asked to repeat it, and those who had previously completed it more than one month prior were simply asked to confirm/edit prior responses.

CDSS

Upon opening the chart of any patient who had completed the questionnaire, clinicians received a notification alerting them to the patient's current asthma control status and prompting them to open the CDSS. If clinicians accessed the CDSS, they viewed the following information: screen 1 - a description of the patient's current control criteria and self-reported medication use; screen 2 - corresponding evidence-based medication escalation/de-escalation recommendations; screen 3 – corresponding AAP yellow zone medication recommendations; screen 4 - a pre-populated AAP (which could be text edited); and screen 5 - a reminder to book close follow-up and to provide the educational website URL (see below) (given that regular review and education are elements of a successful AAP intervention) (the website also included inhaler technique videos and a self-directed web-based asthma educational program). Recommended medications in each screen could be altered through drop-down lists. Accordingly, recommendations in each subsequent screen were determined dynamically based on information confirmed in each prior screen. If users progressed through at least one of these screens, a note was automatically written to the EMR chart documenting the patient's asthma control level, recommendations made by the CDSS, physician actions in response to each recommendation, and any new prescriptions required. If clinicians approved the AAP, it was sent to the chart in a .pdf format, for printing. Patients who had a personal health record (PHR) also automatically received an electronic copy of the AAP within their PHR. Patients also received the URL for a self-directed web-based asthma educational program (on a pre-printed post-it note added to the AAP and/or by email where available) (www.oscarasthma.ca).

Given that access to the eAMS was chart-based and not clinician-based, the CDSS was available for use by any clinician who happened to see an included patient [patients occasionally see clinicians other than their most responsive physician (MRP) for urgent issues]. In cases where a patient had completed the pre-visit questionnaire but the CDSS had not been opened or had been opened by a clinician other than the MRP, the MRP was prompted via an electronic message regarding the patient's current asthma status and asked to complete any remaining actions in the CDSS within 1 month (CDSS recommendations were kept active for 1 month after questionnaire completion, after which updated questionnaire responses were required).

CDSS logic was developed through a review of asthma guidelines,[5] systematic development of evidence-based rules for AAP auto-population,[6] and application of latest evidence to optimize the implementability of provided guidance.[7] The AAP populated by the eAMS was the same preference-based AAP as that described above in the baseline phase.

Aside from the tablet devices and the pre-printed sticky pads with the URL for the self-directed web-based asthma educational program, no additional resources were added to the clinics for the intervention.

Ongoing Feedback

Investigators also provided site leads with a monthly audit report detailing overall system usage, highlighting which clinicians had developed the most AAPs. This feedback was distributed to all participating physicians by site leads.

Data Collection

Primary care (GA, DC, AK, SGo) and respirology experts (SG, LPB) defined all data elements. Four trained reviewers performed electronic chart audit and entered data in a standardized electronic form (in Excel®). The form was refined for clarity and usability through three cycles of testing, each involving 20 visit reviews by each reviewer. Reviewers then independently abstracted data from 40 randomly selected visits to ensure agreement. We abstracted data for all outpatient visits and asthma-related telephone interactions by staff physicians, residents, nurse practitioners (NPs), NP students, or physician assistants (PAs) (i.e. prescribers). Abstracted data included visit time/date, presenting complaint, demographics, respiratory comorbidities, respiratory medications and any changes, previous diagnostic testing (spirometry and/or methacholine challenge), previous hospitalizations or emergency department (ED) visits for asthma, previous referrals/visits to respirologists/allergists (and their findings), clinician documentation of asthma control according to symptom-based Canadian guideline criteria (Table 1),[8] actual asthma control according to symptoms recorded in any place in the chart, provision of a written AAP, and all patient/clinician interactions with the eAMS (intervention period only).

Outcomes

The primary outcome was asthma action plan delivery, measured by the proportion of patients on a controller medication (inhaled corticosteroid, inhaled corticosteroid /long-acting beta agonist combination, and/or leukotriene receptor antagonist) who received a written AAP during the intervention period compared to the baseline period (cumulative proportion by patients and time series analysis by patient visits). Secondary outcomes included: the proportion of visits during which asthma control was assessed according to symptom-based criteria (and the proportion of patients who had asthma control assessed at least once) (patients were considered to have poor control if they met one or more guideline-based criterion for uncontrolled asthma based on review of the current and any prior visits within each corresponding look back period - (Table S1); and the proportion of visits during which controller therapy was escalated (i.e. a controller medication started/added/dose escalated) (and the proportion of patients who had at least one escalation). We calculated the proportion of rescue to controller medication prescriptions in each period. During the intervention period, we also measured the proportion of visits in which patients had good control in which a medication de-escalation was made; the proportion of patients in whom discussions about medication adherence took place, and system uptake.

Sample Size Calculation

Recommendations for a rigorous ITS design indicate that at least 10 pre- and 10 post-data points would be needed to achieve at least 80% power to detect a change (if the autocorrelation is > 0.4)[9]. As this was a novel intervention, there were no data on what the autocorrelation might be or what effect size the intervention was likely to produce. Therefore, we divided data into 26 2-week time points both before and after the intervention. Estimating an optimistic baseline AAP delivery rate of 11%[10], we would require only 15 time points in each phase for a power of 80% to detect a doubling in this rate to 22% with the intervention (a conservative estimate of effect size). Estimating a physician recruitment of 8 physicians across all sites, an average active practice size of 1000 patients per physician, a prevalence of physician-diagnosed asthma with asthma medication use within the last 12 months of 6.5%[11], and at least one eligible patient visit per year, we estimated that 520 eligible patients would be seen each year (approximately 20 visits per 2-week time period).

Analysis

We calculated interrater reliability using percent agreement among the 4 reviewers. We initially used a Fleiss' kappa to determine agreement. However, there were several variables for which there was perfect agreement, resulting in no variability and an inability to compute the kappa statistic. Thus, for consistency, we elected to report percent agreement across variables. We summarized baseline clinician and patient characteristics descriptively, using information from the first visit in patients with multiple visits. The intervention period included all visits that occurred while all components of the eAMS were active, in each respective clinic. We compared patient variables between periods with Fisher's exact/chi square tests and ANOVAs, as appropriate. All analyses were intention-to-treat; however we present additional "on-treatment" analyses for main outcomes. We compared all proportions between periods with the chi square test. The primary outcome (AAP delivery) measured the proportion of patients on an asthma controller medication for at least 1 visit in the relevant study period who received an AAP (excluding those who had received/reviewed an AAP in the last 6 months). In the ITS analysis, we used 26 consecutive 2-week time points to create a baseline model. For each time point, we calculated the proportion of visits by patients on an asthma controller medication (defined as above) associated with AAP delivery (excluding visits where an AAP had been received/reviewed in the prior 6 months). We compared outcomes rates in 26 consecutive 2-week intervals prior to the intervention to those in 26 consecutive 2-week intervals following the intervention, using an interventional autoregressive integrated moving average (ARIMA) model. Model checking examined autocorrelation and partial autocorrelation plots and the Augmented Dicky-Fuller test and Ljung-Box test.[12] We also fit a generalized estimating equation (GEE) model including all visits in the intervention period to examine the trend over time with regard to the outcome (this model did not adjust for any covariates and was tested using a one-sided test with a significance level of 0.05). In measuring asthma control assessment, we eliminated visits in which asthma control had been assessed within the prior 28 days (a standard lookback period for symptom-based asthma control assessment)[13]. In the measuring therapy escalation, we eliminated visits in which patients had had a controller medication escalated within the last three months (the typical duration of a therapeutic trial).[14] To account for individual and clinical risk factors as well as the longitudinal component, we used a generalized linear mixed model (GLMM) with a logit link to identify predictors of main outcomes (covariates tested are listed above) among patients seen in both the baseline and intervention periods. A random effect was included to account for within subject correlation (confidence intervals were bootstrapped). Analyses were performed using R Statistical Software (Version 3.4.0). Statistical significance was defined at a two-sided 0.05 level.

Table S1. Symptom-based criteria for assessing asthma control[8]

Criterion	Controlled	Uncontrolled
Daytime Symptoms *	<4 days/week	≥4 days/week
Night-time Symptoms*	<1 night/week	≥1 night/week
Physical Activity	Normal/No limitations	Restricted due to asthma in previous 3 months
Absenteeism	None	Missed work/school/other activities due to asthma in previous 3 months
Short-acting bronchodilator use*	<4 doses/week	≥ 4 doses/week

* Evaluated as an average of the prior 6 months

RESULTS

Table S2. Baseline Medications in Patients in Whom Asthma Control Could be Ascertained

Baseline Medications┼	Baseline Period (n=167)	Intervention Period (n=585)
Asthma Well Controlled, n (%)		
No controller therapy	0	180/257 (70.0%)
First line controller therapy (inhaled corticosteroid alone* and/or Leukotriene receptor antagonist)	0	45/257 (17.5%)
Inhaled corticosteroid with long-acting beta-agonist	1 (0.6%)	32/257 (12.5%)
Prednisone†	0	0
Asthma Poorly Controlled, n (%)		
No controller therapy	87 (52.1%)	149/328 (45.4%)
First line controller therapy (inhaled corticosteroid alone* and/or Leukotriene receptor antagonist)	41 (24.6%)	85/328 (25.9%)
Inhaled corticosteroid with long-acting beta-agonist	37 (22.2%)	94/328 (28.7%)
Prednisone†	1 (0.6%)	0

┼assessed at the first visit at which asthma control could be ascertained (by chart review), for each patient
* without concurrent use of a long-acting beta-agonist in a combination inhaler or as a separate inhaler
† includes only those patients using prednisone chronically

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