

Factors associated with concordance between parental-reported use and dispensed asthma drugs in adolescents: findings from the BAMSE birth cohort[†]

Elin Dahlén^{1,2*}, Catarina Almqvist^{3,4}, Anna Bergström⁵, Björn Wettermark^{1,2} and Inger Kull^{6,7}

¹Department of Medicine, Centre for Pharmacoepidemiology, Karolinska Institutet, Stockholm, Sweden

²Department of Healthcare Development, Stockholm County Council, Public Healthcare Services Committee, Stockholm, Sweden

³Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden

⁴Lung and Allergy Unit, Astrid Lindgren Children's Hospital, Karolinska University Hospital, Stockholm, Sweden

⁵Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden

⁶Department of Clinical Science and Education, Södersjukhuset, Karolinska Institutet, Stockholm, Sweden

⁷Sachs' Children and Youth Hospital, Södersjukhuset, Stockholm, Sweden

ABSTRACT

Purpose Pharmacological treatment is important in asthma care, but there are methodological challenges in measuring how drugs are used by patients. The aim of this study was to investigate the concordance between register data on dispensed drugs and parental-reported use of asthma drugs in adolescents.

Methods A cross-sectional study comparing data on dispensed drugs from the Swedish Prescribed Drug Register with data on parental-reported use of asthma drugs among 3316 adolescents (age 11–14 years) in a population-based birth cohort in Sweden. Sensitivity, specificity, and positive predicted value for different time windows (3, 6, 12, 18, and 24 months) for dispensing in the register were computed. Logistic regression was used to explore factors associated with concordance.

Results The prevalence of parental-reported use of asthma drugs in the past year was 10.7% ($n = 356$) compared with 8.1% ($n = 269$) for dispensed drugs according to the register ($p \leq 0.001$). The sensitivity increased with an extended time window in the register, whereas the specificity remained high up to 18 months. Although 90% of the adolescents with asthma had parental-reported use of asthma drugs, 30% of them had no such drugs dispensed in the preceding 18 months. The highest concordance was seen for adolescents with severe asthma (OR 4.6, CI 1.2–17.6).

Conclusions An 18-month window is preferable when using dispensing data to study the use of asthma drugs. Still, many adolescents with reported drug use had not purchased any asthma drug in this period. The concordance between parental-reported use and dispensed drugs is higher for adolescents with severe asthma. Copyright © 2014 John Wiley & Sons, Ltd.

KEY WORDS—asthma; drug utilization; register; patient questionnaire; validation study; pharmacoepidemiology

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BACKGROUND

Asthma is one of the most common chronic diseases in children, and as many as one in five children has experienced asthma symptoms at some point in life.¹ The prevalence of asthma among 13–14-year-old children varies between 6 and 27% worldwide, with

a global prevalence of 14% in adolescents.² Asthma guidelines emphasize the importance of assessment and monitoring, patient education, control of environmental factors, and pharmacological treatment.³ Medications can be classified as controllers or relievers. The controllers—inhaled corticosteroids (ICS) and leukotriene receptor antagonists (LTRAs)—are used daily on a long-term basis to keep asthma under clinical control mainly through anti-inflammatory effects. The relievers—beta-2-agonists—are used on an as-needed basis and act quickly to reverse bronchoconstriction and relieve symptoms.³

*Correspondence to: E. Dahlén, Stockholm County Council, Public Healthcare Services Committee, Box 6909, 10239 Stockholm, Sweden. E-mail: elin.dahlen@sl.se

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Even though pharmacological treatment is a keystone in asthma treatment, many studies report low patient adherence to medication.^{4–6} Fifty-five percent of all children underused their ICS,⁵ and less than 10% of children and adolescents were persistent with ICS after 1 year.⁴ Asthma in children and adolescents is an intermittent disease and therefore 100% persistence in treatment is not expected. Adolescents with asthma are a specific group of patients with different problems and needs comparison with children and adults with asthma. The disease varies a lot during growth, which needs to be taken into account when treating an adolescent with asthma.^{7–9} Developmental behavior, peer pressure, and the difficult transition to health care leads to under-diagnosis and under-treatment of asthma in adolescents.

There are three main sources of information on drug utilization patterns: medical records, dispensing/claims databases, and person-reported data. The availability of the different sources varies between countries and therapeutic areas. Registers including data on prescribed or dispensed drugs are valuable sources often used in pharmacoepidemiological studies.¹⁰ A population-based register including all prescribed drugs dispensed to the entire population is available in Sweden since 2005, providing opportunities for research in asthma drug utilization.^{11–13} Still, many drugs that are dispensed are not used. Data on actual use may be collected directly from a patient or parent, thus providing more precise information. Some studies, comparing parental-reported questionnaire data with register-based data on asthma drug use in children, have been performed,^{14–18} although not in Sweden. Caution needs to be taken when extrapolating methods and findings from register studies across countries due to differences in prescription and reimbursement regulations. Furthermore, prior studies have not assessed the optimal time window of exposure in the dispensing data or included any analysis of factors associated with the concordance between drug register data and parental-reported use.

The aim of this study was to investigate how exposure, measured through different time windows in register data on dispensed drugs, corresponded with parental-reported use of asthma drugs. A secondary aim was to identify patient characteristics associated with high concordance between the different data sources.

METHODS

Study population

This study included adolescents and families participating in the prospective birth cohort BAMSE (Children, Allergy, Milieu, Stockholm, Epidemiological Survey), which comprises 4089 adolescents born between 1994

and 1996, who have been followed through parental questionnaires completed when the children were around 0, 1, 2, 4, 8, and 12 years.

The parents completed the 12-year questionnaire (response rate 82%) in spring 2008 when the adolescents were between 11 and 14 years old (mean age 13.0 years).¹⁹ The questionnaire contained questions on an adolescent's health status, habits, use of medication, and family history of asthma: all parental-reported data was for the preceding 12 months.

Study design

This was a cross-sectional study, where dispensed asthma drugs and parental-reported drug use were compared for the same adolescents. The parental-reported drug use from BAMSE was linked to data on dispensed drugs from the Swedish Prescribed Drug Register (SPDR), using each adolescent's personal identity number (PIN).²⁰ The SPDR is held by the National Board of Health and Welfare and contains information about each adolescent (sex, age, and PIN) and the drugs dispensed (Anatomical Therapeutic Chemical [ATC]-codes, date of prescribing and dispensing, and number of packages and dosages). The register contains complete dispensing histories for all inhabitants in the country with PINs included for 99.7% of all prescriptions.

To compare register-based data on dispensed drugs with drug use reported in the questionnaires, different time windows for dispensed drugs were studied in the register (3, 6, 12, 18, and 24 months prior to the date of responding to the questionnaires). The different time windows in the register were adapted to the Swedish reimbursement regulations, with each issued prescription being valid for 1 year.

The asthma drugs included, classified according to the Anatomical Therapeutic Chemical (ATC 2013 WHO Oslo) Classification System,²¹ were the following:

Short-acting β_2 -agonists, SABA (ATC R03AC02 + R03AC03).

Inhaled corticosteroids, ICS (R03BA).

Fixed combinations of ICS and LABA, fixed comb. (R03AK).

Leukotriene receptor antagonists, LTRAs (R03DC).

Long-acting β_2 -agonists, LABA (R03AC12 + R03AC13).

Any asthma medication: At least one of SABA, LABA, ICS, fixed comb., or LTRAs.

Measures of asthma

In this study, asthma was defined as fulfilling at least two of the following three criteria at the time of the

12-year questionnaire: one episode of wheeze in the last 12 months, doctor's diagnosis of asthma at any time since birth, and asthma medicine occasionally or regularly in the last 12 months.^{22,23}

Severe asthma

At least 12 episodes of wheeze in the last 12 months at the time of the 12-year questionnaire and doctor's diagnosis of asthma at any time since birth.

Asthma medication

Any asthma drugs or drugs for wheeze in the last 12 months. The following question from the questionnaire was used: Has your child used any asthma drugs or drugs for wheeze in the last 12 months? If they answered yes, parents were asked to indicate which medicines their child had used. Asthma medicines were listed, broken down by class of medicines (SABA, ICS, fixed comb., LABA, LTRAs, and others), with a check box for each class. Pictures of the different medicines were provided to refresh the parents' memories in answering the question.

Statistical analyses

Using the questionnaire as a reference, the concordance between the SPDR and the questionnaire was studied, to determine the sensitivity, specificity, and positive predictive value of the register presented with 95% confidence intervals (CI). In addition, both the concordance between the parental-reported drug use and dispensed drugs and the concordance between adolescent-reported drug use and dispensed drugs were calculated. A one-sample *t*-test with a finite population correction was used to test if there was a difference in background factors between the original cohort and the study population.

McNemar's test was used to check if there was a difference in classifying drug use between the questionnaire and the register. A logistic regression model was used to analyse how the different characteristics of a patient affected concordance. These characteristics, potentially acting as confounders, were chosen based on knowledge from the literature and clinical experience. Patient characteristics included in the full model were sex, birth year (1994, 1995, and 1996), family history of allergic disease, university education of at least one parent, mother's age at birth < 25 years, adolescents living in more than one home, siblings using asthma medication, and having severe asthma. Crude odds ratios (OR) and OR adjusted for all these factors were calculated with a 95%CI.

The final study population consisted of 3316 adolescents (mean age 13.0 years) who participated in the 12-year questionnaire and for whom there were complete data on parental reports of asthma symptoms and drug use from the BAMSE-study Table 1. A subgroup fulfilling the definition of asthma ($n = 346$) was used when analyzing factors influencing the concordance between register-based data on dispensed drugs and parental-reported drug use. Only a trivial difference in birth year between the study population and the original cohort was seen for the background characteristics, and the groups were regarded as comparable. All statistical analyses were conducted using the statistical software STATA SE 12.1.

RESULTS

The parental-reported prevalence of asthma was 10.4% ($n = 346$) and the prevalence of severe asthma was 1.2% ($n = 38$). A total of 10.7 % ($n = 356$) of all adolescents were reported to use any asthma drugs, compared with 8.1% ($n = 269$) who were dispensed drugs during a 12-month period according to the register ($p \leq 0.001$), Table 2. SABA was reported to be used by 9.1% of the adolescents, compared with 6.3% dispensed ($p \leq 0.001$). For ICS, the reported proportion of adolescents was 5.1%, whereas the dispensed proportion was 3.1% ($p \leq 0.001$). The concordance between adolescent-reported drug use and dispensed drugs was slightly higher compared with the parental-reported drug use and dispensed drugs. However, the difference was not statistically significant.

Concordance between the register and questionnaire for different time windows

The sensitivity for the register was 0.65 (95%CI 0.60–0.70) at the 12-month time window, analyzing any of the asthma drugs studied. Sensitivity increased with an extended time window and was 0.76 when assessing dispensing histories 18 months prior to the questionnaire (Figure 1 and Table 3). The sensitivity was highest for fixed combinations (0.84) and lowest for LABA (0.52). Sensitivity for ICS was 0.61. The specificity was 0.99 (95%CI 0.98–0.99) at the 12-month time window, for any of the asthma drugs studied. Specificity decreased with an extended time window to 0.98 at the 18-month time window (Figure 2 and Table 3). The specificity was 1.0 for the fixed combinations, LABA and LTRAs and 0.78 for SABA (the lowest value). The positive predicted value (PPV) was 0.86 (95%CI 0.82–0.90) at the 12-month time window for the drug group including any asthma drugs. PPV

Table 1. Patient characteristics in the study population and the whole BAMSE cohort

Patient characteristics	The BAMSE cohort (<i>n</i> =4089) No. of adolescents (proportion)	The study population (<i>n</i> =3 316) No. of adolescents (proportion, CI)
Boys	2065 (0.51)	1680 (0.51, CI 0.49–0.52)
Year of birth	1994: 1484 (0.36) 1995: 1467 (0.34) 1996: 1138 (0.28)	1994: 1180 (0.36, CI 0.35–0.36) 1995: 1187 (0.36, CI 0.35–0.37) 1996: 949 (0.29, CI 0.28–0.29)
Mother's age at birth < 25 years	319 (0.08)	237 (0.07, CI 0.06–0.08)
At least one parent with higher education (university)	2161 (0.53)	1809 (0.55, CI 0.53–0.56)
Adolescents with more than one home	852 (0.26)	845 (0.26, CI 0.24–0.27)
Family history of allergic disease*	1200 (0.30)	1015 (0.31, CI 0.29–0.33)
Siblings used or using asthma drugs	299 (0.15)	230 (0.15, CI 0.13–0.16)
12 episodes of wheeze in the last 12 months	45 (0.01)	45 (0.01, CI 0.01–0.02)

*Mother and/or father with a doctor's diagnosis of asthma and asthma medication, and/or doctor's diagnosis of hay fever in combination with allergy to furred pets and/or pollen.

Table 2. The prevalence of asthma drugs reported from the 12-year questionnaire in the BAMSE cohort and dispensing information from the Swedish Prescribed Drug Register. A 12-month time window in the drug register is used (*n*=3316)

Anti-asthmatic drug groups	Parental-reported	Adolescent-reported	Dispensed	McNemar's significance probability (parent-dispensed)	McNemar's significance probability (adolescent-dispensed)
Any asthma medication*	356 (10.7%)	282 (10.3%)	269 (8.1%)	<0.001	<0.001
SABA	302 (9.1%)	231 (8.4%)	208 (6.3%)	<0.001	<0.001
ICS	168 (5.1%)	130 (4.3%)	103 (3.1%)	<0.001	<0.001
Fixed comb.	105 (3.2%)	85 (3.1%)	91 (2.7%)	0.039	0.176
LTRAs†	42 (1.3%)	35 (1.3%)	40 (1.2%)	0.815	1.0
LABA	28 (0.8%)	25 (0.9%)	16 (0.5%)	0.004	0.013

ICS, inhaled corticosteroids; LTRA, leukotriene receptor antagonists.

*Any of the drugs SABA, ICS, fixed combinations, LTRAs, or LABA.

†Leukotriene receptor antagonists.

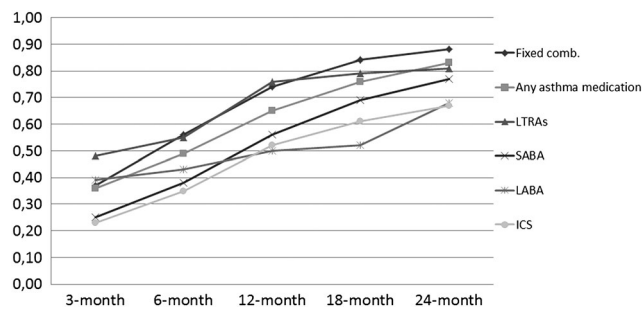


Figure 1. The sensitivity for the drug groups comparing the different time windows in the drug register with the use as reported in the questionnaire (*n*=3316)

decreased with an extended time window to 0.83 for the 18-month time window, and was highest for fixed combinations (0.84) and lowest for ICS (0.73).

Use of asthma medications among adolescents with asthma and factors associated with high concordance

Among the adolescents fulfilling the study definition of asthma (*n*=346) at the age of 12 years, 90% had parental-reported asthma drug use. However, 30% of the adolescents with asthma had not had any asthma

drugs dispensed in the preceding 18 months. A higher concordance between the register and the questionnaire was seen for adolescents with severe asthma (OR-crude 2.53, 95%CI 1.02–6.24) and for boys (OR-crude 1.91, 95%CI 1.20–3.04) (Table 4). A lower concordance was seen for adolescents living in more than one home (OR-crude 0.52, 95%CI 0.32–0.87) and for adolescents with young mothers (OR-crude 0.42, 95%CI 0.21–0.85). After adjustment for confounding factors, only severe asthma remained significantly associated with high concordance between the register and reported use (OR adjusted 4.42, 95%CI 1.16–16.78).

DISCUSSION

In this cross-sectional study of 3316 adolescents, we found that an 18-month window is preferable when using dispensing data to study the use of asthma drugs. However, 30% of the adolescents with reported drug use had not purchased any asthma drug during this period. The concordance between parental-reported use and dispensed drugs was higher for adolescents with severe asthma. For the primary asthma treatment ICS, concordance between the dispensing register and

CONCORDANCE BETWEEN USED AND DISPENSED ASTHMA DRUGS

Table 3. Comparison between the 12-year questionnaire and the Swedish Prescribed Drug Register on the use of asthma medication using a 3, 6, 12, 18 and 24-month time window ($n = 3\,316$)

SPDR	12-year questionnaire		ICS	Fixed comb.	LTRAs [†]	LABA
	Any asthma medication [*]	SABA				
3-month						
Sensitivity (95%CI)	0.36 (0.31–0.41)	0.25 (0.20–0.30)	0.23 (0.17–0.30)	0.37 (0.28–0.47)	0.48 (0.32–0.64)	0.39 (0.22–0.59)
Specificity (95%CI)	1.0 (0.99–1.0)	1.0 (0.99–1.0)	0.35 (0.28–0.43)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	1.0 (1.0–1*)
PPV (95%CI)	0.90 (0.84–0.94)	0.83 (0.74–0.90)	0.89 (0.79–0.96)	0.87 (0.73–0.95)	0.91 (0.71–0.99)	1.0 (0.72–1*)
6-month						
Sensitivity (95%CI)	0.49 (0.44–0.55)	0.38 (0.33–0.44)	0.35 (0.28–0.43)	0.56 (0.46–0.66)	0.55 (0.39–0.70)	0.43 (0.24–0.63)
Specificity (95%CI)	0.99 (0.99–1.0)	0.99 (0.99–1.0)	1.0 (1.0–1.0)	1.0 (1.01.0)	1.0 (1.0–1.0)	1.0 (1.0–1.0)
PPV (95%CI)	0.90 (0.85–0.94)	0.85 (0.77–0.90)	0.89 (0.79–0.96)	0.86 (0.75–0.93)	0.82 (0.63–0.94)	0.92 (0.64–1.0)
12-month						
Sensitivity (95%CI)	0.65 (0.60–0.70)	0.56 (0.50–0.61)	0.52 (0.44–0.60)	0.74 (0.65–0.82)	0.76 (0.61–0.88)	0.50 (0.31–0.69)
Specificity (95%CI)	0.99 (0.98–0.99)	0.99 (0.98–0.99)	0.99 (0.99–1.0)	1.0 (0.99–1.0)	1.0 (1.01.0)	1.0 (1.0–1.0)
PPV (95%CI)	0.86 (0.82–0.90)	0.81 (0.75–0.86)	0.84 (0.76–0.91)	0.86 (0.77–0.92)	0.8 (0.64–0.91)	0.88 (0.62–0.98)
18-month						
Sensitivity (95%CI)	0.76 (0.71–0.80)	0.69 (0.64–0.74)	0.61 (0.54–0.69)	0.84 (0.75–0.90)	0.79 (0.63–0.90)	0.52 (0.31–0.69)
Specificity (95%CI)	0.98 (0.98–0.99)	0.98 (0.98–0.99)	0.99 (0.98–0.99)	1.0 (0.99–1.0)	1.0 (0.99–1.0)	1.0 (1.0–1.0)
PPV (95%CI)	0.83 (0.79–0.87)	0.79 (0.74–0.84)	0.73 (0.65–0.80)	0.84 (0.76–0.90)	0.79 (0.63–0.90)	0.74 (0.49–0.91)
24-month						
Sensitivity (95%CI)	0.83 (0.78–0.86)	0.77 (0.72–0.81)	0.67 (0.60–0.74)	0.88 (0.80–0.93)	0.81 (0.66–0.91)	0.68 (0.48–0.84)
Specificity (95%CI)	0.97 (0.96–0.98)	0.97 (0.97–0.98)	0.98 (0.98–0.99)	0.99 (0.99–0.99)	1.0 (0.99–1.0)	1.0 (1.0–1.0)
PPV (95%CI)	0.76 (0.72–0.81)	0.73 (0.68–0.78)	0.66 (0.59–0.74)	0.70 (0.70–0.86)	0.72 (0.57–0.84)	0.61 (0.42–0.78)

SPDR, Swedish Prescribed Drug Register; ICS, inhaled corticosteroids; LTRA, leukotriene receptor antagonists; PPV, positive predicted value; comb, combination.

^{*}Any of the drugs SABA, ICS, fixed comb., LTRAs or LABA.

[†]Leukotriene receptor antagonists.

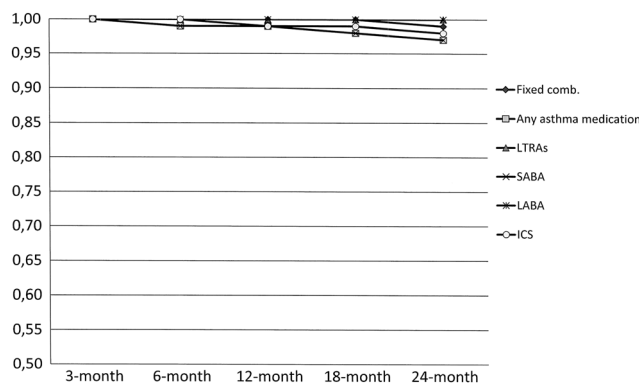


Figure 2. The specificity for the drug groups comparing the questionnaire with the different time windows in the drug register with the use as reported in the questionnaire ($n = 3\,316$)

parental-reported use was 61%. We also found that the 18-month time window in the register gave the best overall agreement with the questionnaires. Adolescents with severe asthma had a high concordance between the two data sources, after adjustment for possible associated factors.

Strengths and limitations

The present paper has several strengths. First of all, data has been gathered from a large population-based birth

cohort with good response rates, over 80% for the 12-year follow up, ensuring a high internal validity. Moreover, the SPDR is complete for the entire population of Sweden and includes all prescribed drugs dispensed in the country. The PINs used for all citizens in Sweden ensure a 100% match between the two sources. However, some limitations are worth mentioning. Parents may have underestimated or overestimated their adolescent's drug use; however, as shown by Danell et al., this is not the case for asthma drugs in our cohort.¹⁹ The SPDR uses only the PIN written on the dispensed prescription when assessing information about drug use. In the questionnaire, parents answered questions about their adolescent's drug use, also taking into account the possibility that asthma drugs are shared within a family.

Interpretation

Even though 90% of the adolescents with asthma had parental-reported drug use, 30% of these adolescents did not purchase any asthma drugs in the preceding 18 months. That is a rather high percentage, indicating that many adolescents do not have asthma medicines to cover their needs. Possible explanations could be sharing medicines with other family members, purchasing large amounts of medicines irregularly, or having mild asthma not requiring medication. However, siblings using asthma

Table 4. Patient characteristics associated with the concordance using the 18-month time window among adolescents with asthma (346).

Confounders	N	OR-Crude (95%CI)	OR adjusted* (95%CI)
Male sex	206	1.91 (1.20–3.04)	1.16 (0.58–2.32)
Birth year 1995 (ref 1994)	136	0.82 (0.48–1.42)	0.55 (0.24–1.26)
Birth year 1996 (ref 1994)	91	0.71 (0.39–1.29)	0.73 (0.29–1.82)
Family history of allergic disease	162	0.66 (0.41–1.04)	1.05 (0.53–2.07)
Higher education	174	1.45 (0.92–2.30)	1.16 (0.58–2.32)
Mother's age at birth < 25 years	35	0.42 (0.21–0.85)	0.11 (0.01–1.60)
Living in more than one home	93	0.52 (0.32–0.87)	0.47 (0.22–1.01)
Siblings using asthma medication	39	0.95 (0.45–2.00)	1.10 (0.49–2.47)
Severe asthma	38	2.53 (1.02–6.24)	4.42 (1.16–16.78)

CI, confidence interval; OR, odds ratio.

*OR adjusted for sex, birth year, family history of allergic disease, higher education, mother's age at birth < 25 years, adolescents living in more than one home, sibling using asthma medication, and adolescents having severe asthma.

The statistically significant values are in bold.

medications did not affect the concordance in our study. The adherence problem has also been emphasized by the World Health Organization.²⁴ In clinical practice, it is important to keep this potential poor adherence in mind.

When studying asthma medicines in drug registers, it is important to consider the irregularity of purchasing asthma drugs because of variation in the disease over time. It is also important to keep in mind that a prescribed drug is not the same as a dispensed drug, which in turn does not imply that the drug is actually used. It is of great importance to ensure that the adolescents (and their parents) are familiar with asthma medications and devices. The opportunity of using different time windows when studying drug use made it possible to choose the optimal time window in the dispensing register to study drug utilization in asthma patients. In our study, we noticed that a 12-month time window, as applied in other studies,^{14,15} was not enough when studying parental-reported asthma drug use in the preceding 12 months.

Comparison with other studies

The agreement between the drug register and parental-reported drug use was lower in this study than in other studies, with sensitivity ranging between 79 and 98%,^{14,15,17,25}; however, our study population is older than most of the others, which could explain the lower concordance. Parents of younger children are probably more involved in administration of drugs than parents of adolescents. In our study, birth year did not affect concordance. The study conducted by Furu et al. had the same definition of asthma drugs as our study, whereas the other studies used a somewhat different definition. This might also affect concordance. In our study, we decided to use parental-reported drug use as the golden standard, because we assumed that the

questionnaires might be closer to the truth than dispensed drugs at pharmacies. This is in contrast with other studies,^{14,15,17} which used the drug register as the reference, and this might also explain our lower sensitivity. The PPV in our study was higher compared with Furu et al. (0.83 and 0.67, respectively). This indicates that even though we had lower sensitivity, we can still consider parental-reported asthma drug use to be a good proxy for having asthma. Moreover, the prescribed drug register is very sensitive to time window length, which reinforced our choice of golden standard. If the drug register is used as the golden standard, sensitivity analyses should be carried out. Only the study by Furu et al. measured the robustness of the register used as the golden standard.

The higher concordance between the register and the questionnaires for adolescents with severe asthma was expected and in line with conventional asthma treatment. The consequences of under-treatment are greater for adolescents with severe asthma, which probably makes parents of such adolescents more knowledgeable about the adolescent's treatment. It may also be explained by more frequent purchasing of medicines to those with severe asthma. Further, boys had a higher concordance of asthma drugs than girls. Under-treatment of girls compared with boys was seen in a study of four-year-old children.²⁶ Living in more than one home was associated with lower concordance, which might be explained by adolescents having their medicines in the other home when needing them. In the present study, we did not identify the dispensing records for parents or siblings to the adolescents included in the BAMSE cohort. This could be carried out to further study medication use in these families, because it is likely that parental-reported drug use might reflect all asthma drug use in the household regardless of which name is on the medicine. A family history of allergic diseases or parent's higher education

did not affect concordance, but a lower concordance was seen for young mothers. In our study, maternal age may be a proxy for low socioeconomic status.

CONCLUSIONS

An 18-month window is preferable when using dispensing data from Swedish pharmacies to study use of asthma drugs. Still, many adolescents with reported drug use had not purchased any asthma drug in this period. The concordance between the parental-reported use and dispensed drugs is higher for adolescents with severe asthma.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

KEY POINTS

- There is a discrepancy between parental-reported use and dispensed asthma drugs in adolescents.
- The choice of time window of observation using register data on dispensed drugs influences sensitivity and PPV but does not affect specificity noticeably. In our study, an 18-month time window gave the best overall agreement with the questionnaires.
- One in three adolescents with parental-reported asthma did not purchase any asthma drugs in the preceding 18 months, indicating that many adolescents may not have asthma medicines to cover their needs.

ETHICS STATEMENT

This study was approved by the Ethics Committee of Karolinska Institutet, Stockholm, Sweden.

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AUTHOR CONTRIBUTIONS

All authors jointly designed the current study. E. D. and I. K. analysed the data. All authors participated in the interpretation of the findings. E. D. wrote the initial draft. All authors participated in critical revision of the manuscript, provided important intellectual input, and approved the final version.

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