Disease Management Programs for Patients With Asthma in Germany: A Longitudinal Population-Based Study

Michael Mehring MD, Ewan Donnachie, Robert Mutschler, Frank Hofmann PhD, Manfred Keller PhD, and Antonius Schneider PhD

BACKGROUND: The primary aim of the disease management program (DMP) for patients with asthma is to improve health outcomes and to reduce costs. Five years after its introduction in Germany, no consensus has yet been reached as to whether DMP has been effective in reaching these goals. OBJECTIVE: To evaluate the DMP for asthma in Bavaria using routinely collected subject medical records. METHODS: A longitudinal population-based study encompassing over 100,000 DMP participants between 2006 (when the program began) and 2010. RESULTS: The prescription rate of oral corticosteroids dropped from 15.7% in 2006 to 13.6% in 2007, and again from 7.5% in 2008 to 5.9% in 2010 ($P < .001$). The proportion of subjects with asthma self-management education increased from 4.4% to 23.4% ($P < .001$). Utilization of an individual asthma action plan increased from 40.3% to 69.3% ($P < .001$). Hospitalization decreased from 2.8% to 0.7% ($P < .001$). CONCLUSIONS: In the first 4 years of DMP there was an improvement in pharmacotherapy and patient self management. The proportion of subjects requiring hospitalization decreased. Our results suggest that the German DMP for asthma has been effective in enhancing the quality of care in regard to an improved symptom frequency, adherence to guidelines, pharmacotherapy, and hospitalization. *Key words: active patient participation; asthma; disease management program; general practice; hospitalization.* [Respir Care 2013;58(7):1170–1177. © 2013 Daedalus Enterprises]

Introduction

The German disease management programs (DMPs) were introduced in 2003. Currently, more than 6 million statutorily insured patients in Germany are enrolled in one of the 6 DMPs.[1] To date DMPS have been introduced for patients with breast cancer, diabetes type 1 and type 2, coronary heart disease, asthma, and COPD.

Various studies suggest that the German DMPs have improved the quality of care for diabetes[2-4] and coronary artery disease.[5] As yet, however, the DMP for asthma patients has not been broadly evaluated. A retrospective matched cohort study conducted by Windt and Glaeske[6] showed that the impact of a DMP for asthma was weak with respect to clinically relevant end points, but found evidence that pharmacotherapy was more guideline-adherent within the DMP.

In general, studies investigating the utility of asthma DMPs have come to varying conclusions. Maciejewski et al found that there are only a few relevant studies exhibiting both good design and rigorous statistical evaluation. After reviewing more than 29 papers, they stated that the evidence is still insufficient to recommend a DMP for asthma.[7] Other research has indicated that since the introduction of DMPs in the United States during the 1990s, there have been improvements in processes of care and disease control. However, conclusive support for DMP

Dr Mehring, Mr Mutschler, and Dr Schneider are affiliated with the Institute of General Practice, Technische Universität München, Munich, Germany. Mr Donnachie, Dr Hofmann, and Dr Keller are affiliated with the National Association of Statutory Health Insurance Physicians of Bavaria, Munich, Germany.

Dr Mehring and Mr Donnachie are co-first authors.

Dr Schneider was partly supported by grants from the German Ministry of Health. The authors have disclosed no conflicts of interest.

Correspondence: Michael Mehring MD, Institute of General Practice, Technische Universität München, Orleansstraße 47, 81667 München, Germany. E-mail: michael.mehring@lrz.tum.de.

DOI: 10.4187/respcare.01968

effects on health outcomes has been lacking.[8] Similar findings were reported in the Netherlands by Steuten et al, who followed up on 658 patients after 1 year of DMP.[9] The generalizability of this result is questionable, having been conducted in a small group of general practices with trained nurse practitioners for asthma. An earlier Cochrane review[10] examined the effectiveness of education programs for asthma, concluding that self-management education for adults improves health outcomes. A study from the United States found that participants in an asthma intervention program experienced an improvement in their asthma control, resulting in reduced hospitalization and substantial cost savings.[11] Nevertheless, the effectiveness of a DMP for asthma in a large population remains unclear.

A central intention of the German DMP was to introduce a data-driven system for continuous quality improvement.[12] To this end, relevant data on each subject are collected in a standardized manner for evaluation and quality improvement purposes. The present investigation aimed to assess whether key indicators of quality improved during the first 4 years of the asthma DMP in Bavaria.

QUICK LOOK

Current knowledge

The primary aims of an asthma disease management program are to improve outcomes and reduce costs, through education that facilitates self-management and prevents hospitalization.

What this paper contributes to our knowledge

During the first 4 years of an asthma disease management program in Germany, self-management improved and hospitalizations declined. Appropriate prescriptions and delivery methods for inhaled medications increased, and adherence to published guidelines improved.

Methods

The German DMP for Asthma

In 2001, a committee of experts reporting to the German Federal Ministry of Health criticized overuse, underuse, and misuse in the care of chronically ill patients, including those with asthma.[13] A DMP was suggested as a quality program to facilitate the continuous improvement of this care. As a result, the DMP for asthma was developed by the federal joint committee *Gemeinsamer Bundesausschuss*, and introduced in Bavaria on April 1, 2006. The aim was to improve care by establishing standards for diagnosis, treatment, documentation, quality assurance, and referral; and by enhancing active patient participation. In parallel to the introduction of DMP, the national asthma guideline for the German healthcare system[14] was developed and brought into effect.

In order to enroll a patient into the asthma DMP the diagnosis must first be confirmed and documented by the coordinating general practitioner, according to the guidelines.[14] Participating subjects receive a check-up at their coordinating general practice either quarterly or half-yearly. The check-up interval is decided by the physician, based on symptom severity and overall patient health. A reminder system for subjects and practices helps ensure that these regular consultations are not overlooked. Health insurance companies support their patients by supplying information to assist self-management and by providing monetary and other incentives (eg, waiving the quarterly consultation fee of €10 that is usually payable when visiting a general practitioner).

Subjects must be treated according to evidence-based guidelines. A standardized medical record is created at each check-up and submitted to various official agencies for quality assurance purposes. This includes details of the physical examination, peak expiratory flow measurements, medical history, symptom frequency, asthma-related medication, patient education, patient-specific treatment goals such as smoking cessation, preparation of an individual action plan, documentation of hospitalization or emergency treatment, and referrals to a pulmonologist.

The asthma DMP was underpinned by the introduction of additional quality improvement measures. General practitioners receive half-yearly feedback reports to benchmark their performance on the basis of quality indicators (eg, hospitalization rates, usage of action plans, and the use of inhaled corticosteroids [ICS] as the primary controller medication). Additionally, participating general practitioners are obliged to complete asthma-specific continuing medical education at least once every 3 years. These are provided by various commercial and non-profit organizations, including the National Association of Statutory Health Insurance Physicians of Bavaria (Kassenärztliche Vereinigung Bayerns). Finally, the Kassenärztliche Vereinigung Bayerns utilizes CME events and its members' journal to engage coordinating physicians in the process of quality improvement, for example, by promoting and distributing a model action plan for patients.[15]

Statistical Evaluation

The Kassenärztliche Vereinigung Bayerns analyzed more than one million DMP anonymous patient records, with each subject identified by a unique pseudonym. Statistical trend analyses were calculated using the Cochran-

Table 1. Baseline Subject Data

	2006	2007	2008	2009	2010
Age range, y					
0–17	4,210 (20.1)	9,117 (18.2)	14,685 (17.3)	17,011 (16.6)	17,314 (15.9)
18–40	4,186 (20.0)	10,159 (20.3)	17,304 (20.4)	20,790 (20.3)	20,799 (19.1)
41–60	6,744 (32.1)	16,443 (32.8)	27,986 (33.0)	33,940 (33.2)	36,395 (33.4)
61–80	5,456 (26.0)	13,348 (26.6)	22,855 (26.9)	27,914 (27.3)	31,186 (28.6)
> 80	386 (1.8)	1,095 (2.2)	2,009 (2.4)	2,709 (2.6)	3,348 (3.1)
Female	10,239 (56.9)	25,968 (57.1)	47,674 (57.2)	57,981 (57.5)	62,349 (58.0)
Male	7,768 (43.1)	19,484 (42.9)	35,670 (42.8)	42,791 (42.5)	45,158 (42.0)
Smoker	2,470 (11.8)	5,764 (11.5)	9,372 (11.0)	11,477 (11.2)	12,107 (11.1)
Accompanying COPD	1,095 (5.2)	1,420 (2.8)	2,724 (3.2)	3,337 (3.3)	3,721 (3.4)
Totals	20,982 (100)	50,162 (100)	84,839 (100)	102,364 (100)	109,042 (100)

Values are no. (%).

Table 2. Medication, Hospital Admission, Self-management Education, and Action Plan for Self Treatment From 2006 to 2010

	2006	2007	2008	2009	2010	*P*
Oral corticosteroids	3,290 (15.7)	6,841 (13.6)	6,392 (7.5)	6,511 (6.4)	6,434 (5.9)	< .001
Inhaled corticosteroids	15,872 (75.6)	37,019 (73.8)	61,659 (72.7)	75,068 (73.3)	80,164 (73.5)	< .001
Short-acting β_2 agonists	16,566 (79.0)	38,091 (75.9)	61,100 (72.0)	74,212 (72.5)	78,985 (72.4)	< .001
Long-acting β_2 agonists	11,317 (53.9)	26,741 (53.3)	47,880 (56.4)	58,259 (56.9)	61,966 (56.8)	< .001
Long-acting β_2 agonists monotherapy	438 (2.1)	1,271 (2.5)	3,060 (3.6)	3,561 (3.5)	3,798 (3.5)	< .001
Other medications	4,696 (22.4)	10,159 (20.3)	13,445 (15.8)	15,431 (15.1)	16,407 (15.0)	< .001
Hospital admission	581 (2.8)	842 (1.7)	694 (0.8)	724 (0.7)	794 (0.7)	< .001
Self-management education	926 (4.4)	6,741 (13.4)	14,517 (17.1)	21,283 (20.8)	25,470 (23.4)	< .001
Action plan for self treatment	8,462 (40.3)	22,824 (45.5)	42,945 (50.6)	60,777 (59.4)	75,618 (69.3)	< .001

Values are no. (%).

Armitage test for trend[16,17] and the chi-square test. A separate cohort analysis, including an evaluation of possible drop-out bias, was conducted to assess whether the symptom frequency of individual DMP participants had improved over time. The cohort was composed of all participants enrolled in the second half of 2006 and followed through to the end of 2010. The study was approved by the medical ethics committee of the university hospital, Klinikum Rechts der Isar, München, Germany. Statistical analysis was conducted with statistics software (R, R Foundation for Statistical Computing, Vienna, Austria),[18] with the TraMineR package for sequence analysis of the cohort.[19]

Results

Since the introduction of DMP, the number of participating subjects has increased steadily. Whereas in the first year, 2006, only 20,982 subjects were enrolled, there was a 5-fold increase over the first 4 years (Table 1). The distribution of age and sex remained more or less constant over the entire observation period.

Both the proportion of smokers and the proportion with accompanying COPD saw significant declining trends over the observational period (Cochran-Armitage test for trend for smokers $P < .001$, accompanying COPD $P = .03$).

The number of participating physicians increased from 5,712 when the program began, to 9,021 in 2010. These were predominantly general practitioners (90%), followed by pediatricians (8%) and pulmonologists in private practice (2%).

Analysis of the prescribed medications reveals a number of distinct findings (Table 2). The most demonstrative result is a clear declining trend in the prescription of oral corticosteroids. Whereas in 2006 up to 15.7% of all participants used oral corticosteroids, by 2010 this had been reduced to 5.9% ($P < .001$). This result may, however, have been influenced by a change in the way oral steroids are documented. From the start of the program until June 30, 2008, the standardized documentation distinguished between oral steroids as a continuous controller medication and as a reliever for use during exacerbations. In order to simplify the documentation, this distinction was removed, effective July 1, 2008. Notwithstanding the effect of this

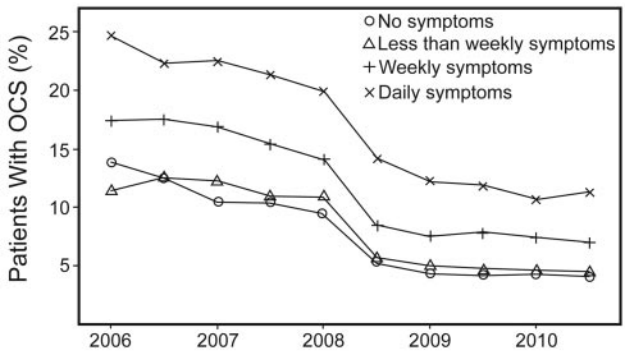

Fig. 1. Proportion of subjects with oral corticosteroid (OCS) therapy, grouped by symptom frequency.

change, the continuous decline between 2006 and 2010 does suggest a real change in prescribing practices. This trend is present across all levels of symptom frequency (Fig. 1), and as such is unlikely to be an artifact caused by an increasing proportion of subjects with less severe symptoms.

The use of ICS remained stable, at around 73%, with a small initial reduction from 75% being most likely due to more severely ill subjects being recruited in the initial stages of the program. The prescription of short-acting β_2 agonists, the most commonly used drug besides ICS, declined from 79.0% to 72.4%. In contrast, the use of long-acting β_2 agonists (LABAs) rose from 53.9% to 56.8%. Remarkably, LABA monotherapy rose slightly, from 2.1% to 3.5%. The portion of subjects with other medications (eg, xanthine derivatives and leukotriene-modifying agents) was also reduced over the period of observation, although again this may in part be due to changes in the standardized documentation.

Table 2 shows that the proportion of subjects with a personalized action plan rose significantly, from 40.3% to 69.3% ($P < .001$). The proportion of subjects with self management education increased from 4.4% to 23.4% ($P < .001$). At the same time, there was a significant reduction in the rate of hospitalization, from 2.8% to 0.7% ($P < .001$).

Table 3 summarizes the distribution of symptom frequency of all participants, revealing that the proportion of subjects without symptoms almost doubled over the course of the observation period. At the same time, the proportion of subjects with daily and weekly symptoms decreased. The Cochran-Armitage test for trend confirmed the statistical significance of these findings ($P < .001$). The proportion of subjects with less than weekly symptoms remained constant, at approximately 43%. In order to rule out the possibility that the observed improvement in symptom frequency was caused merely by the enrolment of subjects with less severe asthma into the program, a cohort analysis was devised to take such potential biases into account.

The cohort analysis observed 18,903 participants enrolled in the second half of 2006. This cohort was considered to be the largest and most representative group, with the longest possible observation period. The question of interest was whether these subjects had experienced an improvement in symptom frequency over the course of their participation in the DMP.

The sequence plot in Figure 2 illustrates the symptom frequency for each individual over time. Subjects are sorted according to their symptom frequency at the beginning and end of the observational period, revealing an increase in the prevalence of mild symptoms (green area) and a decrease of severe symptoms (yellow area). This effect was significant by the Cochran-Armitage test ($P < .001$).

For subjects still present at the end of the follow-up, Table 4 compares the symptom frequency in 2006 with that at the end of 2010. The proportion of subjects whose symptoms improved is remarkably higher than the proportion experiencing a deterioration ($P < .001$, chi-square test). This is particularly striking when the 5,417 subjects with unchanged mild symptoms (less than weekly or no symptoms) are considered, for whom a decrease in symptom severity is not to be expected. As visualized by the even distribution of white space in Figure 2, drop-outs are equally likely to belong to each of the 4 initial symptom groups (chi-square test $P < .001$).

By the end of the observation period, 5,531 members (29%) of the cohort were no longer participating in DMP and can be considered drop-outs. Table 5 repeats the analysis of Table 4 while including these dropouts on a last observation carried forward basis. The proportion of subjects whose symptoms improved over time is still significantly higher than the proportion experiencing a deterioration (chi-square test $P < .001$). Thus we find no evidence to suggest that the improvement in symptom frequency over time was a result of bias due to subject drop-out.

Discussion

To our knowledge, the present study represents the largest longitudinal population-based evaluation in Germany, with the number of participants rising to around 100,000 by 2010. It is the first systematic evaluation of the German DMP for asthma to be conducted independently of any one health insurance company. Our main findings are a reduced prescription of oral corticosteroids, a decreased rate of hospitalization, and an improvement in symptom frequency, together with an increased take-up of patient education and utilization of action plans.

A study by Steuten et al[9] found that the implementation of a DMP for asthma led to improvements in self-management behavior, smoking status, disease-specific

Table 3. Symptom Frequency From 2006 to 2010*

Symptom frequency	2006	2007	2008	2009	2010
None	3,470 (15.0)	12,692 (22.4)	23,138 (23.0)	30,085 (24.9)	33,451 (26.4)
Less than weekly	10,255 (44.3)	23,897 (42.1)	44,589 (44.2)	52,243 (43.3)	55,005 (43.4)
Weekly	5,105 (22.0)	11,119 (19.6)	19,666 (19.5)	22,375 (18.5)	22,359 (17.6)
Daily	4,345 (18.7)	9,028 (15.9)	13,386 (13.3)	15,952 (13.2)	15,935 (12.6)
Totals	23,175 (100)	56,736 (100)	100,779 (100)	120,655 (100)	126,750 (100)

Values are no. (%).
* All participants. Multiple counting was possible by changing of symptom frequency within the same year. Cochrane Armitage test for trend revealed a significant improvement in symptom frequency ($P < .001$).

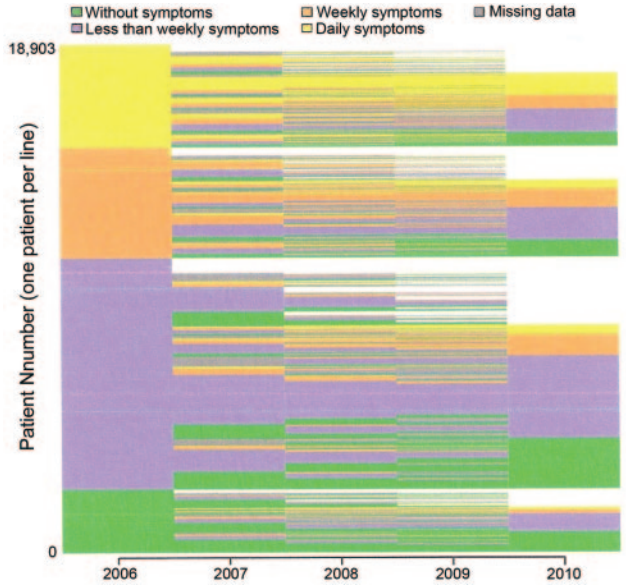

Fig. 2. Sequence plot visualizing the development of symptom frequency for the cohort at the individual level between 2006 and 2010. Each of the 18.903 participants is represented by a line, the color of which is determined by the symptom frequency. White space represents missing data due to drop-out.

knowledge, patient satisfaction, and disease control. However, this was demonstrated in a selection of general practices where, among other conditions, a respiratory nurse specialist performed diagnostic and therapeutic activities to enhance patient education and self-management. Nevertheless, our results show that guideline adherence increased continuously during the period of observation, with an evolving pharmacotherapy and an increased use of patient education and action plans. The reduction in hospitalization is a further notable result. Whereas in the first year of DMP almost 3% of all participants were hospitalized at least once over a 6-month period, this was reduced to less than 1% by 2010. At the same time, the number of participants who had completed a patient education program increased 5-fold, and the utilization of individual action plans almost doubled. Gibson et al[10] have shown that self-management education for patients with asthma reduces hospitalization, emergency room visits, unscheduled visits to the general practitioner, disability, and nocturnal asthma, while improving the overall quality of life. Additionally, a meta-analysis by Lemmens et al[20] found evidence that multiple interventions led to a significant reduction in hospitalization, in comparison with routine care. The reduction in hospitalization may in turn save costs.[9]

A German health insurance company (DAK Health) evaluated the data of approximately 67,000 subjects and found that the proportion of symptom-free subjects increased from 12% to 23% within 1 year. After 2 years the number of subjects with daily symptoms had decreased by around one third.[21] These results are largely corroborated by the present evaluation. Whereas in 2006 only 15% of the subjects were symptom-free, by 2010 this had increased to 26%. Over the same period the number of subjects with daily symptoms declined by around one third. The cohort analysis revealed the same significant trends and showed that this result is not to be explained by more subjects with less severe symptoms being enrolled. The results of the cohort analysis are thus sufficiently robust to state a positive health outcome during the observation. The present evaluation confirmed the positive results of previous studies,[9,22] showing that DMPs for asthma improve disease control and therefore also enhance the health outcome of participants.

The observed improvements in asthma care may conceivably have been achieved by the accompanying quality improvement strategies, as outlined in the methods section. Individual feedback reports and medical education schemes are known to be effective in improving the quality of chronic care.[23-25] Additionally, chronic care may have been also improved by the program itself, by enhancing patient guidance mechanisms. Subjects were required to attend a consultation at least half-yearly, in order to asses the clinical symptoms and treatment effectiveness. Similarly, a randomized controlled trial conducted by Delaronde et al[26] found that a 6-month telephone-based case management intervention improved both the quality of life and the use of asthma medication. Furthermore, a matched

Table 4. Cohort Analysis of Symptom Frequency Changes From 2006 to 2010, Without Dropouts

	Symptoms 2010			
Symptoms 2006	None	Less Than Weekly	Weekly	Daily
None	819 (15.1)	738 (30.2)	163 (6.7)	96 (3.9)
Less than weekly	1,861 (33.8)	3,089 (57.0)	756 (31.0)	361 (14.8)
Weekly	648 (11.8)	1,186 (21.5)	720 (13.3)	327 (13.4)
Daily	508 (9.2)	836 (15.2)	475 (8.6)	789 (14.6)

Values are number (%). Chi-square test revealed a highly significant improvement in symptom frequency ($P < .001$).
Symptoms unchanged: $n = 5,417$ (40.5%).
Symptoms worse: $n = 2,441$ (18.3%)
Symptoms improved: $n = 5,514$ (41.2%).

Table 5. Cohort Analysis of Symptom Frequency Changes From 2006 to 2010, With Dropouts (Last Observation Carried Forward)

	Symptoms 2010			
Symptoms 2006	None	Less Than Weekly	Weekly	Daily
None	1,324 (15.8)	1,392 (33.1)	332 (7.9)	228 (5.4)
Less than weekly	2,093 (33.2)	4,566 (54.3)	1,146 (27.2)	625 (14.9)
Weekly	701 (11.1)	1,412 (22.5)	1,225 (14.6)	485 (11.5)
Daily	534 (8.5)	953 (15.2)	596 (9.5)	1,291 (15.4)

Values are number (%). Chi-squared test revealed a highly significant improvement in symptom frequency ($P < .001$).
Symptoms unchanged: $n = 8,406$ (44.5%)
Symptoms worse: $n = 4,208$ (22.3%)
Symptoms improved: $n = 6,289$ (33.3%)

cohort study conducted by Windt and Glaeske[6] found that the medication regimen of subjects within the DMP had a higher guideline adherence than that observed in non-participating patients. A higher guideline adherence and a decreased hospitalization were also demonstrated by Suh et al[27] in a longitudinal population-based study of a targeted asthma intervention. In addition Lutgenberg et al[28] revealed within a systematic review that evidence-based clinical guidelines are effective in improving the process and structure of care.

With respect to the prescription of ICS, a European study from 1999[29] stated that only 23% of all asthma patients used ICS. Such an under-utilization of ICS was confirmed for German adolescents in a study by Langen et al.[30] Our results are, however, in accord with other investigations,[6,23] showing that up to three quarters of all asthma patients are prescribed ICS. It has been shown beyond doubt that long-term therapy with oral corticosteroids has potentially harmful side effects and should be undertaken only after careful consideration. According to the national asthma guidelines, oral corticosteroids are admissible only as a long-term controller medication at the highest treatment level, when alternative therapy options have failed to achieve symptom control.[14] In the first 4 years of the Bavarian DMP, the proportion of prescribed oral corticosteroids was reduced significantly. These data confirm results from Suh et al,[27] who identified a similar reduction from more than 40% of patients with OCS after a comparable intervention. Likewise, Johnson et al[31] conducted a matched cohort investigation to find that participants in a DMP had a significantly lower usage of OCS than non-participants. On the other hand, Windt and Glaeske[6] observed no significant difference between DMP participants and non-participants. In their study, however, 25.6% of these DMP patients received oral corticosteroids. This seems to be a relatively high proportion, especially in comparison with the present study, perhaps indicating a tendency to include patients with more severe asthma in their study.

One cause for concern may be the increase of LABA monotherapy, from approximately 2.1% to 3.5%, which is an unexpected trend, considering that such a standalone treatment runs contrary to guidelines. It has been shown that this can lead to an increased risk of severe exacerbations, hospitalization, and even to death. Instead, a combination with an ICS should always be used.[14] National and international guidelines such as the Global Initiative for Asthma (GINA) (http://www.ginasthma.org/Guidelines/guidelines-resources.html) explicitly state that monotherapy with LABA should be avoided, a position that has

been reflected in the German national guidelines for many years.[14] Continued efforts are therefore still required to improve prescribing behavior.

The main limitation of the present evaluation is the absence of a suitable control group with which to compare the effectiveness of the asthma DMP with standard care. This might have led to a selection bias toward more motivated and healthier patients. Additionally, systematic differences may exist between those general practitioners participating in the program and those who, for a variety of reasons, do not take part in DMP. The lack of a randomized controlled design thus represents an inherent limitation when assessing the effectiveness of the German DMPs, which were introduced on an almost universal basis in each German federal state.[32] On the other hand, the participation of over 100,000 subjects provides an almost unrivalled data source with which to evaluate the quality of care within DMP. This enables us to conclude with some certainty that, in the first 4 years of DMP in Bavaria, there was a reduction in the prescription of oral corticosteroids, a reduction in hospitalization, and improved symptom frequency.

Conclusions

Our results support trends found in previous investigations[10,20] and highlight an overall improvement in the quality of care for asthma patients. Therefore, we conclude that since the implementation of the DMP for asthma in Bavaria in 2006, adherence to guidelines, symptom frequency, and pharmacotherapy have improved. The proportion of patients requiring hospitalization for asthma-related problems has decreased.

REFERENCES

1. van Lente EJ. Erfahrungen mit strukturierten Behandlungsprogrammen (DMPs) in Deutschland, Versorgungs-Report 2011: Schwerpunkt: Chronische Erkrankungen. Schattauer Berlin 2010;55-82. *Article in German.*
2. Stock S, Drabik A, Büscher G, Graf C, Ullrich W, Gerber A et al. German Diabetes Management Programs improve quality and curb coasts, Health Aff (Millwood) 2010;29(12):2197-2205.
3. Miksch A, Laux G, Ose D, Joos S, Campbell S, Riens B, et al. Is there a survival benefit within a German primary care-based disease management program? Am J Manag Care 2010;16(1):49-54.
4. Stark RG, Schunk MV, Meisinger C, Rathmann W, Leidl R, Holle R, et al. Medical care of type 2 diabetes in German disease management programs: a population-based evaluation. Diabetes Metab Res Rev 2011;27(4):383-391.
5. Leinert J, Riedel W. Ergebnisse der AOK Bundesauswertungen zur gesetzlichen Evaluation der deutschen Disease-Management-Programme. http://www.aok-gesundheitspartner.de/imperia/md/gpp/bund/dmp/evaluation/konferenz_juni09/dmp_konf29_30_06_09_infas.pdf. *Accessed April 18, 2013. Article in German.*
6. Windt R, Glaeske G. Effects of a German asthma disease management program using sickness fund claims data. J Asthma 2010;47(6):674-679.
7. Maciejewski ML, Chen S, Au DH. Adult asthma disease management: an analysis of studies, approaches, outcomes, and methods. Respir Care 2009;54(7):878-886.
8. Mattke S, Seid M, Ma S. Evidence for the effect of disease management: is $1 billion a year a good investment? Am J Manag Care 2007;13(12):670-676.
9. Steuten L, Vrijhoef B, Van Merode F, Wesseling GJ, Spreeuwenberg C. Evaluation of a regional disease management programme for patients with asthma or chronic obstructive pulmonary disease. Int J Qual Health Care 2006;18(6):429-436.
10. Gibson PG, Powell H, Coughlan J, Wilson AJ, Abramson M, Haywood P, et al. Self-management education and regular practitioner review for adults with asthma. Cochrane Database Syst Rev 2003;(1):CD001117.
11. Castro M, Zimmermann NA, Crocker S, Bradley J, Leven C, Schechtman KB, et al. Asthma intervention program prevents readmissions in high healthcare users. Am J Respir Crit Care Med 2003;168(9):1095-1099.
12. Lauterbach KW. Disease Management in Deutschland: Voraussetzungen, Rahmenbedingungen, Faktoren zur Entwicklung, Implementierung und Evaluation. Gutachten im Auftrag des Verbandes der Angestellten-Krankenkassen e.V. (VdAK) und des Arbeiter-Ersatzkassen-Verbandes e.V. (AEV) 2001 http://gesundheitspolitik.org/01_gesundheitssystem/disease-management/allgemeine-infos/DMP_Gutachten_Lauterbach_kurz.pdf. *Accessed April 18, 2013. Article in German.*
13. Advisory Council for the Concerted Action in Health Care. Appropriateness and efficiency, volume III: overuse, underuse and misuse. 2001 executive summary. http://www.svr-gesundheit.de/fileadmin/user_upload/Gutachten/2000-2001/Kurzf-engl01.pdf. *Accessed April 18, 2013.*
14. Bundesärztekammer (BÄK) KB (AWMF). Nationale VersorgungsLeitlinie Asthma: Langfassung. 2. Auflage, Version 1.2, 2010. http://www.versorgungsleitlinien.de/themen/asthma/pdf/nvl_asthma_lang.pdf. *Accessed April 18, 2013. Article in German.*
15. Donnachie E, Hofmann F, Keller M. Qualitätsbericht 2010: Disease Managment Programme in Bayern. http://www.kvb.de/fileadmin/kvb/dokumente/Praxis/Infomaterial/Versorgung/KVB-Bericht-DMP-qualitaetsbericht-2010.pdf. *Accessed April 18, 2013.*
16. Cochran WG. Some methods for strengthening the common chi square tests. Biometrics 1954;(10):417-451.
17. Armitage P. Tests for linear trends in proportions and frequencies. Biometrics 1955;(11):375-386.
18. Bates D, Chambers J, Dalgaard P, Falcon S, Gentleman R, Hornik K, et al; The R Core Development Team. R: a language and environment for statistical computing. http://www.r-project.org. *Accessed April 18, 2013.*
19. Gabadinho A, Ritschard G, Müller NS, Studer M. Analyzing and visualizing state sequences in R with TraMineR. J Statistic Softw 2011;(40):1-37.
20. Lemmens KMM, Nieboer AP, Huijsman R. A systematic review of integrated use of disease-management interventions in asthma and COPD. Respir Med 2009;103(5):670-691.
21. Haacker R. Studie: Asthma Gesundheitsprogramm verringert Beschwerden deutlich. http://www.presse.dak.de/ps.nsf/Show/8C5D575675D0B049C12577E600253E40/$File/101125_Asthmastudie_I.pdf. *Accessed April 18, 2013. Article in German.*
22. Armour C, Bosnic-Anticevich S, Brillant M, Burton D, Emmerton L, Krass I, et al. Pharmacy Asthma Care Program (PACP) improves outcomes for patients in the community. Thorax 2007;62(6):496-592.

23. Schneider A, Wensing M, Biessecker K, Quinzler R, Kaufmann-Kolle P, Szecsenyi J. Impact of quality circles for improvement of asthma care: results of a randomized controlled trial. J Eval Clin Pract 2008;14(2):185-190.
24. 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(10):1423-1431.
25. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. Lancet 2003;362(9391): 1225-1230.
26. Delaronde S, Peruccio DL, Bauer BJ. Improving asthma treatment in a managed care population. Am J Manag Care 2005;11(6):361-368.
27. Suh DC, Shin SK, Okpara I, Voytovich RM, Zimmerman A, et al. Impact of a targeted asthma intervention program on treatment costs in patients with asthma. Am J Manag Care 2001;7(9):897-906.
28. Lugtenberg M, Burgers JS, Westert GP. Effects of evidence-based clinical practice guidelines on quality of care: a systematic review. Qual Saf Health Care 2009;18(5):385-392.
29. Rabe KF, Vermeire PA, Soriano JB, Maier WC. Clinical management of asthma in 1999: the Asthma Insights and Reality in Europe (AIRE) study. Eur Respir J 2000;16(5):802-807.
30. Langen U, Knopf H, Melchert H. [Drug therapy of asthma. Results of the 1998 German National Health Interview and Examination Study]. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 2006;49(9):903-910. *Article in German.*
31. Johnson A, Berg G, Fleegler E, Sauerbrun M. A matched-cohort study of selected clinical and utilization outcomes for an asthma care support program. Dis Manag 2005;8(3):144-154.
32. Wegscheider K. DMP: Methodik für faire Vergleiche. Monitor Versorgungsforschung 2011;4(1):25-27.