Identifying and characterizing psoriasis and psoriatic arthritis patients in Ontario administrative data: a population-based study from 1991 to 2015

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Abstract

Objectives: We assessed the accuracy of case definition algorithms for psoriasis and psoriatic arthritis (PsA) in health administrative data, and used primary care electronic medical records to describe disease and treatment characteristics of these patients.

Methods:
We randomly sampled 30,424 adult Ontario residents from the Electronic Medical Record Primary Care database and identified 2,215 patients with any possible psoriatic disease-related terms in their electronic medical record. The relevant patient records were chart abstracted to confirm diagnoses of psoriasis or PsA.This validation set was then linked to health administrative data to assess the performance of different algorithms of physician billing diagnosis codes, hospitalization diagnosis codes and medications for psoriatic disease. We report the performance of selected case definition algorithms and describe the disease characteristics of the validation set.

Results: Our reference standard identified 1028 patients with psoriasis and 77 patients with PsA, for an overall prevalence of 3.4% for psoriasis and 0.3% for PsA. Most patients with PsA (66%) had a rheumatology-confirmed diagnosis, while only 30% of the psoriasis patients had dermatology-confirmed diagnosis. The use of systemic medications was much more common in PsA than psoriasis. All algorithms had excellent specificity (97-100%). The sensitivity and positive predictive value were moderate and varied between different algorithms (34-72%).

Conclusions: The accuracy of case definition algorithms for psoriasis and PsA varies widely. However, selected algorithms produced population prevalence estimates which were within the expected ranges, suggesting that they may be useful for future research purposes.

Psoriasis is an immune-mediated skin disease that tends to be a chronic disease with an unpredictable course(1). Psoriasis is associated with a significant impact on quality of life as well as comorbidities such as depression and cardiovascular diseases(2-4). In addition, up to a third of the patients with psoriasis develop an inflammatory arthritis termed Psoriatic Arthritis (PsA) which runs a course of a chronic, progressive disease that can lead to severe joint damage and disability (5).

Currently there is limited information about the population-level epidemiology, quality of care and disease outcomes of psoriasis and PsA in Canada. Canada's public health system provides universal coverage for hospital and physician services which allows secondary use of administrative health databases for research. Canadian administrative data have been used extensively in the past to investigate disease outcomes, co-morbidities and quality of care of several rheumatic conditions. However, it has not been used to specifically investigate psoriasis and PsA. While administrative data provide an efficient source of population-based data, the databases were designed for administrative purposes not for research(6). The accuracy of diagnostic coding can be an issue, particularly since there are few incentives for physicians to code well when only information regarding the services provided is audited(7). Therefore, it is important to establish methods to accurately identify patients with a particular medical condition in administrative data before these resources can be used for research.

We recently published a study about the prevalence and incidence of psoriatic disease in Ontario, Canada(8). As part of the same study we developed methods to identify patients with psoriasis and PsA in administrative data. In this manuscript, we report the accuracy of various diagnostic coding algorithms for psoriasis and PsA. Additionally, we describe the characteristics of patients with psoriasis and PsA from the primary care setting.

Methods

Study Design and databases

Ontario is the most populated province in Canada with over 13.4 million residents in 2018. All Ontarians are insured by a single payer, universal health insurance, the Ontario Health Insurance Plan (OHIP) that covers all hospital and physician services and procedures; however, outpatient prescription medications are funded only for patients aged 65 years or older and residents who have very high drug costs relative to their income. All health care encounters are recorded in administrative health care databases, which are linked using an encoded health insurance number that is unique to each Ontarian eligible to receive insured health services in the province.

The validation process was based on the initial identification of reference standard cases of psoriasis, PsA and non-psoriatic cases. Similar to previous validation studies of other case definitions for Ontario administrative data, we used the Electronic Medical Record Primary Care (EMRPC) database (also known as EMRALD), a primary care electronic medical record (EMR) database, for our reference standard (9-12). At the time of the study, EMRPC included electronic clinical data from over 350 primary care physicians across Ontario and over 400,000 patients who were anonymously linked with provincial administrative databases(12). Clinically relevant information in EMRPC includes all electronic data about primary care consultations including current and past medical history, laboratory and imaging test results, prescriptions and consultation letters from specialists and discharge summaries. We randomly sampled 30,424 adult Ontario

residents from EMRPC and identified 2,215 patients with any possible psoriatic disease-related terms in their EMR. The relevant patient records were chart abstracted to confirm diagnosis of psoriasis or PsA.The entire sample was then linked with the provincial administrative health databases using the unique health insurance number to identify the optimal combination of diagnostic billing codes and hospitalization data ("algorithms") that will identify true cases.

All analyses were performed at ICES (www.ices.on.ca) using linked, coded data sets. The study was approved by the Research Ethics Board at Sunnybrook Health Sciences Centre, Toronto, Canada.

Use of data in this project was authorized under section 45 of Ontario's *Personal Health Information Protection Act*, which does not require review by a Research Ethics Board.

Creation of validation set

We derived a validation data set that included true-positive (psoriasis and/or PsA patients) and true-negative (cases without psoriasis or PsA) reference standards from EMRPC. First, we obtained a random sample of 30,424 patients from EMRPC (15% of the sample population) that included individuals aged 20 years or older, had a valid health insurance number and whose EMR start date was at least 2 years prior to the study date. Within this random sample of 30,424 individuals we performed a targeted search for any possible psoriatic disease-related terms (listed in supplementary Table 1) in the EMRs. The search included structured fields (e.g. medical conditions list, family history, prescriptions) and free text entries (e.g. family physician visit notes, consultation summaries from specialists). A total of 2,215 patients with suspected psoriasis and PsA were identified.

We then performed a chart abstraction of these patients to determine whether they had psoriasis and/or PsA. We assumed that patients with no psoriasis-related terms in their EMR did not have psoriasis/PsA and these were classified as true negative cases without reviewing their charts. Using a standardized data abstraction tool, 2,215 patients had their entire medical record reviewed by one of three trained physicians who were blinded to the patients' diagnoses codes in the administrative data. Each patient was classified as "Definite", "Possible" or "Not" psoriasis and/or PsA based on the level of evidence in the medical chart using predefined criteria. The diagnosis of psoriasis relies on a typical clinical appearance, since widely validated classification criteria are unavailable(13). Since the majority of patients with psoriasis in Ontario are managed by their primary care physician, we accepted a clinical diagnosis by any physician as the gold standard for psoriasis. For PsA, we accepted a clinical diagnosis by a rheumatologist or an internal medicine specialist as the gold standard for PsA. The highest levels of evidence to support a PsA were: 1) diagnosis by a rheumatologist, or internal medicine specialist; or 2) a primary care physician-documented PsA diagnosis with supporting evidence (e.g. joint involvement, or treatment) but without a supporting specialist consultation note. When the diagnosis of PsA or psoriasis was unclear ("possible") or changed over time, the case was reviewed by a rheumatologist who is an expert in psoriatic disease (LE) to classify the patient. If the uncertainty regarding the diagnosis of psoriasis was not resolved at this point, the case was discussed with a dermatologist with an expertise in psoriasis (CFR). The decision was based on the level of evidence available in the EMR.

In addition, we obtained information from the medical records regarding the disease characteristics and use of medications. Inter-rater reliability was assessed by abstracting 10 charts by each of the

three abstractors. Kappa scores for inter-rater reliability for the diagnosis of psoriasis and PsA showed perfect agreement (100%).

Development of algorithms in administrative data

Once the reference standard of 2,215 patients were classified as having or not having psoriasis and/or PsA, we linked all 30,424 cases from EMRPC with the provincial administrative databases. Administrative data were obtained for these cases for the period April 1, 1991 to March 31, 2015. The aim was to identify the optimal combination of health care encounters ("algorithms") that would identify true cases considering the reference standard diagnosis as the gold standard.

We used the OHIP Claims History Database to identify physician billing diagnosis codes. OHIP is the provincial insurance plan covering all Ontarians(14). Physicians are reimbursed by submitting claims to OHIP for medical services provided. A diagnosis code is provided with each claim which represents the main reason for the visit. These diagnoses are coded using a modification of the International Classification of Diseases Version 9 (ICD-9)(15). This system includes a specific diagnosis code for psoriasis (696), however, there is no specific code for PsA. Therefore, we used a combination of codes for "other seronegative spondyloarthritis" (721) and psoriasis (696) to identify patients with PsA.

Hospital diagnoses for psoriasis and PsA were identified using the Canadian Institute for Health Information's Discharge Abstract Database (CIHI-DAD), which contains detailed information regarding treatments and procedures rendered during all acute hospital admissions. See supplementary Table 2-3 for a list of ICD and OHIP diagnosis codes and medication codes tested for the algorithm development.

We pre-specified a set of over 300 algorithms using combinations of psoriasis and PsA diagnosis codes on physician bills, primary and secondary hospital discharge diagnoses, prescription drug claims, and various time intervals between the health care services and whether the service was provided by a relevant specialist (rheumatologist/internal medicine for PsA, dermatologist for psoriasis). The algorithms were applied to all administrative data for the study period (1991 to 2015).

Statistical analysis

Descriptive statistics were used to characterize the patients who comprised our reference standard in EMRPC. We calculated the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for each algorithm. For the primary analysis we considered only patients who were classified as "definite" psoriasis or PsA after the chart abstraction as cases for the corresponding diseases. We performed a sensitivity analysis considering both classification to "definite" and "possible" as cases. We decided a priori to prefer algorithms yielding the highest combination of PPV and sensitivity. We reviewed the reasons for false positive and false negative cases using the optimal algorithms.

Results

A total of 2,215 patients with psoriatic disease related terms in the EMR were identified out of a random sample of 30,424 patients in EMRPC (15% of the sample population, Figure 1). Based on our reference standard definition, we identified 1,028 patients with definite psoriasis (401 with

possible psoriasis) and 77 patients with definite PsA (63 with possible PsA) which resulted in overall psoriasis and PsA prevalence of 3.38% and 0.25%, respectively. The sex distribution was almost equal between males and females (47.1% of the psoriasis and 46.7% of the PsA patients were males).

Characteristics of psoriatic disease patients in primary care

The disease characteristics of the patients based on EMR chart abstraction are shown in Table 1. Only 30% of the patients with psoriasis had a documented diagnosis by a dermatologist in the EMR. Fifteen percent of the patients with psoriasis were defined as having severe psoriasis, based on the use of systemic medications, phototherapy or description of severe or extensive skin psoriasis in the EMR. In the majority of the patients with PsA (66%) the diagnosis was documented by a rheumatologist. Most of the patients with available information about the nature of joint involvement had peripheral arthritis (94%) and 27% had axial involvement. Dactylitis and enthesitis were documented in 29% and 5%, respectively.

A total of 85.7% and 71.8% of the patients with PsA and psoriasis, respectively, were prescribed topical or systemic medications for their skin and/or joint disease (Table 2). However, while most of the patients with PsA were treated with systemic medications (58.4% non-biologic systemic and 28.5% biologic medications), only a small proportion of psoriasis patients were using systemic treatments or phototherapy (8.6% systemic non-biologic and 4.6% biologics, 6.2% phototherapy).

Performance of algorithms for psoriasis

The properties of selected psoriasis and PsA case definition algorithms are presented in Tables 3-4. For psoriasis, all algorithms had excellent specificity (96.7-100%), however, sensitivity was low to moderate and varied between the different algorithms (33.8-71.2%), depending on the number of psoriasis diagnosis codes obtained from physician billing claims. The algorithms also had a low to moderate PPV for identifying psoriasis (range 42.7-73.2%). The PPV improved with algorithms that required multiple physician billing codes for psoriasis, however, algorithms with psoriasis codes by dermatologists did not improve the PPV and led to reduction in sensitivity. Extending the duration of observation window for diagnosis codes improved the sensitivity. Sensitivity analysis that combined patients classified as “definite” and “possible” psoriasis as cases in the reference standard led to a slight improvement in the PPV (48.9-76.1%) while sensitivity was reduced (23.9-59.6%).

Performance of algorithms for PsA

Regarding PsA, similar to psoriasis the algorithms had excellent specificity (100%), however, the sensitivity was approximately 50% and the PPV was moderate ranging from 53.2 to 67.9%. The PPV improved with algorithms that included more PsA diagnosis codes particularly when assigned by rheumatologists. Algorithms that incorporated information about prescription of psoriasis-specific medications resulted in only minor increase in the sensitivity. A sensitivity analysis that included patients classified as “definite” or “possible” PsA as cases in the reference standard led to an improvement in the PPV (62.3-72.7%) and reduction in sensitivity (28.6-31.4%).

Discordance analysis

To further understand the potential causes for the discordance between selected optimal algorithms and the reference standard diagnosis, we reviewed the false positive and false negative cases. The optimal algorithm for psoriasis was “at least 1 hospitalization psoriasis code ever OR 3 physician diagnosis codes (claims) for psoriasis by any physician”, which had a sensitivity of 40.6%, PPV

71% and specificity of 99.4%. Using this algorithm there were 609 patients that were classified as false negative (the administrative data algorithm failed to identify as psoriasis) and 170 patients that were misclassified as false positive cases (the administrative data algorithm mistakenly identified as psoriasis). Among those who were classified as false negative, 80% of the patients have never seen a dermatologist and were solely managed by their family physician, 65% of them were not prescribed any psoriasis treatment, therefore, these were largely patients with mild or inactive psoriasis. The majority of the false positive psoriasis patients (85%) were patients whose administrative data diagnosis code predated the EMR data which indicates patients with a remote history of psoriasis that was inactive in recent years.

The optimal algorithm for PsA was "1 hospitalization PsA code ever OR 3 physician diagnosis codes for seronegative spondyloarthritis at least 1 by a rheumatologist and 1 physician code for psoriasis". This algorithm had a sensitivity of 48.1%, PPV 67.3% and specificity of 99.9%. The use of this administrative data algorithm failed to identify 40 patients (false negative) and wrongly identified 19 patients as PsA (false positive). Of those who were identified as false negative, 23% of the patients did not have a definite diagnosis of psoriasis (no history or possible psoriasis), therefore, they were not identified, as the algorithm required a psoriasis diagnosis code. A total of 45% had no consultation notes from rheumatologists in the EMR and 58% were not using any medications for PsA, therefore, it is likely that these patients had mild PsA. Regarding the patients classified as false positive PsA, 26% were classified as possible PsA based on EMR data, in 30% the diagnosis of PsA was ruled out or they had other rheumatologic conditions (miscoding by the rheumatologist). In 14% there was no mention of PsA in EMR or the diagnosis code claims predated EMR data.

Discussion

Population-based information about the epidemiology and health care utilization of psoriatic disease in North America is limited. Administrative data can be used to improve these gaps in knowledge, however the accuracy of tools used to identify patients needs to be validated. In this study, we described the validation process and identified the optimal algorithms for identifying patients with psoriasis and PsA in Ontario administrative health data. Additionally we described the disease characteristics, access to specialists and medication use in a primary-care setting.

The study showed that the optimal algorithms for psoriasis and PsA had excellent specificity with adequate PPV and modest sensitivity. The PPV for both psoriasis and PsA of the tested algorithms was lower than that reported in other validation studies in administrative data(16-19). This is likely attributed to different study samples (reference standards) which affected the disease prevalence and severity as well as the type of comparator groups. These factors have significant impact on the performance of the algorithms tested. In general, sampling from specialty clinics results in falsely elevated PPVs due to high prevalence of case patients. A common alternative approach for validation includes sampling patients by the presence or absence of diagnosis codes in administrative data and confirmation of the diagnosis disease status by chart review(16, 17). However, while this approach provides metrics such as PPV and NPV, unbiased estimates of performance of the algorithm cannot be generated since the prevalence of the disease remains unknown. Our study used a random sample of two diseases with low prevalence in the primary care setting. This provided relatively unbiased assessment of the accuracy of the algorithms to

detect psoriasis and PsA and partially explains the lower sensitivity and PPV compared to previous validation studies.

The algorithm properties can also be discussed in the context of common clinical practice of psoriatic disease in Ontario. The chart abstraction revealed that the majority of the patients with psoriasis in Ontario are solely managed by their family physicians. Since physicians are required to enter only a single diagnosis code per visit, it is likely that family physicians enter diagnostic codes for other concomitant co-morbidities when visits involve several health issues. This practice explains the relatively low sensitivity of the psoriasis algorithms and the lack of significant improvement in PPV in algorithms requiring administration of psoriasis code by a dermatologist. The addition of psoriasis-specific medications to the algorithms was tested, however, since the administrative database includes prescription drug claims for a subset of the population, this information did not significantly improve the properties of the algorithms. By an extension of the duration of the observation period for assigning >1 diagnosis code of psoriasis to "ever" rather than shorter time periods, we allow patients with lower rate of healthcare encounters related to psoriasis to meet the criteria for inclusion in the cohort. This is expected to include more patients with milder psoriasis who tend to be followed less regularly.

Identification of PsA was further complicated by lack of a specific OHIP diagnosis code for PsA. Consequently we used a combination of diagnosis codes for psoriasis and seronegative spondyloarthritis. Most PsA patients were managed by rheumatologists, and diagnostic codes for spondyloarthritis were rarely assigned by non-rheumatologists, which likely increased the accuracy of the diagnosis. However, the requirement for a psoriasis diagnostic code in addition to a spondyloarthritis code explains the lower sensitivity, since many of the patients with PsA had mild psoriasis which may have not required medical attention and therefore did not result in a claims-based diagnosis. When we changed our definition of PsA based on the level of evidence in EMR to a more liberal definition of PsA, such as allowing those with possible PsA diagnosis, the PPV increased, but the sensitivity was lower. Overall, the estimated population prevalence of psoriasis and PsA, as indicated by both the proportion of the reference standard and the number of patients identified with the condition using our optimal algorithms were well within the expected range for the prevalence of psoriasis and PsA in the general population(20-22).

The study also provided information about the pattern of psoriatic disease and use of systemic medications in the primary care setting. The proportion of patients with PsA among psoriasis patients was 7% which is lower than the reported prevalence typically found in a dermatology setting (20-30%)(5, 23). This estimate is close to the reported prevalence in a previous population based study and may be attributed to milder psoriasis which is associated with lower risk of PsA but also potentially to under-diagnosis of PsA(24). Only 7.6% of the patients with psoriasis ever used systemic medications, many were using these medications for their PsA. It is not possible to determine the precise proportion of patients with active moderate to severe psoriasis using EMR data, however, according to a 2014 study, 55% of patients with moderate-to-severe psoriasis are not being treated to the established standards of care(25). The low access of patients to specialty care and low usage of systemic medications highlight potential gaps in the care of psoriasis patients in Ontario. In contrast, the majority of the patients with PsA in our reference standard set were seen by a rheumatologist and a significant proportion of them were using systemic non-biologic (58.4%) and biologic medications (28.5%).

The study had several limitations. The case definition was based on chart abstraction and relied on the clinical diagnosis of the assessing physician. The diagnosis of psoriasis primarily relies on

clinical assessment. In the absence of a diagnostic test, ambiguous cases may have been misclassified as psoriasis by less experienced clinicians. Misclassification is also a potential risk when documentation is missing in the EMR (e.g. lack of consultation notes from specialists). Strengths of the study include the randomly selected reference standard population and the rigorous case ascertainment. We also report the accuracy of multiple administrative data algorithms, which allows researchers to select an algorithm based upon the characteristics of the intended study population and study aims.

In summary, our study showed that administrative data algorithms can identify patients with psoriasis and PsA who receive regular primary care with an adequate accuracy. These algorithms are less effective in capturing patients who do not have access to rheumatology and dermatology specialty care, possibly due to milder disease. These results will inform future population based studies using Ontario administrative data which will fill in the gaps in knowledge about the epidemiology of psoriatic disease.

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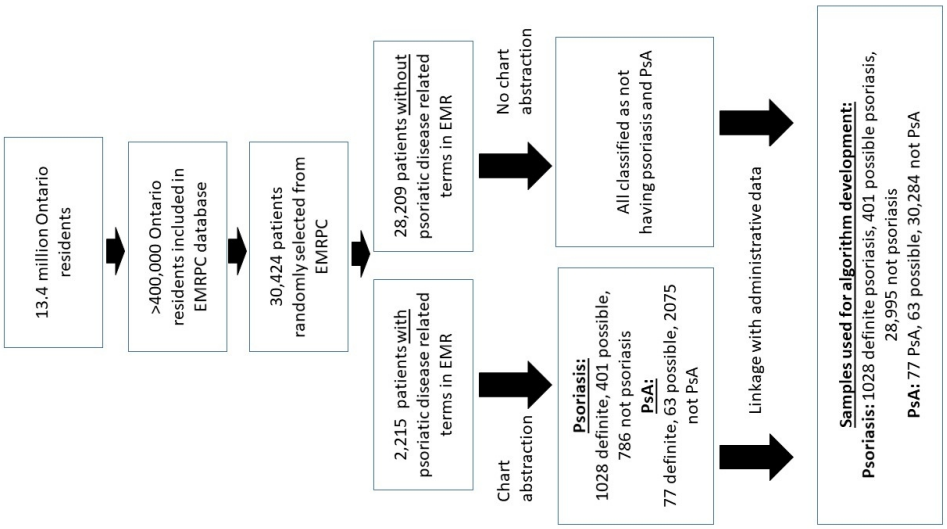

Figure 1 - Selection of the study population

108x60mm (300 x 300 DPI)

Table 1 – characteristics of the patients with psoriasis and PsA in EMRPC (Definite cases)		
	PsA (N=77)	**Psoriasis (N=1028)**
Sex: Male	36 (46.7%)	484 (47.1%)
Physician documenting the diagnosis		
- Family physician	72 (93.5%)	959 (93.2%)
- Rheumatologist	51 (66.2%)	104 (10.1%)
- Dermatologist	10 (12.9%)	307 (29.9%)
- Other specialist	38 (49.3%)	241 (23.4%)
Body part affected by psoriasis*		
- Scalp	29 (48.3%)	344 (43%)
- Groin	11 (18.3%)	97 (12.1%)
- Axilla	<6**	16 (2%)
- Nails	20 (33.3%)	75 (9.4%)
- Palmo-plantar	<6**	69 (8.6%)
- Other	49 (81.6%)	538 (67.3%)
- Not documented	17	228
Pustular psoriasis*	< 6**	24 (2.3%)
Severe psoriasis	25 (32.4%)	151 (14.7%)
- Systemic medications	17 (22%)	71 (6.9%)
- Phototherapy	8 (10.3%)	63 (6.1%)
- Description in EMR	14 (18.2%)	78 (7.6%)
Distribution of PsA**		
- Peripheral joints	61/64 (95.3%)	
- Axial joints	16/60 (26.7%)	
- Dactylitis	14/49 (28.6%)	
Psoriasis		
- Definite	68 (88.3%)	
- Possible/no psoriasis	9 (11.7%)	
PsA		
- Definite		68 (6.6%)
- Possible		37 (3.6%)
- No PsA		923 (89.8%)
*The denominator includes only patients with complete data **Suppressed to protect patient privacy		

Table 2 – Treatments used by the reference standard cases for psoriasis and PsA (only definite cases included)		
	PsA (N=77)	**Psoriasis (N=1028)**
Use of any medication for psoriasis or PsA	66 (85.7%)	739 (71.8%)
Phototherapy	8 (10%)	64 (6.2%)
Topical medications - Dovobet - Dovonex - Tar-based - Other	47 (61%) 16 (20.8%) 26 (33.7%) <6** 32 (41.6%)	705 (68.5%) 139 (13.5%) 285 (27.7%) 10 (0.9%) 93 (9%) 526 (51.2%)
Non-biologic systemic medications - Methotrexate - Leflunomide - Cyslosporine - Acitretin - Apremilast - Sulfasalazine -	45 (58.4%) 36 (46.8%) 8 (10.3%) 0 (0%) <6** 0 (0%) 13 (16.9%)	88 (8.6%) 61 (5.9%) 8 (0.6%) <6** 17 (1.7%) <6** 13 (1.3%)
Systemic Biologic medications - Adalimumab - Infliximab - Golimumab - Etanercept - Certolizumab - Secukinumab - Ustekinumab - Efalizumab	22 (28.5%) 9 (11.6%) <6** 6 (7.8%) 11 (14.3%) 0 (0%) 0 (0%) <6** 0 (0%)	47 (4.6%) 17 (1.7%) <6** <6** 18 (1.8%) 0 (0%) <6** 9 (0.9%) <6**
**Suppressed to protect patient privacy		

Table 3 – The accuracy of selected psoriasis case definition algorithms

Algorithm	Definite psoriasis* (N=1,028)				Definite and possible psoriasis* (N=1,429)				Prevalence (per 100 population)
	Sensitivity (95% CI), %	Specificity (95% CI), %	PPV (95% CI), %	NPV (95% CI), %	Sensitivity (95% CI), %	Specificity (95% CI), %	PPV (95% CI), %	NPV (95% CI), %	
1 H or 1 P ever	70.9 (68.2, 73.3)	96.7 (96.5, 96.9)	42.7 (40.4, 45.1)	99 (98.8, 99.1)	58.5 (56, 61)	97.0 (96.8, 97.2)	48.9 (47,51)	97.9 (97.8, 98.1)	5.61%
1 H or 1 P ever by a dermatologist	50 (46.9, 53)	98.1 (97.9, 98.2)	47.8 (44.8, 50.8)	98.2 (98.1, 98.4)	39.5 (37, 42.1)	98.2 (98.1, 98.4)	52.5 (49.5, 55.5)	97 (96.9, 97.2)	3.54%
1 H or 2 P ever	51.9 (48.8, 54.9)	98.9 (98.7, 99)	61.5 (58.3, 64.8)	98.3 (98.2, 98.5)	40 (37.5, 42.6)	99 (98.9, 99.1)	65.9 (62.7, 69.1)	97.1 (96.9, 97.3)	2.85%
1 H or 2 P ever at least 1 by a dermatologist	43.1 (40.1, 46.2)	99.1 (99, 99.2)	63.1 (59.5, 66.6)	98 (97.9, 98.2)	33 (30.5, 35.4)	99.2 (99.1, 99.3)	66.9 (63.4, 70.4)	97.1 (96.9, 97.2)	2.31%
1 H or 2 P in 1 years	44 (41, 47.1)	99.1 (99, 99.2)	63.1 (59.6, 66.6)	98.1 (97.9, 98.2)	33.8 (31.3, 36.3)	99.2 (99.1, 99.3)	67.3 (63.8, 70.7)	96.8 (96.6, 97)	2.36%
1 H or 2 P in 2 years	46.6 (43.5, 49.6)	99 (98.9, 99.2)	62.9 (59.5, 66.4)	98.1 (98, 98.3)	35.7 (32.2, 38.2)	99.1 (99, 99.2)	67 (63.7, 70.4)	96.9 (96.7, 97.1)	2.50%
1 H or 2 P in 3 years	47.6 (44.6, 50.7)	99 (98.9, 99.1)	62.5 (59.1, 65.9)	98.2 (98, 98.3)	36.6 (34.1, 39.1)	99.1 (99, 99.2)	66.7 (63.4, 70)	96.9 (96.7, 97.1)	2.58%
1 H or 3 P ever	40.6 (37.6, 43.6)	99.4 (99.3, 99.5)	71 (67.3, 74.6)	98 (97.8, 98.1)	30.8 (28.4, 33.2)	99.5 (99.4, 99.6)	74.7 (71.2, 78.2)	96.7 (96.5, 96.9)	1.94%
1 H or 3 P ever at least 1 by a dermatologist	36.4 (33.4, 39.3)	99.5 (99.5, 99.6)	73.2 (69.3, 77)	97.8 (97.6, 98)	27.2 (24.9, 29.5)	99.6 (99.5, 99.7)	76.1 (72.4, 79.8)	96.5 (96.3, 96.7)	1.68%
1 H or 3 P in 2 years	31.8 (28.9, 34.6)	99.6 (99.5, 99.6)	71.6 (67.4, 75.7)	97.7 (97.5, 97.8)	23.9 (21.7, 26.1)	99.6 (99.5, 99.7)	74.6 (70.6, 78.6)	96.4 (96.2, 96.6)	1.50%
1 H or 3 P in 3 years	33.8 (30.9, 36.7)	99.5 (99.4, 99.6)	71.2 (67.2, 75.2)	97.7 (97.6, 97.9)	25.4 (23.1, 27.7)	99.6 (99.5, 99.7)	74.2 (70.4, 78.1)	96.4 (96.2, 96.6)	1.61%
1 H or 1 P ever or 1 prescription of anti-psoriatic treatment	72.1 (69.4, 74.8)	96.6 (96.3, 96.8)	42.3 (40, 44.6)	99 (98.9, 99.1)	59.6 (57, 62.1)	96.9 (96.7, 97.1)	48.5 (46.2, 50.8)	98 (97.8, 98.1)	5.77%
1 H or 2 P ever or 1 prescription of anti-psoriatic treatment	55.1 (52.1, 58.1)	98.7 (98.6, 98.8)	59.6 (56.4, 62.7)	98.4 (98.3, 98.6)	42.7 (40.1, 45.3)	98.8 (98.7, 98.9)	64.1 (61, 67.1)	97.2 (97. 97.4)	3.13%

Table 4 – The accuracy of selected PsA case definition algorithms

Algorithm	Definite PsA* (N=77)				Definite and possible PsA* (N=140)				Prevalence (per 100 population)
	Sensitivity (95% CI), %	Specificity (95% CI), %	PPV (95% CI), %	NPV (95% CI), %	Sensitivity (95% CI), %	Specificity (95% CI), %	PPV (95% CI), %	NPV (95% CI), %	
1 H or (1 P(Ps) and 1 P(SpA)) ever	53.2 (42.1, 64.4)	99.9 (99.8, 100)	53.2 (42.1, 64.4)	99.9 (99.8, 100)	34.3 (26.4, 42.1)	99.9 (99.9, 100)	62.3 (51.5, 73.2)	99.7 (99.6, 99.8)	0.25%
1 H or (1 P(Ps) and 2 P(SpA)) ever	50.6 (39.5, 61.8)	99.9 (99.9, 100)	63.9 (51.9, 76)	99.9 (99.8, 99.9)	30.7 (23.1, 38.4)	99.9 (99.9, 100)	70.5 (59, 81.9)	99.7 (99.6, 99.7)	0.20%
1 H or (1 P(Ps) and 2 P(SpA)) ever at least 1 by a specialist	50.6 (39.5, 61.8)	99.9 (99.9, 100)	65 (52.9, 77.1)	99.9 (99.8-99.9)	30.7 (23.1, 38.4)	99.9 (99.9-100)	71.7 (60.3, 83.1)	99.7 (99.6, 99.7)	0.20%
1 H or (1 P(Ps) and 3 P(SpA)) ever	48.1 (36.9, 59.2)	99.9 (99.9, 100)	66.1 (53.7, 78.5)	99.9 (99.8, 99.9)	28.6 (21.1, 36.1)	99.9 (99.9, 100)	71.4 (59.6, 83.3)	99.7 (99.6, 99.7)	0.18%
1 H or (1 P(Ps) and 3 P(SpA)) ever at least 1 by a specialist	48.1 (36.9, 59.2)	99.9 (99.9, 100)	67.3 (54.9, 79.7)	99.9 (99.8, 99.9)	28.6 (21.1, 36.1)	100 (99.9, 100)	72.7 (61, 84.5)	99.7 (99.6, 99.7)	0.18%
1 H or ((1 P(Ps) ever or 1 prescription of topical anti-psoriatic treatment) and 2 P(SpA) ever)	51.9 (40.8, 63.1)	99.9 (99.9, 100)	64.5 (52.6, 76.4)	99.9 (99.8, 99.9)	31.4 (23.7, 39.1)	99.9 (99.9, 100)	71 (59.7, 82.3)	99.7 (99.6, 99.7)	0.20%
1 H or ((1 P(Ps) ever or 1 prescription of topical anti-psoriatic treatment) and 2 P(SpA) ever at least 1 by a specialist)	51.9 (40.8, 63.1)	99.9 (99.9, 100)	65.6 (53.7, 77.5)	99.9 (99.8, 99.9)	31.4 (23.7, 39.1)	99.9 (99.9, 100)	72.1 (60.9, 83.4)	99.7 (99.6, 99.7)	0.20%
1 H or ((1 P(Ps) ever or 1 prescription of topical anti-psoriatic treatment) and 3 P(SpA) ever at least 1 by a specialist)	49.4 (38.2, 60.5)	99.9 (99.9, 100.0)	67.9 (55.6, 80.1)	99.9 (99.8, 99.9)	29.3 (21.7, 36.8)	100 (99.9, 100)	73.2 (61.6, 84.8)	99.7 (99.6, 99.7)	0.18%

H: Hospitalization PsA code; P(Ps)=physician psoriasis diagnostic code; P(SpA)=physician spondyloarthritis diagnostic code; Specialist = rheumatologist; topical anti-psoriatic treatment=tar, retinoids or vitamin D derivate