Supplementary material

Accuracy of diagnostic codes and algorithms used to identify rheumatoid arthritis and juvenile idiopathic arthritis in electronic health records: systematic review and meta-analysis

Supplementary Appendix 1. Search Terms

Population	Rheumatoid Arthritis terms	"Arthritis, Rheumatoid" [Mesh] OR "Arthritis, Juvenile" [Mesh] OR "Felty Syndrome" [Mesh] OR "Caplan Syndrome" [Mesh] OR (("Arthritis, Rheumatoid"[Mesh]) AND "Lung Diseases, Interstitial"[Mesh]) OR "Rheumatoid Arthritis" [Text word] OR "Rheumatoid Vasculitis" [Text word] OR "Rheumatoid Nodule" [Text word] OR "Rheumatoid Nodules" [Text word] OR "Juvenile Idiopathic Arthritis" [Title/Abstract: ~3] OR "Juvenile Chronic Arthritis" [Title/Abstract: ~3] OR "Juvenile Rheumatoid Arthritis" [Title/Abstract: ~3] OR "Felty Syndrome" [Text word] OR "Caplan Syndrome" [Text word] OR (("Rheumatoid Arthritis") AND ("Interstitial Lung Disease")) OR "RA-ILD" [Text word] OR "(rheumat* AND arthritis)"
Data source	Database terms	"Database" [Publication type] AND "Databases, Factual" [Mesh] OR "Database Management Systems" [Mesh] OR "Medical Records Systems, Computerized" [Mesh] OR "Electronic Health Records" [Mesh] OR "Medical Record Linkage" [Mesh] OR "Administrative Claims, Healthcare" [Mesh] OR "Hospital Records" [Mesh] OR "Patient Discharge" [Mesh] OR "Electronic Data Processing" [Mesh] OR "Automatic Data Processing" [Text word] [Title/Abstract: ~3] OR "Insurance database" [Text word] [Title/Abstract: ~2] OR "Record linkage" [Text word] [Title/Abstract: ~2] OR "Data Warehouse" [Text word] [Title/Abstract: ~2] OR "Registered Person Database" [Text word] [Title/Abstract: ~3] OR "Electronic Medical Records" [Text word] [Title/Abstract: ~3] OR ("Billing" AND ("Data" OR "Claims" OR "Codes")) [Title/Abstract: ~3] OR ("Claims" AND ("Administrative" OR "Data*")) [Title/Abstract: ~3] OR (("Administrative" OR "Healthcare") AND ("Data*" OR "Records") OR "Administrative Data*" [Text word] OR "Administration Database" [Text word] OR "Physician claims" [Text word] OR "Hospital Billing" [Text word]

Index classification	Definition/Algorithm terms	"Algorithm*" [Mesh] OR "Current Procedural Terminology" [Mesh] OR "International Classification of Diseases" [Mesh] OR "Diagnostic Algorithm*" [Text word] OR "Classification Algorithm*" [Text word] OR "Claim Based Algorithm*" [Text word] OR "Diagnostic codes" [Text word] OR "Diagnostic Definition*" [Text word] OR "ICD codes" [Text word] OR "ICD" [Text word] OR "ACR Criteria" [Text word]
Outcome measures	Validation/Accuracy terms	"Validation Study" [Publication type] AND "Sensitivity and Specificity" [Mesh] OR "Predictive Value of Tests" [Mesh] OR "Reproducibility of Results" [Mesh] OR "Data Accuracy" [Mesh] OR "ROC Curve" [Mesh] OR "Receiver Operating Characteristic Curve" [Title/Abstract: ~4] "Predictive value" [Text word] OR "Diagnostic Accuracy" [Title/Abstract: ~3] OR "Positive Predictive Value" [Title/Abstract: ~3] OR "Negative Predictive Value" [Title/Abstract: ~3] OR "Accuracy" [Text word] OR "Sensitivity" [Text word] OR "Specificity" [Text word] OR "Validity" [Text word] OR "Validation Process" [Text word] OR "Case Ascertainment" [Text word] OR "Diagnostic performance" [Text word]

Supplementary Appendix 2. Search strategy and validation process

In an attempt to validate our search strategy, we conducted a first search in MEDLINE to determine if we could retrieve all the articles included in the previous systematic review, combining the terms related with administrative databases, definitions/algorithms and validation/accuracy measures with an AND. As we did not identify all relevant studies, we combined the administrative databases and definitions/algorithms terms with an OR to build a more sensitive search. With this search strategy we were able to retrieve all relevant articles, with the exception of those studies that did not answer our PICO question directly, i.e. whose main objective was different from validating an algorithm for identifying rheumatoid arthritis

in EHRs (e.g. studies that evaluate risk or incidence rates as their main objective). We reviewed these studies (those that could be accessed in full-text) to identify terms that would allow us to retrieve them in a new search. The terms identified included 'confirm*', 'verified' 'verification' 'identified', 'valid*' and 'definite diagnosis' which were incorporated to the validation/accuracy measures search strategy. We repeated the first process retrieving all relevant studies but without identifying those indirect studies, which was to be expected as these articles do not answer our focused PICO question. We therefore opted to maintain the initial search strategy, combining the administrative databases and definitions/algorithms terms with an OR (the most sensitive search strategy).

MEDLINE Search 11h November 2024

	Combined terms	Outputs
#1	"algorithm*"[MeSH Terms] OR "Current Procedural Terminology"[MeSH Terms] OR "International Classification of Diseases"[MeSH Terms] OR "diagnostic algorithm*"[Text Word] OR "classification algorithm*"[Text Word] OR "claim based algorithm*"[Text Word] OR "Diagnostic codes"[Text Word] OR "diagnostic definition*"[Text Word] OR "ICD codes"[Text Word] OR "ICD"[Text Word] OR "ACR Criteria"[Text Word]	549,088
#2	"databases, factual"[MeSH Terms] OR "Database Management Systems"[MeSH Terms] OR "medical records systems, computerized"[MeSH Terms] OR "Electronic Health Records"[MeSH Terms] OR "Medical Record Linkage"[MeSH Terms] OR "administrative claims, healthcare"[MeSH Terms] OR "Hospital Records"[MeSH Terms] OR "Patient Discharge"[MeSH Terms] OR "Electronic Data Processing"[MeSH Terms] OR "Automatic Data Processing"[Text Word] OR "Insurance database"[Text Word] OR "Record linkage"[Text Word] OR "Data Warehouse"[Text Word] OR "Registered Person Database"[Title/Abstract:~3] OR "Electronic Medical Records"[Text Word] OR ("Billing"[All Fields] AND ("Data"[All Fields] OR "Claims"[All Fields] OR "Codes"[All Fields])) OR ("Claims"[All Fields] AND ("Administrative"[All Fields] OR "data*"[All Fields])) OR (("Administrative"[All Fields] OR "Healthcare"[All Fields]) AND ("data*"[All Fields] OR "Records"[All Fields])) OR "administrative data*"[Text Word] OR "Administration Database"[Text Word] OR "Physician claims"[Text Word] OR "Hospital Billing"[Text Word]	706,807
#3	("Validation Study"[Publication Type] AND "Sensitivity and Specificity"[MeSH Terms]) OR "Predictive Value of Tests"[MeSH Terms] OR "Reproducibility of Results"[MeSH Terms] OR "Data Accuracy"[MeSH Terms] OR "ROC Curve"[MeSH Terms] OR "Receiver Operating Characteristic	3,169,224

	Curve"[Title/Abstract:~4] OR "Predictive value"[Text Word] OR "Diagnostic Accuracy"[Title/Abstract:~3] OR "Positive Predictive Value"[Title/Abstract:~3] OR "Negative Predictive Value"[Title/Abstract:~3] OR "Accuracy"[Text Word] OR "Sensitivity"[Text Word] OR "Specificity"[Text Word] OR "Validity"[Text Word] OR "Validation Process"[Text Word] OR "Case Ascertainment"[Text Word] OR "Diagnostic performance"[Text Word]	
#4	(#1 OR #2) AND #3	251,729
#5	"Comment"[Publication Type] OR "Case Reports"[Publication Type] OR "Editorial"[Publication Type] OR "Literature Review"[All Fields]	4,072,939
#6	#4 NOT #5	248,230
#7	"Arthritis, Rheumatoid" [Mesh] OR "Arthritis, Juvenile" [Mesh] OR "Felty Syndrome" [Mesh] OR "Caplan Syndrome" [Mesh] OR (("Arthritis, Rheumatoid"[Mesh]) AND "Lung Diseases, Interstitial"[Mesh]) OR "Rheumatoid Arthritis" [Text word] OR "Rheumatoid Vasculitis" [Text word] OR "Rheumatoid Nodule" [Text word] OR "Rheumatoid Nodules" [Text word] OR "Juvenile Idiopathic Arthritis" [Title/Abstract: ~3] OR "Juvenile Chronic Arthritis" [Title/Abstract: ~3] OR "Juvenile Rheumatoid Arthritis" [Title/Abstract: ~3] OR "Felty Syndrome" [Text word] OR "Caplan Syndrome" [Text word] OR (("Rheumatoid Arthritis") AND ("Interstitial Lung Disease")) OR "RA-ILD" [Text word] OR "(rheumat* AND arthritis)"	184,236
#8	#6 AND #7	1,030

CENTRAL Search 11th November 2024

ID	Search Hits	Outputs
#1	[mh "algorithm"]	8223
#2	[mh "algorithms"]	8223
#3	[mh "Current Procedural Terminology"]	5
#4	[mh "International Classification of Diseases"]	117
#5	diagnostic NEXT algorithm*:ti,ab,kw	228
#6	classification NEXT algorithm*: ti,ab,kw	185
#7	claim NEXT based NEXT algorithm*:ti,ab,kw	4
#8	"Diagnostic codes":ti,ab,kw	90
#9	Diagnostic NEXT Definition*:ti,ab,kw	11
#10	"ICD codes":ti,ab,kw	66
#11	"ICD":ti,ab,kw	6328
#12	"ACR Criteria":ti,ab,kw	1271
#13	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12	16165

#14	[mh "databases, factual"]	1411
#15	[mh "Database Management Systems"]	34
#16	[mh "medical records systems, computerized"]	1218
#17	[mh "Electronic Health Records"]	898
#18	[mh "Medical Record Linkage"]	40
#19	[mh "administrative claims, healthcare"]	13
#20	[mh "Hospital Records"]	18
#21	[mh "Patient Discharge"]	2767
#22	[mh "Electronic Data Processing"]	136
#23	"Automatic Data Processing":ti,ab,kw	3
#24	"Insurance database":ti,ab,kw	88
#25	"Record linkage":ti,ab,kw	161
#26	"Data Warehouse":ti,ab,kw	170
#27	"Registered Person Database":ti,ab,kw	0
#28	"Electronic Medical Records":ti,ab,kw	1154
#29	(("Billing") AND ("data" OR "claims" OR "codes")):ti,ab,kw	329
#30	(("Claims") AND ("Administrative" OR "Data")):ti,ab,kw	1804
#31	Administrative NEXT data*:ti,ab,kw	1010
#32	"Administration Database":ti,ab,kw	10
#33	"Physician claims":ti,ab,kw	12
#34	"Hospital Billing":ti,ab,kw	63
#35	("Claims" AND ("Administrative" OR "data")):ti,ab,kw	1804
#36	(("Administrative" OR "Healthcare") AND ("Data" OR "Records")):ti,ab,kw	18006
#37	#14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36	25819
#38	#13 OR #37	41151
#39	[mh "Sensitivity and Specificity"]	21953
#40	[mh "Predictive Value of Tests"]	10133
#41	[mh "Reproducibility of Results"]	16684
#42	[mh "Data Accuracy"]	152
#43	[mh "ROC Curve"]	2187
#44	"Receiver Operating Characteristic Curve":ti,ab,kw	1751
#45	"Predictive value":ti,ab,kw	17907
#46	Diagnostic near/3 Accuracy:ti,ab,kw	9715
#47	"Positive Predictive Value":ti,ab,kw	2634
#48	"Negative Predictive Value":ti,ab,kw	2236
#49	"Accuracy":ti,ab,kw	30828
#50	"Sensitivity":ti,ab,kw	75359
#51	"Specificity":ti,ab,kw	25214
#52	"Validity":ti,ab,kw	14676
#53	"Validation Process":ti,ab,kw	4189
#54	"Case Ascertainment":ti,ab,kw	36
#55	"Diagnostic performance":ti,ab,kw	1315
#56	#39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 #	135226
#57	#38 AND #56	6707
#58	(“Comment”):pt OR (“Case Reports”):pt OR (“Editorial”):pt OR (“Literature Review”)	2519

#59	#57 NOT #58	6643
#60	[mh "Arthritis, Rheumatoid"]	8149
#61	[mh "Arthritis, Juvenile"]	464
#62	[mh "Felty Syndrome"]	0
#63	[mh "Caplan Syndrome"]	0
#64	[mh "Arthritis, Rheumatoid"] AND [mh "Lung Diseases, Interstitial"]	23
#65	"Rheumatoid Arthritis":ti,ab,kw	18690
#66	"Rheumatoid Vasculitis":ti,ab,kw	7
#67	"Rheumatoid Nodule":ti,ab,kw	17
#68	"Rheumatoid Nodules":ti,ab,kw	38
#69	"Juvenile Idiopathic Arthritis":ti,ab,kw	795
#70	"Juvenile Chronic Arthritis":ti,ab,kw	53
#71	"Juvenile Rheumatoid Arthritis":ti,ab,kw	573
#72	"Felty Syndrome":ti,ab,kw	6
#73	"Caplan Syndrome":ti,ab,kw	0
#74	(("Rheumatoid Arthritis") AND ("Interstitial Lung Disease")):ti,ab,kw	86
#75	"RA ILD":ti,ab,kw	30
#76	rheumat* AND arthritis:ti,ab,kw	23152
#77	#60 OR #61 OR #62 OR #63 OR #64 OR #65 OR #66 OR #67 OR #68 OR #69 OR #70 OR #71 OR #72 OR #73 OR #74 OR #75 OR #76	23774
#78	#59 AND #77	93

Embase Search 12th November 2024

#1	'algorithm'/exp OR 'algorithm' OR 'current procedural terminology'/exp OR 'current procedural terminology' OR 'international classification of diseases'/exp OR 'international classification of diseases' OR 'diagnostic algorithm*':ti,ab,kw OR 'classification algorithm':ti,ab,kw OR 'claims based algorithm':ti,ab,kw OR 'diagnostic codes':ti,ab,kw OR 'diagnostic definition':ti,ab,kw OR 'icd codes':ti,ab,kw OR 'icd':ti,ab,kw OR 'acr criteria':ti,ab,kw	965,982
#2	'factual database'/exp OR 'factual database' OR 'database management system'/exp OR 'database management system' OR 'electronic medical record system'/exp OR 'electronic medical record system' OR 'electronic health record'/exp OR 'electronic health record' OR 'medical record'/exp OR 'medical record' OR 'administrative claims (health care)'/exp OR 'administrative claims (health care)' OR 'hospital discharge'/exp OR 'hospital discharge' OR 'insurance database':ti,ab,kw OR 'record linkage':ti,ab,kw OR 'data warehouse':ti,ab,kw OR 'registered next/2 person next/2 database':ti,ab,kw OR 'electronic medical records':ti,ab OR ('billing':ti,ab,kw AND ('data':ti,ab,kw OR 'claims':ti,ab,kw OR 'codes':ti,ab,kw)) OR ('claims':ti,ab,kw AND ('administrative':ti,ab,kw OR 'data*':ti,ab,kw)) OR (('administrative':ti,ab,kw OR 'healthcare':ti,ab,kw) AND ('data*':ti,ab,kw OR 'records':ti,ab,kw)) OR 'administrative data*':ti,ab,kw OR 'administration database':ti,ab,kw OR 'physician claims':ti,ab,kw OR 'hospital billing':ti,ab,kw	1,230,052
#3	#1 OR #2	2,089,508
#4	'sensitivity and specificity'/exp OR 'sensitivity and specificity' OR 'predictive value'/exp OR 'predictive value' OR 'reproducibility'/exp OR 'reproducibility' OR 'data accuracy'/exp OR 'data accuracy' OR 'receiver	3,213,131

	operating characteristic'/exp OR 'receiver operating characteristic' OR 'receiver operating characteristic curve':ti,ab,kw OR 'predictive value':ti,ab,kw OR 'diagnostic next/2 accuracy':ti,ab,kw OR 'positive next/2 predictive value':ti,ab,kw OR 'negative next/2 predictive value':ti,ab,kw OR 'accuracy':ti,ab,kw OR 'sensitivity':ti,ab,kw OR 'specificity':ti,ab,kw OR 'validity':ti,ab,kw OR 'validation process':ti,ab,kw OR 'case ascertainment':ti,ab,kw OR 'diagnostic performance':ti,ab,kw	
#5	#3 AND #4	363,956
#6	'comment':it OR 'case reports':it OR 'editorial':it OR 'literature review':it	812,392
#7	#5 NOT #6	362,739
#8	'rheumatoid arthritis'/mj OR 'rheumatoid arthritis' OR (('rheumatoid arthritis'/mj OR 'rheumatoid arthritis') AND ('interstitial lung disease'/mj OR 'interstitial lung disease')) OR 'rheumatoid arthritis':ti,ab,kw OR 'rheumatoid vasculitis':ti,ab,kw OR 'caplan syndrome':ti,ab,kw OR ('rheumatoid arthritis':ti,ab,kw AND 'interstitial lung disease':ti,ab,kw) OR 'ra-ild':ti,ab,kw OR ('rheumat*':ti,ab,kw AND 'arthritis':ti,ab,kw)	307,962
#9	#7 AND #8	2,987

Supplementary Appendix 3. Methods

Data items

The target condition was a diagnosis of RA recorded in EHRs or other administrative databases. The "index" classification was a definition (codes) or algorithm used to identify RA in EHRs and the "reference standard" the register of a diagnosis for RA in medical records or confirmed by a rheumatologist, or any other reference standard as defined by the authors of the original study.

True positives (TP) cases were considered as a diagnosis of RA by a code or algorithm confirmed by the "reference standard" (i.e., medical records review) and true negatives (TN) as cases not identified with RA by both definition or algorithm and the "reference standard". False positives (FP) were considered as those cases identified with RA by a definition or algorithm in EHRs but not confirmed by the "reference standard" and false negatives (FN) as those cases not identified by the definition or algorithm in the EHRs but confirmed with RA by the "reference standard".

Diagnostic accuracy measures

Primary diagnostic accuracy measures were sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). When a study did not provide results on these measures, we used the data from the two-by-two tables to calculate the accuracy statistics when available. For a practical interpretation of the accuracy measures, studies with values ≥80% were considered to have high accuracy, values from 60-80% moderate accuracy and values <60% were considered to have low accuracy as previously reported. The unit of assessment was at the individual level. The statistics were calculated following the formulas:

Sensitivity: TP / (TP + FN)

Specificity: TN / (TN + FP)

PPV: TP / (TP + FP)

NPV: TN / (TN + FN)

Synthesis of results

We classified the definitions and algorithms in the studies according to the number and type of codes (e.g., ICD, prescriptions, diagnostic test, procedural codes) used to ascertain the diagnosis of RA. Additionally, we were guided by the classification used by Shrestha et al [18] in their systematic review to classify the algorithms (with modifications made as necessary):

- *Less restrictive algorithms*: those that required a single diagnostic code for the condition under study from one outpatient visit or unspecified source (i.e., single ICD code for RA). An algorithm requiring a single diagnostic code from one outpatient visit or one prescription record was classified as less restrictive as the stricter code (prescription) is not required to identify the condition (as the definition is based on presence of either code).

- *Restrictive algorithms*: those that required more than one code of any kind or if it required one or more strict code such a procedural, prescription, diagnostic test, or hospitalisation codes (rather than a single diagnosis/disease code). For example:
  - An algorithm that required a diagnosis ICD code from two separate outpatient visits.
  - An algorithm that required one ICD code from an outpatient visit and one prescription code.
  - An algorithm that required a single hospitalisation visit.

The definitions and algorithms were generally classified as restrictive or less restrictive as described above. Furthermore, we developed sub-categories among restrictive algorithms to stratify analysis, based on anticipated accuracy and how frequently they were evaluated by included studies. We identified 4 main sub-categories:

- RA diagnoses codes + DMARD prescription codes: These algorithms require at least the presence of ICD codes and DMARD prescriptions to identify RA cases. Some algorithms are based solely on this combination of codes, while others include more specific prescription codes (i.e., biologic agents, glucocorticoids) in their algorithms and ≥1 ICD code for RA. For example:
  a. >2 ICD codes for RA + prescription codes (DMARDs).
  b. 1 ICD code for RA (hospitalisation) OR (≥2 ICD codes for RA + DMARDs OR biologic agents).
- ≥2 ICD codes for RA: These algorithms require at least 2 ICD codes for RA in EHRs on different dates, without combination with other types of codes (i.e., prescription codes,

laboratory values). This only includes non-specific coding, and requirements for diagnoses to be recorded by a rheumatologist or specialist are included in sub-category 3. For example:

a. ≥2 ICD codes for RA by physician

b. ≥2 ICD codes recorded in claims data

- ≥1 ICD code for RA by rheumatologist: These algorithms include and are limited to ≥1 ICD codes for RA recorded by a rheumatologist or specialist with or without other ICD codes for RA (i.e., physician or claims data) and without combination with other types of codes (i.e., prescription codes or laboratory values). For example:

  a. ≥2 ICD codes for RA by rheumatologist

  b. 2 RA codes (physician) with ≥1 by specialist in 1 year

- ≥1 ICD hospitalisation code for RA: These algorithms require at least one ICD hospitalisation code for identifying RA in EHRs. They may or may not be combined with other ICD codes for RA (i.e., outpatient, physician or emergency ICD codes). For example:

  a. 1 RA code ever (hospitalisation)

  b. 1 RA code (hospitalisation) OR ≥2 RA codes (outpatient)

Supplementary Appendix 4. Table 1

Table 1. Characteristics of included studies (n= 35)

Author, Year, Country	Study Design	Administrative Data Source, Time period	Record type	Study Population N	Sample size	Gender	Age (years)	Diagnosis	Codes for Algorithm definition	Reference standard
Allebeck et al. 1983, Sweden	Cross-sectional study	Stockholm county Medical Information System 1975-1978	Hospital Discharge Records	Female patients between 15-50 years with a sole diagnosis of RA N= NR	n= 291 analysed= 276	F= 100%	15-50	RA	ICD-8 codes for RA (712.38, 712.39)	Medical record review by one author based on diagnostic criteria for RA from Rome (1961) and New York (1966)
Almutairi et al. 2021, Australia	Retrospective Cohort study	Finance and Business Office at Sir Charles Gairdner Hospital (SCGH), Perth 2008-2020	Hospital Discharge Records	Patients listed in the SCGH AHD with a primary or secondary ICD 10-AM diagnostic discharge record for RA N= NR	n=200 Analysed= 87	F= 67.8%	64.7 ± 17.2	RA	ICD-10-AM codes for RA (M05.0-M06.9) Biological infusion AR-DRG code I40Z	Medical charts from the Medical Records Department at SCGH (Rheumatologist-reported diagnosis and ACR/EULAR classification)
Carrara et al. 2015, Italy	Nested Case-Control and Cohort diagnostic study	*Training set:* Rheumatology Unit, IRCCS Policlinico San Matteo Foundation, Pavia 2007-2010 *Validation set:* Secondary rheumatology centre: EMRs of the Rheumatology outpatient clinic of the Clinical Institute Beato Matteo of Vigevano Primary care EMRs: convenience sample of six primary care physicians of the Local Health Authority of Pavia	NHS assistance (demographic and administrative records) Certification of CDs for the exemption from co-payment Hospital Discharge Records (HDRs) Outpatient Drug Prescription Records	Patients ≥16 years assisted by a tertiary rheumatology clinic (Rheumatology Unit, IRCCS Policlinico San Matteo Foundation) N= NR	*Training set:* n=900 Analysed= 827 RA= 301 Non-RA= 526 *Validation set:* n= 138 Analysed= 106 RA= 32 n=6087 Analysed= 6087	RA= F= 72.4% Non-RA= F= 77%	RA= 66.8 ± 13.1 Non-RA= 57.7± 15.7	RA	RA certification by rheumatologist/absence of certification of other CADs. ICD-9-CM code 714.0 in HDRs DMARDs prescriptions	Medical Records clinically validated by an external investigator or according to specific classification criteria

					RA= 40					
Carroll et al.^ 2012 USA	Retrospective Cohort study	Vanderbilt University Medical Center's Synthetic Derivative (VUMC SD) Northwestern medical Enterprise Data Warehouse (EDW) Partners Healthcare (PH) database used by BWH and MGH NR	Electronic Health Records (linked to BioVU repository) Electronic Health Records (Hospital Records) Hospital Records Narrative EMRs data	VUMC SD: ≥ 18 adults accrued into BioVU with ≥1 ICD-9 code for RA (714.*) N= 10,000 EDW: Patients with ≥1 ICD-9 code for RA (714.*) N= 6,124 PH: Patients with ≥1 ICD-9 code for RA (714.*) N= 29,432	VUMC SD n= 376 EDW n= 400 PH: n= 500	VUMC SD RA= F= 80% Non-RA= F= 73.8% EDW RA= F= 81.4% Non-RA= F= 72.6% PH RA= F= 77.1% Non-RA= 75%	VUMC SD RA= 52.9 ± 13.1 Non-RA= 56.2 ± 16.5 EDW RA= 54.3 ± 14.8 Non-RA= 58.9 ± 16.8 PH: RA= 60.7 ± 15.9 Non-RA= 56.0 ± 18.6	RA	>1 ICD-9 RA code (714.xx) Medication prescriptions RF and anti-CCP lab results	Medical chart review by rheumatologists
Cho et al. 2013, South Korea	Retrospective Cohort study	The Korean National Health Insurance (NHI) claims database July 2009-December 2009	Administrative and Claims data	Patients with diagnostic code for seropositive RA (M05.xx) when individual co-payment beneficiaries program began (July 2009) N= 73,858	n= 59,823 RA= n= 50,082 Non-RA= 9,741	F= 80.3%	55.8 ± 12.9	Seropositive RA	ICD-10 code for RA (M05.xx) Drug prescriptions	Official report from a doctor documenting that the patient fulfils the 1987 ACR criteria (registered in the program)
Convertino et al. 2021, Italy	Retrospective Cohort study	Tuscan Healthcare Administrative Databases (THAD) 2014-2016	Hospital discharge records Emergency Department Accesses records Drugs supply and exemption co-payments	First-ever users of DMARDs with at least one record of visit to the Rheumatology Unit N= NR	n=277	NR	53.3 ± 13.9	RA	ICD-9 codes for RA (714*) Exemption code from co-payment (006)	Chart Medical Records of the Rheumatology Unit of Pisa University Hospital; diagnosis by rheumatologist

Curtis et al. 2018, USA	Retrospective Cohort study	Administrative Medical and pharmacy claims data from Medicare and a commercial Health Plan 2005-2012	Claims data	RA patients participating in the Corrona (North America RA registry) linked to Medicare/Commercial health plan N= NR	n= 6,509	Medicare F=74.8% Commercial Claims F= 80.1%	Medicare 67.2 ± 9.8 Commercial Claims= 48.1 ± 10.6	Incident RA	ICD-9 codes for RA (714.0, 714.2, 714.81, 714.x) Medications	Clinical diagnosis by rheumatologist in the Corrona registry
Fowles et al. 1995, USA	Retrospective Cohort study	Medicare Part B 1990-1991	Claims data	Maryland Medicare beneficiaries N= 1,998	n= 1,998 Analysed= 1,596	NR	NR	RA	ICD-9-CM codes for RA	Medical record review by trained nurses
Hanly et al. 2015, Canada	Matched Case-Control study	Medical Services Insurance (MSI) program, Nova Scotia Health Data Nova Scotia databases (3) 1997-2011	Claims data Hospital Discharge records Physician billings	Nova Scotia residents enrolled in the MSI program with ≥1 rheumatologist consultation at the Arthritis Center of Nova Scotia N= 25,888 (RA= 2,692)	RA= n= 535 non-RA= n= 2,140	F= 67.9%	56.0 ± 17.8	Prevalent and Incident RA	ICD-9 and ICD-10 codes for RA (714.0, 714.1, 714.2, M05-M05.9, M06.0, M06.8, M06.9)	Medical chart review Rheumatologist's diagnosis at the Arthritis Center of Nova Scotia
Harrold et al. 2013, USA	Retrospective Cohort study	Kaiser Permanente, Northern California (KPNC) Autoimmune Disease Registry 1996-2009	Electronic Medical Records	Children ≤15 years with ≥1 ICD-9 code for JIA (696.0, 714, 720) enrolled in the KPNC N= 1,153	n= 97 JIA cases= 67	JIA cases= F= 64%	JIA cases= 6-10= 21% 11-15= 46%	Incident and Prevalent JIA	ICD-9 codes (696.0, 714, 720) Laboratory tests	Manual chart review (Clinical diagnosis by adult or pediatric rheumatologist)
Huang et al.^ 2020, USA	Retrospective Cohort study	EMRs data from two large academic hospitals in Boston (BWH and MGH) 1994/1996-2017	Hospital discharge records Claims data Narrative EMRs data	Patients with ≥1 RA ICD-9 or ICD-10 code and ≥2 notes with length >500 characters in EMRs (RA data mart) N= 53,144	n=200 n=100 (RA ICD-10 codes only)	RA= F= 78.7% Non-RA= F= 71.2%	RA= 65.4 ± 16.1 Non-RA= 66.4 ± 17.4	RA	ICD-9 and ICD-10 RA codes (714.x, M05.x, M06.x) RF and anti-CCP lab results DMARDs prescriptions	Medical chart review, RA diagnosis by a rheumatologist Presence of 2010 ACR/EULAR criteria

Ibfelt et al. 2017, Denmark	Retrospective Cohort study	The Danish Rheumatologic Database (DANBIO) The Danish National Patient Registry (DNPR) 2001-2011	Clinical and treatment data by rheumatologists Hospital records	Patients registered with an RA diagnosis in DANBIO and DNRP in 2011 N= 2,298	n=1,678 Analysed= n=1,532	NR	NR	Incident RA	ICD-10 RA diagnostic codes (M05.9, M06.0, M06.8, M06.9)	Medical record review by rheumatologist diagnosis
Katz et al. 1997, USA	Cross-sectional study	8 Rheumatology practices in Massachusetts, Colorado, and Virginia Medicare (Part B) 03/1993-10/1993	Physician claims (Part B)	Patients with RA documented in the medical records at the 8 rheumatology practices N= NR	n= 160 Analysed: 153	NR	NR	RA	ICD-9-CM code for RA (714.0, 714.1, 714.2, 714.3, 714.30, 714.31, 714.32, 714.33) CPT codes (20550, 20600, 20605, 20610)	Medical records review, diagnosis by rheumatologists and 1990 ACR criteria
Kim et al. 2011, USA	Retrospective Cohort study	Medicare and the Pennsylvania Assistance Contract for the Elderly (PACE) program 1994-2004	Claims data	Pennsylvania residents ≥65 years, low-moderate income N= 9,482	n= 158	F= 82.9%	79.3 ± 7.1	RA	ICD-9 code for RA (714) DMARDs prescriptions	Medical records by rheumatologists Definition: diagnosis of RA by rheumatologist and fulfilment of 1987 ACR criteria
Kronzer et al.[¥] 2020, USA	Retrospective Cohort study	Mayo Clinic Biobank included in the Rochester Epidemiology Project (REP) 1995-2009	Electronic Health Records	Mayo Clinic Biobank participants included in the REP with ≥1 ICD-9 RA code N= NR	n= 497 RA= 213 Non-RA= 284	RA= F= 75% Non-RA= F= 68%	RA= 65 ± 14 Non-RA= 63 ± 16	Prevalent and Incident RA	eMERGE algorithm: ICD-9 code for RA (714.x) RF lab value ICD-9 codes for SLE and PA *(exclusion criteria)*	Manual chart review against 1987 ACR or 2010 ACR/EULAR criteria
Kubota et al. 2021, Japan	Retrospective Cohort study	64 Hospitals of Tokushukai Medical Group, Tokushukai Information System	Claims data Clinical data	Patients with a RA code in at least 1 monthly claim	n= 19,734 Analysed=	F= 50.3%	≤24 yr= 17.7%	RA	ICD-10 codes for RA	Chart review by rheumatologists

		2018-2019		N= 1,590,669	12,982		25-64 yr= 42,8% ≥65 yr= 39,5%		Medication prescription ICD-10 codes for SADs *(exclusion criteria)*	
Liao et al.^ 2010, USA	Retrospective Cohort study	EMRs data from two large academic hospitals in Boston (BWH and MGH) 1994/1996-2008	Hospital discharge records Claims data Narrative EMRs data	Patients with >1 ICD-9 RA code (714.xx) or anti-CCP testing (RA data mart) N= 29,432	Training set: n= 500 Validation set: n= 400	Training set RA= F= 77% Non-RA F= 74%	Training set RA= 60.4 ± 16 Non-RA= 56.1 ± 19	RA	>1 ICD-9 RA code (714.xx) Electronic prescriptions RF and anti-CCP lab results	Medical record review by blinded 2 rheumatologists (clinical diagnosis and 1987 ACR criteria)
Linauskas et al. 2018, Denmark	Retrospective cohort study	The Danish Diet, Cancer, and Health Cohort study The Danish National Patient Registry (DNPR) The Danish National Prescription Registry 1977-2016	Hospital Discharge records Drug reimbursement data	Participants from the Danish Diet, Cancer, and Health Cohort with ≥1 RA (712.39, M05, M06) code registered at hospitals in the DNPR N= 331	n= 331	F= 70%	65 (35-83)	Incident RA	ICD-8 – ICD-10 codes for RA (712.39, M05, M06) DMARDs prescription	Medical records, RA diagnosis verified against 1958 ACR, 1987 ACR or 2010 ACR/EULAR criteria. If unmet, clinical assessment by rheumatologist
Losina et al. 2003, USA	Cross-sectional study	Medicare database Ohio, Pennsylvania, and Colorado 1995	Claims data (hospital and surgeon's)	Inpatient Medicare beneficiaries who received primary THR in 1995 N= NR	n= 922	NR	NR	RA	ICD-9-CM for RA (714, 714.0)	Medical record review from Physician Review Organizations in each state by trained nurses
Nanji et al 2012, Canada	Retrospective Cohort study	2 primary care clinics in Grande Prairie, Alberta (4 family physicians) NR	Electronic Health Records	Patients with RA codes in the EHRs of 4 family physicians N= NR	n= 31	NR	NR	RA	ICD-9 codes for RA (714, 714.0)	Chart review by rheumatologist clinical diagnosis
Ng et al. 2012, USA	Retrospective Cohort study	The Veterans Health Administration (VHA) database-Michael E. DeBakey VAMC, Houston	Electronic Health records Claims data	Patients with ≥2 ICD-9 RA codes at least 6 months apart	n= 543	F= 9%	62 ± NR	RA	≥2 ICD-9 codes for RA (714) at least 6 months apart	Medical record review 2 ICD-9 codes as noted + at least 4 1987 ACR criteria or

		1998-2009		N= 1,779					DMARDs prescriptions	positive anti-CCP or patient self-report of RA management by non-VA rheumatologist
Paltta et al. 2021, Finland	Case-Control study	Five Hospital Biobanks in Finland Finnish Care Register for Health Care (CRHC) Finnish National Health Insurance system 2007-2018	Hospital Discharge records Medical reimbursement registers for DMARDs	Patients from 5 Hospital Biobanks in Finland N= NR	RA= 250 Analysed= 233 Non-RA= 250	F= 69%	Me: 50 (IQR 40-59) at diagnosis	Seropositive and seronegative RA	ICD-10 codes for RA (M0.58, M05.9 and M06.0) DMARDs reimbursement codes 202, 281, 313 for RA	Chart review by a rheumatologist or resident in rheumatology
Pedersen et al. 2004, Denmark	Retrospective Cohort study	The Danish Diet, Cancer, and Health Cohort study and the Danish Nationwide Twin Population linked to The Danish National Patient Registry (DNPR) 1977-2001	Hospital Discharge records	Patients >15 years registered in the DNPR with ICD-8 or ICD-10 code for RA from the 2 cohorts N= 48,707	n= 217	F : M ratio 2.7 : 1	57 (15-72)	RA	ICD-8, ICD-10 codes for RA (712.19, 712.39, 712.59, M05, M06)	Medical records review by rheumatologist (clinically confirmed RA and 1987 ACR criteria)
Peterson et al. 2023, USA	Retrospective Cohort study	Vanderbilt University Medical Center (VUMC) database 1990-NR	Electronic Health records (clinical, laboratory, medication data)	≥1 ICD-9 or ICD-10 codes for JIA N= 3,190	Training set n= 200 Validation set n= 100	JIA= F= 75% Non-JIA= F= 63%	JIA= Median= 19 (13-23) Non-JIA= Median= 32 (22-48)	JIA	ICD-9, (714.3, 714.30, 714.31, 714.32, 714.33) ICD-10 (M08.0, M08.1-M08.4, M08.8, M08.9, L40.54) codes for JIA	Chart review by paediatric rheumatologist (JIA ICD code at age ≤20 years and a rheumatology clinic note documenting diagnosis)
Singh et al. 2004, USA	Retrospective Cohort study	Minneapolis Veterans Affair (VA) administrative health database (AHDs) 2001- 2002	Electronic Health records (administrative, pharmacy and laboratory records)	Patients at the Minneapolis VA rheumatology clinic N= 737	n= 252 Analysed= 184	F= 6%	64.4 ± 12.9	RA	ICD-10 code 714.0 for RA DMARDs prescriptions	Chart review from medical records: RA diagnosis by a rheumatologist on 2 separate occasions >6 weeks apart

									Positive RF code	
Shiff et al. 2017, Canada	Retrospective Cohort study	The Population Health Research Data Repository: Manitoba health insurance registry Hospital Discharge Abstracts Database (DAD) Medical Claims Database 1980-2012	Insurance coverage data Hospital Discharge records Physician billings	Children <16 yrs seen by pediatric rheumatologist at the Children's Hospital, Winnipeg, with a diagnosis of rheumatic disease from the Pediatric Rheumatology Clinical Database N= 1,812	n= 1,122 JIA= 707 Non-JIA= 415	JIA= F= 68.7% Non-JIA= F= 64.6%	JIA= 6-10= 21% 11-15= 44% Non-JIA= 6-10= 24% 11-15= 46.5%	JIA	ICD-9-CM (714, 720), ICD-10-CA (M05, M06, M08, M45) codes for JIA	Diagnosis by a pediatric rheumatologist
Stringer et al. 2015, Canada	Cross-sectional study	Nova Scotia (NS) Medical Service Insurance (MSI) database Clinical database of the pediatric rheumatology clinic, IWK Health Centre 2005/2006-2008/2009	Insurance data	Children <16 years with ICD-9 code for JIA in NS N= NR	n= 94	NR	NR	Incident JIA	ICD-9 code for JIA (714)	Clinical chart review (diagnosis by rheumatologist based on 2004 ILAR criteria)
Sugiyama et al. 2024, Japan	Cross-sectional study	Two large Hospitals in the Chiba-prefecture, Japan (private and community hospitals) 2012-2016	Claims data	Patients treated at either hospital during 2012-2016 meeting the claims based-algorithm N= 3,294	n= 400 Analysed= 389 Incident RA= 134	F= 72.8%	64.4 ± 14.9	Prevalent and Incident RA	ICD-10 codes for RA (M05, M06) Codes for relevant therapies and treatments	Medical records: 1. RA diagnosis by a physician 2. ACR/EULAR 2010 criteria 3. Overall adjudicator decision-confirmed cases
Thomas et al. 2008, UK	Retrospective Cohort study	General Practice Research Database (GPRD), Primary care Medical Records, UK 1987-2002	Electronic Primary Care Medical Records	Patients with RA or JIA registered in the GPRD N= RA= 31,830 JIA= 2,901	RA=319 Analysed= 258 JIA= 101 Analysed= 91	RA= F= 71% JIA= F= 57%	RA= Me: 51 (IQR 42-61) JIA= Me: 7 (IQR 4-10.5)	RA JIA	RA and JIA codes *(codes not specified)*	RA= 1987 ACR Criteria JIA= 2001 ILAR Criteria From AIS and Clinical Practices

Waldenlind et al 2014, Sweden	Retrospective Cohort study	National Patient Register and Prescribed Drug Register at the Karolinska University Hospital 2005-2012	Hospital Discharge Records Drug prescriptions	Patients with ≥1 primary or secondary ICD-10 code for seropositive or seronegative RA N= NR	n= 211 Prevalent RA n= 100 Analysed= 100 Incident RA n=111 Analysed= 103	Prevalent RA F= 72% Incident RA F= 75%	Prevalent RA 57.9 ± 16.1 Incident RA 57.7 ± 17.4	Prevalent and Incident RA	ICD-10 codes for RA (M05.9, M06.0)	Chart review from medical records 2010 ACR/EULAR criteria, 1987 ACR criteria or Clinical diagnosis
Wei et al. 2016, USA	Cross-sectional study	Vanderbilt University Medical Center (VUMC), Tennessee Administrative claims data NR	Electronic Health Records Clinical Notes Billing codes	Patients identified in VUMC EHRs according to the 7 specified categories N= NR	n= 175 (25 per each category)	NR	NR	RA	ICD-9 Clinical notes Medication prescription	Manual chart review by 5 authors with medical background
Widdifield et al. 2013, Canada	Retrospective Cohort study	18 Ontario rheumatology clinics linked to health administrative data (Ontario Health Insurance Plan (OHIP) database, CIHI-DAD and NACRS) 1991-2011	Physician billing codes Hospital discharge records Pharmacy data	≥20 years active adults seen in rheumatology clinics with a visit between March 2009-2011 and seen at least twice N= NR	n= 450 analysed= 447 RA= n= 148 Non-RA= n= 299	RA= F= 77.2% Non-RA= F= 64.8%	RA= 61.8 ± 14.1 Non-RA= 57.9 ± 64.8	RA	ICD-9 and ICD-10 codes for RA (714, M05, M06) Medication prescription	Medical records, clinical diagnosis by rheumatologists
Widdifield et al. 2014, Canada	Retrospective Cohort study	83 physicians in urban and rural Ontario linked to the Electronic Medical Record data Administrative Linked Database (EMRALD). Ontario Health Insurance Plan (OHIP) Database, CIHI-DAD, NACRS and ODB 1991-2011	Physician billing codes Hospital discharge records Pharmacy claims data	Patients seen in primary care clinics with at least 1 visit in the previous year (2010) and enrolled in the physician practice N= 73,014	≥20 years: n= 7,500 RA= n= 69 non-RA= n= 7431 ≥65 years: n= 3,426	NR	≥20 years: 49 ± 17	RA	ICD-9 and ICD-10 codes for RA (714, M05, M06) Medication prescription	Medical record review 1- diagnosis by rheumatologist, orthopaedic surgeon, or internal medicine specialist or, 2- primary care physician diagnosis with supporting evidence

Zheng et al.[¥] 2022, USA	Case-control study	University of California, Los Angeles (UCLA) Health System 2009-2019	Electronic Health Records (diagnosis, laboratory records)	RA: ≥18 patients from UCLA Health System with at least one ICD-9 or ICD-10 code N= 22,266 and 2,385 confirmed with RA by clinician chart review Non-RA: Patients without ICD-9 or ICD-10 codes and with the exclusion criteria diagnosis (SLE and PA) N= 2,381	n=4,766 RA=2,385 Non-RA= 2,381	RA= F= 83.1% Non-RA= F= 70%	NR	RA	eMERGE algorithm ICD-9 and ICD-10 codes for RA (714, 714.0, 714.1, 714.2, M05.*, M06.* RF lab value ICD-9 and ICD-10 codes for SLE and PA *(exclusion criteria)*	Clinician chart review 2010 ACR/EULAR criteria in a subsample (n=300) by rheumatologist expert, fellows and research associate
Zhou et al. 2016, UK	Retrospective Cohort study	CIPHER-SAIL databank (primary care general practice records linked with the rheumatology secondary care clinical system-Cellma) in ABMU and Cardiff regions 1999-2013	Electronic Health Records (primary-Read codes- and secondary care-SNOMED-CT)	Patients >16 years registered in the general practice database contained in the SAIL databank and linked to Cellma system *Developing set:* ABMU cohort= N= 15,459 *Validation set:* Cardiff cohort+ N= 5,208 N= 20,667	n= 20,667 RA n= 2,588	NR	NR	RA	Read codes and SNOMED-CT for RA, medications, and laboratory tests	Diagnosis of RA according to specialist rheumatologist recorded in Cellma

Abbreviations: RA= Rheumatoid Arthritis; NR= Not Reported; NHS= National Health Service; CDs= Chronic Diseases; DMARDs= Disease-modifying Antirheumatic Drugs; JIA= Juvenile Idiopathic Arthritis; AIS= Additional Information Services; Me= Median; IQR= Interquartile Range; RF= Rheumatoid Factor; SLE= Systemic Lupus Erythematosus; PA= Psoriatic Arthritis; EMRs= Electronic Medical Records; BWH= Brigham and Women's Hospital; MGH= Massachusetts General Hospital; anti-CCP= antibodies to cyclic citrullinated peptide; VAMC= Veterans Affairs Medical Center;

THR= Total Hip Replacement; LiiRA= Lipids, Inflammation, and Cardiovascular risk in rheumatoid Arthritis; CPT= Current Procedural Terminology; CIHI-DAD= Canadian Institute for Health Information discharge Abstract Database; NACRS= National Ambulatory Care Reporting System; ODP= Ontario Drug Benefit Program; REP= Rochester Epidemiology Project; SADs= Systemic Autoimmune Diseases; CRANE= University of Nebraska Medical Center Clinical Research Analytics Environment; ILD= Interstitial Lung Disease; THA= Total Hip Arthroplasty; TKA= Total Knee Arthroplasty; AMI= Acute Myocardial Infarction; CIPHER-SAIL=Centre for Improvement in Population Health through E-Records- Secure Anonymised Information Linkage; ABMU= Abertawe Bro Morgannwg University.

^ Studies validating the same algorithm and same administrative data source.

¥ Studies validating the eMERGE algorithm

Supplementary Appendix 5. Table 2

Table 2.1. Accuracy measures of individual studies assessing RA codes and algorithms in electronic health records (n=31).

Author, Year, Country	Algorithm definition	Reference standard	Measures of Accuracy/Results				
			Sensitivity (95% CIs)	Specificity (95% CIs)	PPV (95% CIs)	NPV (95% CIs)	Other (95% CIs)
Allebeck et a. 1983, Sweden	Sole diagnosis RA (712.38 or 712.39 codes)	≥3 New York criteria	NA	NA	56.5%*	NA	
		Diagnosis by rheumatologist	NA	NA	65.2%*	NA	
Almutairi et al. 2021, Australia	≥1 RA primary codes (M05.00–M06.99)	Rheumatologist diagnosis	90%	28.5%	93.5%	7.6%	
		ACR/EULAR criteria	89.8%	16.6%	80.5%	30%	
	≥1 RA primary biological infusion codes (I40Z)	Rheumatologist diagnosis	25%	71.4	90.9%	7.7%	
		ACR/EULAR criteria	20.3%	55.5%	63.6%	15.3%	
	≥2 secondary RA secondary codes (M05.00–M06.99)	Rheumatologist diagnosis	71.2%	71.4%	96.6%	17.8%	
		ACR/EULAR criteria	71%	44.4%	83%	28.5%	
	≥2 RA primary codes (M05.00–M06.99) + biological infusion codes (I40Z)	Rheumatologist diagnosis	60%	85.7%	97.9%	15.8%	
		ACR/EULAR criteria	56.5%	44.4%	79.6%	21%	
	≥2 RA secondary codes (M05.00–M06.99) + biological infusion codes (I40Z)	Rheumatologist diagnosis	76.2%	57.1%	95.3%	17.4%	
		ACR/EULAR criteria	73.9%	27.7%	79.7%	21.7%	
Carrara et al. 2015, Italy	*Step 1*: RA certification OR ICD 9-CM 714 in HDRs OR leflunomide OR tocilizumab OR abatacept OR gold salts	Medical Records clinically validated by an external investigator or according to specific classification criteria	82.4% (77.6-86.5)	96.2 % (94.2-97.7)	NR	NR	
	Step 2: Step 1 OR (methotrexate AND antimalarials AND no certification for other CADs)		85.4% (80.9-89.2)	95.6% (93.5-97.2)	NR	NR	
	Step 3: Step 2 OR (GCs ≥3 prescriptions AND antimalarials AND no certification for other CADs		91.4% (87.6-94.3)	92.2% (89.6-94.3)	NR	NR	
	Step 4: Step 3 OR (methotrexate ≥3 prescriptions AND no certification for other CADs (final model)	Training set	96.3% (93.6-98.2)	90.3% (87.4-92.7)	85.0% (80.8-88.7)	97.7% (95.9-98.9)	
		Validation set-rheumatological sample	93.7% (79.2-99.2)	90.5% (81.5-96.1)	81.1% (64.8-92.0)	97.1% (89.9-99.6)	
		Validation set- General population	92.5% (79.6-98.4)	99.8% (99.6-99.9)	72.5% (58.3-84.1)	99.9% (99.8-99.99)	
Carroll et al.¥ 2012,	*Algorithm (regression coefficient):*	Testing set- Partners Healthcare	79%	NR	88%	NR	ROC= 97%

USA	NLP RA (1.11) + NLP seropositive (0.74) + ICD-9 RA normalized 714.xx (0.71) + ICD RA 714.xx (0.66) + NLP erosions (0.46) + codified RF negative (0.36) + NLP methotrexate (0.3) + codified anti-TNF (0.29) + NLP anti CCP positive (0.27) + NLP anti-TNF (0.2) + NLP other DMARDs (0.13) – ICD JRA 714.3x (0.98) – ICD SLE 710 (0.57) – NLP PsA (0.51)	Testing set- EDW	60%	NR	87%	NR	ROC= 92%
		Testing set- VUMC-SD	57%	NR	95%	NR	ROC= 95%
Cho et al. 2013 South Korea	RA code (M05.xx) + Biologics + Triple DMARDs + Any other DMARDs	Official report from a doctor documenting that the patient fulfils the 1987 ACR criteria	96.5%	61.9%	93.3%	76.2%	Accuracy: 91.2 PLR: 2.54 / NLR: 0.06
	RA code (M05.xx) + Biologics + Triple DMARDs + Any NSAIDs		88.7%	31.1%	87.7%	33.2%	Accuracy: 79.8 PLR: 1.29 / 0.36
	RA code (M05.xx) + Biologics + Triple DMARDs + Any NSAIDs and any DMARDs		85.1%	70.0%	94.0%	46.1%	Accuracy: 82.8 PLR: 2.84 / NLR: 0.21
	RA code (M05.xx) + Biologics + Leflunomide + Any other DMARDs		96.5%	61.4%	93.2%	76.2%	Accuracy: 91.1 PLR: 2.50 / NLR: 0.06
	RA code (M05.xx) + Biologics + Leflunomide + Any NSAIDs		89.3%	30.9%	87.6%	34.6%	Accuracy: 80.2 PLR: 1.29 / NLR: 0.35
	RA code (M05.xx) + Biologics + Leflunomide + Any NSAIDs and any DMARDs		85.8%	69.5%	93.9%	47.3%	Accuracy: 83.3 PLR: 2.81 / NLR: 0.20
	RA code (M05.xx) + Biologics + MTX & Leflunomide + Any other DMARDs		96.5%	60.6%	92.9%	76.2%	Accuracy: 90.8 PLR: 2.45 / NLR: 0.06
	RA code (M05.xx) + Biologics + MTX & Leflunomide + Any NSAIDs		88.3%	30.8%	87.3%	32.9%	Accuracy: 79.3 PLR: 1.28 / NLR: 0.38
	RA code (M05.xx) + Biologics + MTX & Leflunomide + Any NSAIDs and any DMARDs		84.7%	68.8%	93.6%	45.6%	Accuracy: 82.2 PLR: 2.72 / NLR: 0.22
	Final: RA code (M05.xx) + Biologics + any DMARDs		96.5%	58.7%	92.3%	76.2%	Accuracy: 90.3 PLR: 2.33 / NLR: 0.06
Convertino et al. 2021, Italy	RA according to HDRs or EDAs (ICD-9 code 714*)	Chart Medical Records; diagnosis by Rheumatologist	0.53 (0.43-0.63)	0.89 (0.83-0.93)	0.74 (0.63-0.84)	0.76 (0.70-0.82)	
	RA according to exemption code from co-payment (006)		0.77 (0.67-0.84)	0.90 (0.85-0.94)	0.82 (0.73-0.89)	0.87 (0.81-0.91)	
	RA according to HDRs or EDAs (ICD-9 code 714*) AND RA according to exemption code from co-payment (006)		0.37 (0.28-0.47)	0.95 (0.90-0.98)	0.81 (0.67-0.91)	0.72 (0.65-0.77)	
	RA according to HDRs or EDAs (ICD-9 code 714*) OR RA according to exemption code from co-payment (006)		0.93 (0.86-0.97)	0.84 (0.78-0.90)	0.78 (0.70-0.85)	0.95 (0.91-0.98)	
Curtis et al. 2018 USA	ICD-9 codes 714.0, 714.2, 714.81	Clinical diagnosis by rheumatologist in the Corrona registry					
	≥1 year (Medicare)		NR	NR	0.70 (0.64-0.77)	NR	
	≥1 year (Commercial Health Plan)		NR	NR	0.73 (0.58-0.89)	NR	
	≥2 year (Medicare)		NR	NR	0.73 (0.64-0.82)	NR	

	≥2 year (Commercial Health Plan)		NR	NR	0.68 (0.48-0.89)	NR	
	ICD-9 codes 714.xx						
	≥1 year (Medicare)		NR	NR	0.71 (0.64-0.77)	NR	
	≥1 year (Commercial Health Plan)		NR	NR	0.74 (0.61-0.88)	NR	
	≥2 year (Medicare)		NR	NR	0.75 (0.66-0.83)	NR	
	≥2 year (Commercial Health Plan)		NR	NR	0.71 (0.52-0.91)	NR	
Fowles et al. 1995, USA	Any ICD-9-CM code for RA diagnosis in the claims	Medical record review	44.4%*	99.7%*	44.4%*	99.7%*	Agreement: 99.4% *K*= 0.44
Hanly et al. 2015 Canada	A1: Two physician visits for RA at least 2 months apart	Medical chart review Rheumatologist's diagnosis	83.0% (79.8-86.2)	80.8% (79.1-82.5)	51.9% (48.6-55.3)	95.0% (94.0-96.0)	Accuracy: 81.2 (79.4-83.0)
	A2: A1, excluding individuals with at least 2 visits, at least 2 months apart, subsequent to the second RA visit, with 2 identical diagnosis of other IAs and CTDs and excluding diagnosis of RA when it was not confirmed by rheumatologist		68.8% (64.9-72.7)	80.8% (79.1-82.5)	47.2% (43.7-50.7)	91.2% (90.0-92.5)	Accuracy: 78.3 (76.5-80.2)
	A3: 3 RA diagnostic billing codes over any time period		83.2% (80.0-86.3)	81.6% (80.0-83.2)	53.0% (49.7-56.4)	95.1% (94.1-96.1)	Accuracy: 81.9 (80.2-83.7)
	A4: ≥1 hospitalisation where RA was in the diagnostic codes		20.7% (17.3-24.2)	98.5% (97.9-99.0)	77.1% (70.2-83.9)	83.2% (83.2-84.7)	Accuracy: 82.9 (81.5-84.4)
	A5: ≥1 RA code by rheumatologist		87.7% (84.9-90.5)	75.5% (73.7-77.3)	47.2% (44.1-50.3)	96.1% (95.1-97.0)	Accuracy: 77.9 (76.0-80.0)
	A6: A1 OR A5 OR A4 AND A2		92.0% (89.7-94.3)	74.3% (72.4-76.1)	47.2% (44.1-50.2)	97.4% (96.6-98.1)	Accuracy: 77.8 (75.8-79.8)
	A7: Any single diagnostic code for RA		94.8% (92.9-96.7)	62.5% (60.4-64.5)	38.7% (36.1-41.3)	98.0% (97.2-98.7)	Accuracy: 68.9 (66.5-71.4)
Huang et al.¥ 2020 USA	*2010 Algorithm (regression coefficient):* NLP RA (0.970) + NLP seropositive (2.77) + ICD RA normalized 714.xx (66.0) + ICD RA 714.xx (0.639) + NLP erosions (1.26) + codified RF negative (0.851) + NLP methotrexate (0.632) + codified anti-TNF (0.959) + NLP anti CCP positive (1.31) + NLP anti-TNF (0.521) + NLP other DMARDs (0.298) – ICD JRA 714.3x (2.25) – ICD SLE 710 (0.959) – NLP PsA (0.856)	Validation set General RA mart (n=200)	0.76	0.95	0.91	0.87	ROC: 0.932
	2017 Updated Algorithm:	Validation set General RA mart (n=200)	0.77	0.95	0.91	0.87	ROC: 0.937

	Same model and regression coefficients incorporating ICD-10 codes (M05.x, M06.x) and updated medications to include newer anti-TNFs, anti-L6 and JAK inhibitors	Validation set RA subjects with ICD-10 codes (no RA ICD-9 codes) (n=100)	0.47	0.95	0.93	0.60	ROC= 0.784
	Rule-based algorithm: ≥3 ICD-9 RA codes	Validation set General RA mart (n=200)	0.79	0.59	0.54	0.82	-
	Rule-based algorithm: ≥3 ICD-9 or ICD-10 RA codes	Validation set General RA mart (n=200)	0.89	0.58	0.56	0.90	-
	≥3 ICD-10 RA codes	Validation set RA subjects with ICD-10 codes (no RA ICD-9 codes) (n=100)	0.58	0.50	0.58	0.50	-
Ibfelt et al. 2017 Demark	ICD-10 RA diagnostic codes (M05.9, M06.0, M06.8, M06.9)	DANBIO (n= 573)	NR	NR	92%	NR	
	(DNPR= RA diagnosis in 2011 AND at least on additional visit with a RA diagnosis within 90 days after the first visit)	DNPR (n= 1,371)	NR	NR	79%	NR	
Katz et al. 1997 USA	ICD-9-CM codes for RA (714.0, 714.1, 714.2, 714.3, 714.30, 714.31, 714.32, 714.33)	Medical records review-diagnosis by rheumatologists and 1990 ACR criteria	0.90 (0.85-0.95)	NR	0.95 (0.92-0.98)	NR	
Kim et al. 2011 USA	*No DMARD prescription filling required:* ≥2 claims associated with RA ICD-9-CM code 714	RA by rheumatologist	NR	NR	55.7% (46.8-64.4)	NR	
		≥4 ACR criteria	NR	NR	33.6% (25.6-42.4)	NR	
	≥3 claims associated with RA ICD-9-CM code 714	RA by rheumatologist	NR	NR	65.5% (55.8-74.3)	NR	
		≥4 ACR criteria	NR	NR	40% (30.8-49.8)	NR	
	≥2 RA claims by rheumatologist and separated by 7 days	RA by rheumatologist	NR	NR	66.7% (55.5-76.6)	NR	
		≥4 ACR criteria	NR	NR	39.3% (28.8-50.6)	NR	
	At least 1 DMARD prescription filling is required ≥2 claims associated with RA ICD-9-CM code 714	RA by rheumatologist	NR	NR	86.2% (74.6-93.9)	NR	
		≥4 ACR criteria	NR	NR	58.6% (44.9-71.4)	NR	
	≥3 claims associated with RA ICD-9-CM code 714	RA by rheumatologist	NR	NR	87.5% (75.9-94.8)	NR	
		≥4 ACR criteria	NR	NR	60.7% (46.8-73.5)	NR	
	≥2 RA claims by rheumatologist and separated by 7 days	RA by rheumatologist	NR	NR	88.9% (76.0-96.3)	NR	
		≥4 ACR criteria	NR	NR	55.6% (40.0-70.4)	NR	

Kronzer et al. 2020, USA	eMERGE RA algorithm: β = 1.937*log(1 + *RAICD*) + 1.639**LabCount* − 0.529*log(1 + *SLE*) − 0.122*log(1 + *Psoriatic*)− 0.954*log(1 + *Diagnoses*)^	Manual chart review against 1987 ACR or 2010 ACR/EULAR criteria	53%	99%	97%	74%	ROC: 76%
	RA duration:		28%	99%	90%	76%	ROC: 63%
	2 to <5 years						
	5 to <10 years		63%	97%	94%	80%	ROC: 80%
	≥10 years		71%	99%	99%	74%	ROC: 85%
	Electronic Health Record lookback:		13%	100%	100%	61%	ROC: 56%
	1 year						
	3 years		38%	99%	98%	68%	ROC: 68%
	5 years		45%	99%	96%	71%	ROC: 72%
	10 years and 15 years		52%	99%	97%	73%	ROC: 75%
Kubota et al. 2021 Japan	1A: RA code in one or more monthly claims	Chart review by rheumatologists	86.3% (78-4-94.2)	99.6% (99.5-99.7)	56.8% (47.5-66.0)	99.9% (99.9-100)	
	1B: RA code in 1 inpatient or ≥2 outpatient monthly claims		83.6% (75.1-92.1)	99.7% (99.6-99.8)	58.7% (49.9-68.1)	99.9% (99.9-100)	
	2A: Any DMARD in ≥1 monthly claim		61.6% (50.5-72.8)	99.9% (99.8-99.9)	72.6% (61.5-83.7)	99.8% (99.7-99.9)	
	2B: Any DMARD in ≥2 monthly claims		60.3% (49.0-71.5)	99.9% (99.8-99.9)	74.6% (63.5-85.7)	99.8% (99.7-99.9)	
	3A: Oral corticosteroid in ≥1 monthly claim		NA	NA	NA	NA	
	3B: Oral corticosteroid in ≥2 monthly claim		NA	NA	NA	NA	
	4: SADs (other than RA) or Polymyalgia rheumatica (Exc.cri)		NA	NA	NA	NA	
	1A AND 2A		58.9% (47.6-70.2)	99.9% (99.9-100)	86% (76.4-95.6)	99.8% (99.7-99.9)	
	1A AND 2B		57.5% (46.2-68.9)	100% (99.9-100)	89.4% (80.5-98.2)	99.8% (99.7-99.8)	
	1B AND 2A		58.9% (47.6-70.2)	100% (99.9-100)	89.6% (80.9-98.2)	99.8% (99.7-99.9)	
	1B AND 2B		57.5% (46.2-68.9)	100% (99.9-100)	89.4% (80.5-98.2)	99.8% (99.7-99.8)	
	1A AND 3A		35.6% (24.6-46.6)	99.8% (99.8-99.9)	55.3% (41.1-69.5)	99.6% (99.5-99.7)	
	1A AND 3B		26% (16.0-36.1)	99.9% (99.8-99.9)	55.9% (39.2-72.6)	99.6% (99.5-99.7)	
	1A AND (2A OR 3A)		72.6% (62.4-82.8)	99.8% (99.7-99.9)	69.7% (59.4-80.1)	99.8% (99.8-99.9)	
	1A AND (2B OR 3B)		65.8% (54.9-76.6)	99.9% (99.8-99.9)	76.2% (65.7-86.7)	99.8% (99.7-99.9)	

	1B AND (2A OR 3B)		67.1% (56.3-77.9)	99.9% (99.8-99.9)	77.8% (67.5-88.0)	99.8% (99.7-99.9)
	1A AND (2B or (3A AND 4))		72.6% (62.4-82.8)	99.9% (99.8-99.9)	79.1% (69.4-88.8)	99.8% (99.8-99.9)
	1B AND (2B or (3A AND 4))		72.6% (62.4-82.8)	99.9% (99.8-100)	80.3% (70.7-89.9)	99.8% (99.8-99.9)
	1B AND (2A or (3B AND 4))		67.1% (56.3-77.9)	99.9% (99.9-100)	84.5% (75.2-93.8)	99.8% (99.7-99.9)
	2B OR (1B AND 3A AND 4)		75.3% (65.5-85.2)	99.8% (99.7-99.9)	70.5% (60.4-80.6)	99.9% (99.8-99.9)
Liao et al. [¥] 2010 USA	*Algorithm (regression coefficient):* NLP RA (1.11) + NLP seropositive (0.74) + ICD-9 RA normalized 714.xx (0.71) + ICD RA 714.xx (0.66) + NLP erosions (0.46) + codified RF negative (0.36) + NLP methotrexate (0.3) + codified anti-TNF (0.29) + NLP anti CCP positive (0.27) + NLP anti-TNF (0.2) + NLP other DMARDs (0.13) – ICD JRA 714.3x (0.98) – ICD SLE 710 (0.57) – NLP PsA (0.51)					
	Algorithm 1: Narrative and codified (complete)	Validation set General RA Mart	63% (51-75)	NR	94% (91-96)	NR
	Algorithm 2: Codified only		51% (42-60)	NR	88% (84-92)	NR
	Algorithm 3: NLP only		56% (46-66)	NR	89% (86-93)	NR
Linauskas et al. 2018 Denmark	*Overall*	Medical records, RA diagnosis verified against 1958 ACR, 1987 ACR or 2010 ACR/EULAR criteria. If unmet, clinical assessment by rheumatologist	NR	NR	61.9% (56.6-67.0)	NR
	Firs-time RA diagnosis registration ever in the DNPR (712.39, M05, M06)					
	Firs-time RA diagnosis registration ever in the DNPR (712.39, M05, M06) AND ≥1 DMARDs prescription		NR	NR	87.7% (82.5-91.5)	NR
	ICD-8 codes		NR	NR	78.4% (61.5-89.2)	NR
	Firs-time RA diagnosis registration ever in the DNPR					
	Firs-time RA diagnosis registration ever in the DNPR AND ≥1 DMARDs prescription		NR	NR	92.6% (72.8-98.3)	NR
	ICD-10 M05 code		NR	NR	62.0% (53.9-69.5)	NR
	Firs-time RA diagnosis registration ever in the DNPR					
	Firs-time RA diagnosis registration ever in the DNPR AND ≥1 DMARDs prescription		NR	NR	80.2% (71.6-86.7)	NR
	ICD-10 M06 code		NR	NR	25.0% (18.5-32.8)	NR
	Firs-time RA diagnosis registration ever in the DNPR					
	Firs-time RA diagnosis registration ever in the DNPR AND ≥1 DMARDs prescription		NR	NR	41.1% (30.2-52.9)	NR

Losina et al. 2003	Codes 714 or 714.0 in Medicare (part A/hospital) claims	Medical record review by trained nurses	0.65 (0.49-0.80)	NR	0.86 (0.73-0.99)	NR	
USA	Codes 714 or 714.0 in Medicare (part A/hospital and part B/surgeon's) claims		NR	NR	NR	NR	
Nanji et al. 2012 Canada	ICD-9 codes 714 or 714.0	Chart review by rheumatologist clinical diagnosis	NA	NA	70.9%*	NA	
Ng et al. 2012 USA	*All patients (with or without DMARDs therapy for ≥180 days*	Medical record review	NA	NA	30.9% (27.7-34.2)	NR	
	2 RA codes (any visit)						
	2 RA codes + ≥1 RA code in rheumatologist visit		47.6 (41.4-53.8)	68.3 (62.5-74.1)	40.2 (34.1-46.3)	NR	
	2 RA codes + ≥1 RA code in rheumatologist visit + last rheumatologist visit with and RA code		39.3 (30.5-48.0)	91.5 (86.5-96.5)	67.3 (58.9-75.8)	NR	
	Patients with DMARD therapy for ≥180 days		88.1 (84.7-91.5)	74.1 (69.6-78.7)	60.4 (55.3-65.5)	NR	
	2 RA codes (any visit)						
	2 RA codes + ≥1 RA code in rheumatologist visit		44.6 (35.7-53.6)	93.3 (88.9-97.8)	75.0 (67.2-82.8)	NR	
	2 RA codes + ≥1 RA code in rheumatologist visit + last rheumatologist visit with and RA code		38.1 (27.7-48.5)	98.4 (95.7-100)	91.4 (85.4-97.4)	NR	
Paltta et al. 2021, Finland	≥1 ICD 10 (M0.58, M05.9 or M06.0) code on CRHC visit with RA	All RA/chart review	NR	NR	0.82 (0.76-0.87)	1.00 (0.98-1.00)	PLR: 6.89 (5.21- 9.12) NLR: 0.01 (0.00-0.04)
		Sero(+) RA/chart review	NR	NR	0.75 (0.67-0.83)	1.00 (0.98-1.00)	PLR: 9.48 (6.71-13.4) NLR: 0.01 (0.00-0.09)
		Sero(-) RA/chart review	NR	NR	0.71 (0.62-0.79)	1.00 (0.98-1.00)	PLR: 8.44 (6.12-11.6) NLR: 0.01 (0.00-0.10)
	≥1 ICD 10 (M0.58, M05.9 or M06.0) code on CRHC visit with RA and reimbursement for DMARDs with inclusion diagnosis (202, 281, 313)	All RA/chart review	NR	NR	0.89 (0.83-0.94)	1.00 (0.98-1.00)	PLR: 16.4 (10.2-26.4) NLR: 0.01 (0.00-0.05)
		Sero(+) RA/chart review	NR	NR	0.93 (0.84-0.98)	1.00 (0.98-1.00)	PLR: 62.2 (23.5-164.4) NLR: 0.02 (0.00-0.12)
		Sero(-) RA/chart review	NR	NR	0.79 (0.68-0.87)	1.00 (0.98-1.00)	PLR: 16.3-10.1-26.2) NLR: 0.02 (0.00-0.12)
	≥1 ICD 10 (M0.58, M05.9 or M06.0) code on CRHC visit with RA and ACPA positivity	All RA/chart review	NR	NR	0.98 (0.91-1.00)	1.00 (0.98-1.00)	PLR: 246.03 (34.8-1740.2) NLR: 0.02 (0.00-0.11)
		Sero(+) RA/chart review	NR	NR	0.96 (0.87-1.00)	1.00 (0.98-1.00)	PLR: 123.2 (30.9-490.03) NLR: (0.02 (0.00-0.13)
		Sero(-) RA/chart review	NR	NR	-	-	-
Pedersen et al. 2004 Denmark	ICD-8 or ICD-10 codes for RA (712.19, 712.39, 712.59, M05, M06)	Clinical diagnosis (n=217)	NA	NA	58.9%	NA	
		1987 ACR criteria (n=199)	NA	NA	46%	NA	

Singh et al. 2004, USA	1 ICD-10 code 714 alone	RA diagnosis by a rheumatologist on 2 separate occasions >6 weeks apart	100% (NA)	55% (48-62)	66.2% (59-73)	100% (NA)	ROC: 0.77 (0.69-0.85)
	ICD-10 714 and ≥3-month prescription of a DMARD		84.9% (80-90)	82.7% (77-88)	81.1% (75-87)	86.2% (81-91)	ROC: 0.84 (0.77-0.90)
	ICD-10 code 714 and a positive RF		88.2% (83-93)	91.4% (87-96)	92.6% (88-97)	86.5% (81-92)	ROC: 0.90 (0.84-0.95)
	≥3-month prescription of a DMARD and positive RF		76.5% (70-83)	95.7% (92-99)	95.6% (92-99)	77% (70-84)	ROC: 0.86 (0.80-0.92)
	ICD-10 code 714 and a DMARD prescription and positive RF		76.5% (70-83)	97.1% (94-100)	97% (94-100)	77.3% (71-84)	ROC: 0.87 (0.81-0.93)
Sugiyama et al. 2024, Japan	*Prevalent group (n=389)*	Physician diagnosis	NR	NR	77.6% (73.5-81.8)	NR	
	One definite diagnosis within a claim month (M05, M06) AND no diagnosis of psoriasis (L40, L41, M07) AND prescription of any DMARD OR Glucocorticoid (n=389)	ACR/EULAR criteria	NR	NR	22.6% (18.5-26.8)	NR	
		Overall adjudicator decision-confirmed cases	NR	NR	55.5% (50.6-60.5)	NR	
	One definite diagnosis within a claim month (M05, M06) AND no diagnosis of psoriasis (L40, L41, M07) AND any DAMRD (n=290)	Physician diagnosis	NR	NR	88.6% (84.6-91.2)	NR	
		ACR/EULAR criteria	NR	NR	29.0% (23.7-34.2)	NR	
		Overall adjudicator decision-confirmed cases	NR	NR	71.7% (66.5-76.9)	NR	
	Incident group (n=134)	Physician diagnosis	NR	NR	59.7% (51.4-68.0)	NR	
	One definite diagnosis within a claim month (M05, M06) AND no diagnosis of psoriasis (L40, L41, M07) AND prescription of any DMARD OR Glucocorticoid (n=134)	ACR/EULAR criteria	NR	NR	23.9% (16.7-31.3)	NR	
		Overall adjudicator decision-confirmed cases	NR	NR	38.8% (30.6-47.1)	NR	
	One definite diagnosis within a claim month (M05, M06) AND no diagnosis of psoriasis (L40, L41, M07) AND any DAMRD (n=78)	Physician diagnosis	NR	NR	76.9% (67.6-86.3)	NR	
		ACR/EULAR criteria	NR	NR	41.0% (30.1-51.9)	NR	
		Overall adjudicator decision-confirmed cases	NR	NR	64.1% (53.5-74.8)	NR	
Thomas et al. 2008, UK	>1 RA code (on different dates)	1987 ACR criteria applied from CPs records	80%	81%	84%*	76.2%*	OR: 16.8 (8.66-32.7) AOR: 5.18 (2.06-12.9)
	RA diagnostic group 1 or 2#		93%	49%	69.9%*	84.5%*	OR: 12.6 (5.77-27.7) AOR: 6.33 (1.84-21.7)
	≥1 DMARD prescription in GPRD with no prior alternative indication for the DMARD		78%	96%	96%*	77%*	OR: 81.4 (27.5-241.02) AOR: 55.5 (15.1-203.5)

	No alternative diagnosis on computer after last RA code		86%	40%	64.8%*	69.5%*	OR: 4.20 (2.22-7.97) AOR: 2.58 (0.94-7.11)
	An appropriate GPRD DMARD prescription OR no appropriate DMARD prescription and being in RA Group 1-2, having no alternative GPRD diagnosis for RA after last RA code and having >1 RA code during follow-up		84% (73-94)	86% (72-92)	NR	NR	NR
Waldenlind et al 2014 Sweden	*Prevalent group (n=100)* ≥2 visits to rheumatologist between 2005-2008 listing an ICD-10 code M05.9 or M06.0	1987 ACR and 2010 ACR/EULAR criteria	NA	NA	91%*	NA	
	Incident group (n=102) First ever visit to a rheumatologist in 2008 listing an ICD-10 code M05.9 or M06.0		NA	NA	83.3%*	NA	
Wei et al. 2016 USA	ICD-9 only	Manual chart review by 5 authors with medical background	0.05	NR	0.36	NR	F-score= 0.08
	≥2 ICD-9 codes		0.31	NR	0.77	NR	F-score= 0.44
	Primary Clinical notes only		0.60	NR	0.20	NR	F-score= 0.30
	Medications only		0.00	NR	0.00	NR	F-score= 0.00
	ICD-9 AND primary notes		0.25	NR	0.76	NR	F-score= 0.38
	ICD-9 AND medications		0.00	NR	0.64	NR	F-score= 0.01
	Primary notes AND medications		0.01	NR	0.88	NR	F-score= 0.03
	ICD-9 AND medications AND primary notes		0.08	NR	0.84	NR	F-score= 0.15
Widdifield et al. 2013, Canada	*Patients ≥20 years (n=447)* 1 Hospitalisation (H) ever	Medical records, clinical diagnosis by rheumatologists	23% (16-30)	96% (94-99)	76% (63-88)	72% (67-76)	
	1 H ever OR 1 Emergency Room (ER) visit ever		27% (20-34)	96% (93-98)	76% (64-87)	73% (68-77)	
	1 Physician diagnostic code (P) ever		100% (100-100)	60% (54-65)	55% (49-61)	100% (100-100)	
	1 P ever by a specialist		99% (98-100)	77% (72-82)	68% (62-74)	100% (99-100)	
	(1 H ever) OR (2 P with ≥1 P by a specialist in 1 year)		98% (96-100)	82% (78-86)	73% (67-79)	99% (97-100)	
	(1 H ever) OR (2 P with ≥1 P by a specialist in 2 years)		99% (97-100)	81% (77-86)	72% (66-79)	99% (98-100)	
	(1 H ever) OR (2 P with ≥1 P by a specialist in 3 years)		99% (97-100)	81% (76-85)	72% (65-78)	99% (98-100)	
	(1 H ever) OR (3 P with ≥1 P by a specialist in 1 year)		94% (90-98)	87% (84-91)	79% (73-85)	97% (95-99)	
	(1 H ever) OR (3 P with ≥1 P by a specialist in 2 years)		97% (94-100)	85% (81-89)	76% (70-82)	98% (96-100)	
	(1 H ever) OR (3 P with ≥1 P by a specialist in 3 years)		97% (94-100)	85% (81-89)	76% (70-82)	98% (96-100)	

	Patients ≥65 years (n= 159)		93%	84%	77%	96%
	1 P AND ≥1 DMARD or biologic agent		(86-100)	(77-91)	(67-87)	(91-100)
	2 P ≥60 days apart AND ≥1 DMARD or biologic agent		93%	88%	82%	96%
			(86-100)	(82-95)	(72-91)	(92-100)
	(1 H ever) OR (2 P AND ≥1 DMARD or biologic agent in 1 yr)		91%	92%	87%	95%
			(84-99)	(87-97)	(78-95)	(91-99)
	(1 H ever) OR (3 P AND ≥1 DMARD or biologic agent in 1 yr)		90%	96%	93%	94%
			(82-97%)	(92-100)	(86-100)	(90-99)
	(1 H ever) OR (3 P with ≥1 P by specialist AND ≥1 DMARD or biologic agent in 1 yr)		90%	96%	93%	94%
			(82-97%)	(92-100)	(86-100)	(90-99)
Widdifield et al. 2014, Canada	*Patients ≥20 years (n= 7500)*	Medical record review	22%	100%	88%	99%
	1 Hospitalisation (H) ever	1- diagnosis by rheumatologist,	(12-32)	(100-100)	(73-100)	(99-100)
	1 H ever OR 1 Emergency Room (ER) visit ever	orthopaedic surgeon, or	23%	100%	80%	99%
		internal medicine specialist or,	(13-33)	(100-100)	(63-98)	(99-100)
	1 physician diagnostic code (P) ever	2- primary care physician	90%	97%	20%	100%
		diagnosis with supporting	(83-97)	(96-97)	(16-25)	(100-100)
	1 P ever by a specialist	evidence	81%	99%	51%	100%
			(72-90)	(99-100)	(42-60)	(100-100)
	2 P by any physician in 1 year		84%	99%	46%	100%
			(75-93)	(99-99)	(37-55)	(100-100)
	2 P by any physician in 2 years		84%	99%	45%	100%
			(75-93)	(99-99)	(36-53)	(100-100)
	2 P by any physician in 3 years		84%	99%	42%	100%
			(75-93)	(99-99)	(34-51)	(100-100)
	3 P by any physician in 1 year		80%	100%	63%	100%
			(70-89)	(99-100)	(52-73)	(100-100)
	3 P by any physician in 2 years		80%	100%	60%	100%
			(70-89)	(99-100)	(50-71)	(100-100)
	3 P by any physician in 3 years		80%	100%	59%	100%
			(70-89)	(99-100)	(49-69)	(100-100)
	2 P with ≥1 P by specialist in 1 year		78%	100%	67%	100%
			(69-88)	(100-100)	(56-77)	(100-100)
	2 P with ≥1 P by specialist in 2 years		78%	100%	67%	100%
			(69-88)	(100-100)	(56-77)	(100-100)
	2 P with ≥1 P by specialist in 3 years		78%	100%	64%	100%
			(69-88)	(100-100)	(54-75)	(100-100)
	3 P with ≥1 P by specialist in 1 year		77%	100%	82%	100%
			(67-87)	(100-100)	(72-91)	(100-100)
	3 P with ≥1 P by specialist in 2 years		77%	100%	80%	100%
			(67-87%)	(100-100)	(71-90)	(100-100)

	3 P with ≥1 P by specialist in 3 years		77% (67-87%)	100% (100-100)	80% (71-90)	100% (100-100)	
	(1 H ever) OR (2 P with ≥1 P by specialist in 1 year)		80% (70-89)	100% (100-100)	66% (56-76)	100% (100-100)	
	(1 H ever) OR (2 P with ≥1 P by specialist in 2 years)		80% (70-89)	100% (100-100)	66% (56-76)	100% (100-100)	
	(1 H ever) OR (2 P with ≥1 P by specialist in 3 years)		80% (70-89)	100% (99-100)	64% (54-74)	100% (100-100)	
	(1 H ever) OR (3 P with ≥1 P by specialist in 1 year)		78% (69-88)	100% (100-100)	79% (79-89)	100% (100-100)	
	(1 H ever) OR (3 P with ≥1 P by specialist in 2 years)		78% (69-88)	100% (100-100)	78% (69-88)	100% (100-100)	
	(1 H ever) OR (3 P with ≥1 P by specialist in 3 years)		78% (69-88)	100% (100-100)	78% (69-88)	100% (100-100)	
	(1 H ever) OR (2 P ≥8 weeks apart in 2 years)		83% (74-92)	99% (99-100)	52% (43-61)	100% (100-100)	
	Patients ≥65 years (n= 3426)		84% (75-93)	97% (96-97)	32% (25-39)	100% (100-100)	
	1 P AND 1≥ Rx (corticosteroids, DMARDs, biologics) ever		81% (71-91)	99% (98-99)	53% (43-63)	100% (99-100)	
	2 P AND 1≥ Rx (corticosteroids, DMARDs, biologics) ever		83% (73-92)	99% (99-100)	67% (56-77)	100% (100-100)	
	(1 H ever) OR (2 P AND ≥1 Rx in 1 year)		75% (64-85)	100% (99-100)	73% (63-84)	100% (99-100)	
	(1 H ever) OR (3 P AND ≥1 Rx in 1 year)		75% (64-85)	100% (99-100)	80% (69-90)	100% (99-100)	
	(1 H ever) OR (3 P with ≥1 P by specialist AND ≥1 Rx in 1 year)						
Zheng et al. 2022, USA	eMERGE RA algorithm: β = 1.937*log(1 + *RAICD*) + 1.639**LabCount* − 0.529*log(1 + *SLE*) − 0.122*log(1 + *Psoriatic*)− 0.954*log(1 + *Diagnoses*)^	Clinician chart review	71.9%	95.2%	93.8%*	77.2%*	F-score: 0.814
		2010 ACR/EULAR subset	74.5%	99.5%	86.4%*	74.4%*	
Zhou et al. 2016, UK	*Phenotyping model (Decision tree) (8 code groups):* - If number of occurrences of RARTH is 0 then return that RA is 0. If number of occurrences of RARTH is >0 then move to the next branch - If INTENSITY_RA# is low (>2) then RA=0. If INTENSITY_RA is high (≤2) then move to the next branch of tree - If evidence of PSORIATIC DIAGNOSIS >0 AND PREDNISOLONE prescription codes occurs ≤43 times then return RA=0, but if prednisolone codes occur >43 times then return RA	*Validation set* Secondary care/GP overlap population in Cardiff (Cardiff-Cellma) *Validation set* Primary care population (ABMU-Cellma) *Worst-case scenario (no record in outpatients signifies not RA)*	86.2% 83%	94.6% 99%	85.6% 30.9%	NR NR	Accuracy: 92.3%

- If no evidence of Psoriatic diagnosis AND evidence of METHOTREXATE OR SULPHASALAZINE (>18 prescriptions) OR LEFLUNOMIDE the return RA - If no evidence of DMARDs but evidence of ALTERNATIVE_RA (alternative diagnosis) then return RA=0, if no evidence of alternative diagnosis then return RA=1	*Best-case scenario (no record in outpatients signifies patient with RA treated elsewhere)*	94%	99%	91.3%	NR

Abbreviations: NR: Not Reported; NA= Not Applicable; CADs= Chronic Autoimmune Diseases; HDRs= Hospital Discharge Records; EDAs= Emergency Department Admissions; GCs= Glucocorticoids; RA= Rheumatoid Arthritis; CRCH= Finnish Care Register for Health Care; PLR: Positive Likelihood Ratio; NLR: Negative Likelihood Ratio; ACPA= Anti-citrullinated Protein Antibody; CPs= Clinical Practices; OR= Odds Ratio; AOR= Adjusted Odds Ratio; GPRD= General Practice Research Database; DMARDs= Disease-modifying Antirheumatic Drugs; RF= Rheumatoid Factor; ROC= Receiving Operating Characteristic curve area; NLP= Natural Language Processing; PsA= Psoriatic Arthritis; MTX: Methotrexate; EDW= Enterprise Data Warehouse; VUMC-SD= Vanderbilt University Medical Center's Synthetic Derivative; IAs= Inflammatory Arthritis; CTDs= Connective Tissue Diseases; DNPR= Danish National Patient Registry; RARTH= RA codes as defined in the NHS Wales QOF Rheumatoid Arthritis Indicator Set

* Calculated from data provided by 2x2 tables or when information was available.

¥ Studies validating the same algorithm and same administrative data source.

Four level of strength of evidence based on GPRD codes for potential RA cases, where 1= strongest evidence and 4= weakest evidence (Group 1 included codes for seropositive or erosive RA, Group 2 comprised "rheumatoid arthritis codes- such as RA of knee, Group 3 codes for systemic manifestations of RA and Group 4 codes for seronegative RA or other weak evidence for RA).

^ *RAICD*, the total number of RA ICD-9 and ICD-10 diagnoses (714, 714.0, 714.1, 714.2, M05.*, M06. *); *LabCount*, whether the highest RF lab value seen in the patient's charts is either abnormal (LabCount = 1) or normal/unavailable (Lab Count = 0); *SLE*, the total number of SLE ICD-9/10 diagnoses; *Psoriatic*, the total number of psoriatic arthritis ICD-9/10 diagnoses; and *Diagnoses*, the total number of ICD-9/10 diagnoses in the patient's charts. Patients who scored greater than 0.632 were predicted as positive for RA.

Table 2.2. Accuracy measures of individual studies assessing JIA codes and algorithms in electronic health records (n=5).

Author, Year, Country	Algorithm definition	Reference standard	Measures of Accuracy/Results				
			Sensitivity (95% CIs)	Specificity (95% CIs)	PPV (95% CIs)	NPV (95% CIs)	Other (95% CIs)
Harrold et al. 2013, USA	≥1 diagnosis code from any provider	Manual chart review (Clinical diagnosis by adult or paediatric rheumatologist)	100%	NR	69% (59-78)	NR	
	≥2 diagnosis codes from any provider		87% (76-93)	NR	91% (80-96)	NR	
	≥1 diagnosis code from rheumatology		81% (69-89)	NR	90% (79-96)	NR	
	Incident JIA ≥1 diagnosis code from any provider		100%	NR	45% (35-56)	NR	
	≥1 diagnosis code from rheumatology		95% (84-99)	NR	70% (57-81)	NR	
	≥1 diagnosis code from rheumatology + ≥2 laboratory test performed (ANA, RF, HLA-B27)		93% (79-98)	NR	75% (61-86)	NR	
	≥1 diagnosis code from rheumatology + ≥2 laboratory test performed (ANA, RF, HLA-B27) + ≥12 months of pre-diagnostic enrolment		95% (81-99)	NR	82% (67-91)	NR	
Peterson et al. 2023, USA	≥1 ICD-9 codes alone	Chart review by paediatric rheumatologist (JIA ICD code at age ≤20 years and a rheumatology clinic note documenting diagnosis)	82%	NR	48%	NR	F-measure= 61%
	≥2 ICD-9 codes alone		75%	NR	68%	NR	F-measure: 71%
	≥3 ICD-9 codes alone		72%	NR	79%	NR	F-measure: 75%
	≥4 ICD-9 codes alone		68%	NR	82%	NR	F-measure: 75%
	≥1 ICD-10 codes alone		76%	NR	63%	NR	F-measure: 61%
	≥2 ICD-10 codes alone		69%	NR	76%	NR	F-measure: 73%
	≥3 ICD-10 codes alone		72%	NR	85%	NR	F-measure: 75%
	≥4 ICD-10 codes alone		63%	NR	88%	NR	F-measure: 74%
	≥1 ICD-9 OR ICD-10 codes	Training set	100%	NR	48%	NR	F-measure: 64%
	≥2 ICD-9 OR ICD-10 codes		93%	NR	67%	NR	F-measure: 78%
	≥3 ICD-9 OR ICD-10 codes		89%	NR	78%	NR	F-measure: 83%
	≥4 ICD-9 OR ICD-10 codes		87%	NR	83%	NR	F-measure: 85%
	≥1 ICD codes + “JIA” OR “JRA”		94%	NR	67%	NR	F-measure: 78%
	≥2 ICD codes + “JIA” OR “JRA”		88%	NR	75%	NR	F-measure: 81%
	≥3 ICD codes + “JIA” OR “JRA”		87%	NR	84%	NR	F-measure: 86%
	≥4 ICD codes + “JIA” OR “JRA”		86%	NR	86%	NR	F-measure: 86%
	≥1 ICD codes + “enthesitis” OR “uveitis”		80%	NR	83%	NR	F-measure: 81%
	≥2 ICD codes + “enthesitis” OR “uveitis”		79%	NR	88%	NR	F-measure: 83%
	≥3 ICD codes + “enthesitis” OR “uveitis”		77%	NR	92%	NR	F-measure: 84%

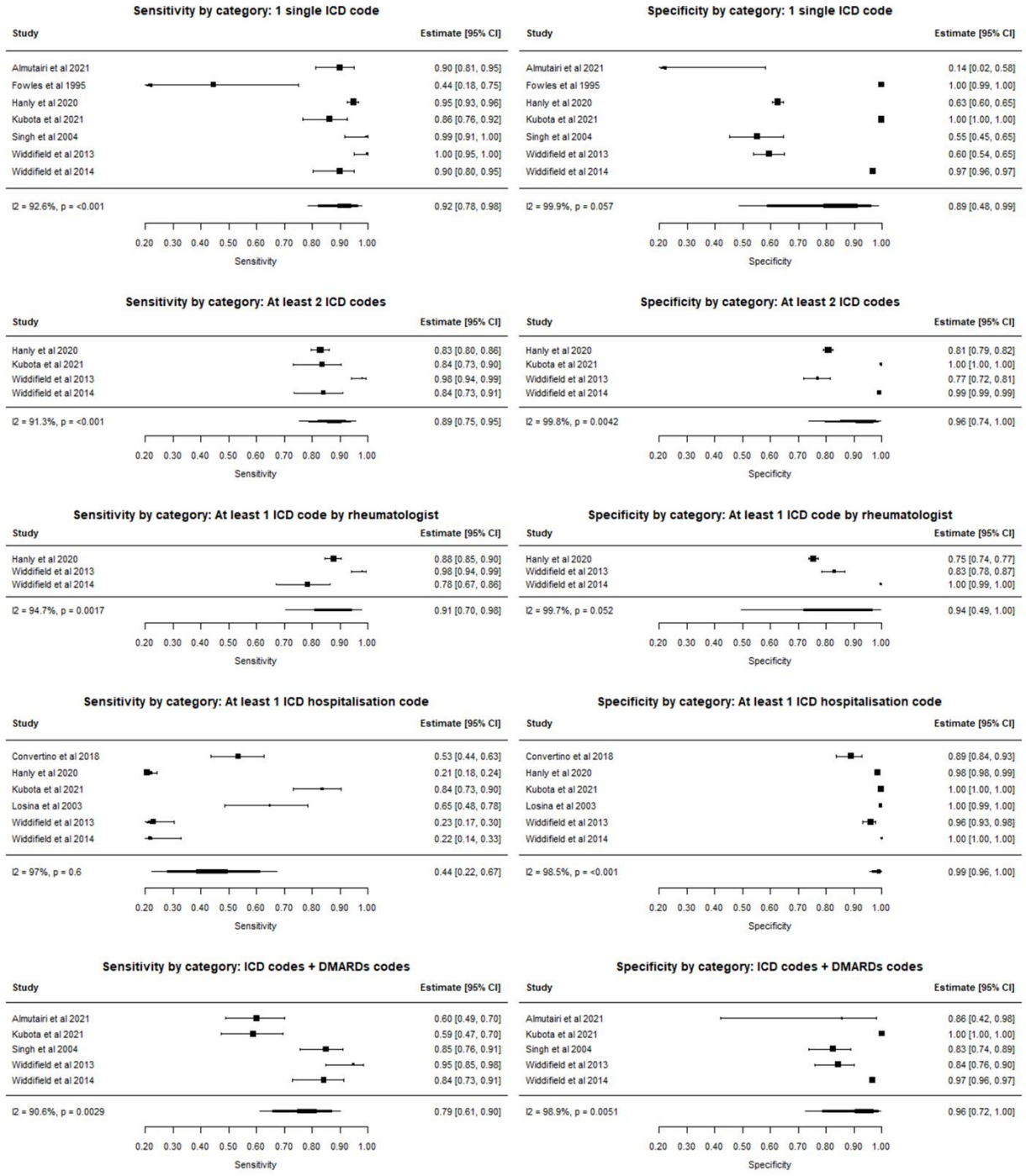
	≥4 ICD codes + “enthesitis” OR “uveitis”		78%	NR	96%	NR	F-measure: 86%
	≥1 ICD codes + “JIA” OR “JRA” AND “enthesitis” OR “uveitis”		78%	NR	88%	NR	F-measure: 83%
	≥2 ICD codes + “JIA” OR “JRA” AND “enthesitis” OR “uveitis”		77%	NR	91%	NR	F-measure: 83%
	≥3 ICD codes + “JIA” OR “JRA” AND “enthesitis” OR “uveitis”		77%	NR	94%	NR	F-measure: 83%
	≥4 ICD codes + “JIA” OR “JRA” AND “enthesitis” OR “uveitis”		77%	NR	96%	NR	F-measure: 85%
	≥4 ICD codes + “enthesitis” OR “uveitis” with exclusions (CTDs=710.0, 710.3, 710.4, M32, M33)	Training set	NR	NR	97%	NR	F-measure: 87%
		Validation set	NR	NR	92%	NR	F-measure: 75%
	≥4 ICD codes + “enthesitis” OR “uveitis” AND “JIA” OR “JRA” with exclusions (CTDs=710.0, 710.3, 710.4, M32, M33)	Training set	NR	NR	97%	NR	F-measure: 86%
		Validation set	NR	NR	94%	NR	F-measure: 75%
	≥4 ICD codes + “uveitis” with exclusions (CTDs=710.0, 710.3, 710.4, M32, M33)	Training set	NR	NR	97%	NR	F-measure: 85%
		Validation set	NR	NR	92%	NR	F-measure: 75%
Shiff et al. 2017, Canada	≥1 H or ≥2 diagnosis by any provider ever ≥1 day apart	Diagnosis by a paediatric rheumatologist	90.8% (88.7-92.9)	84.8% (81.3-88.3)	91.1% (89.0-93.2)	NR	
	≥1 H or ≥2 diagnosis by any provider ever ≥8 weeks apart		86.6% (84.0-89.0)	88.7% (85.7-91.7)	92.9% (90.9-94.9)	NR	
	≥1 H or ≥2 diagnosis in 2 years by any provider ≥8 weeks apart		88.2% (85.7-90.7)	90.4% (87.5-93.3)	93.9% (92.0-95.8)	NR	
	≥1 H or ≥2 diagnosis in 3 years by any provider ≥8 weeks apart		88.1% (85.6-90.6)	89.7% (86.6-92.8)	93.5% (91.5-95.5)	NR	
	≥1 H or ≥2 diagnosis in 5 years by any provider ≥8 weeks apart		88.0% (85.4-90.6)	88.2% (84.7-91.7)	93.0% (90.9-95.1)	NR	
	≥1 H or ≥3 diagnosis in 2 years by any provider ≥8 weeks apart		82.1% (79.2-85.0)	92.6% (90.0-95.2)	94.9% (93.1-96.7)	NR	
	≥1 H or ≥3 diagnosis in 3 years by any provider ≥8 weeks apart		81.9% (78.9-84.9)	92.1% (89.4-94.8)	94.5% (92.6-96.4)	NR	
	≥1 H or ≥3 diagnosis in 5 years by any provider ≥8 weeks apart		82.2% (79.1-85.3)	91.8% (88.8-94.8)	94.7% (92.8-96.6)	NR	
Stringer et al. 2015, Canada	2 JIA codes (714) ≥8 weeks apart within 2 years by any physician	Clinical chart review (diagnosis by rheumatologist based on 2004 ILAR criteria)	85%	NR	60%	NR	
	1 JIA code (714) by paediatric rheumatologist		86%	NR	58%	NR	
	2 JIA codes (714) ≥8 weeks apart within 2 years by paediatric rheumatologist		81%	NR	65%	NR	
	2 JIA codes (714) ≥8 weeks apart within 2 years by any physician excluding paediatric rheumatologist		53%	NR	52%	NR	
Thomas et al. 2008, UK	>1 specific JIA code (on different dates)	2001 ILAR criteria applied from CPs records (n=29)	72%	100%	100%*	36.4%*	
	>1 specific JIA code and/or nonspecific arthritis code		84%	100%	100%*	50%*	
	2 NSAID prescriptions in GPRD within 6 months of each other		96%	100%	100%*	80%*	

≥1 DMARD prescription in GPRD record with no prior alternative indication for the DMARD	40%	100%	100%*	21%*
No alternative diagnosis in GPRD record after last JIA code	100%	0%	86.2%*	-

Abbreviations: JIA= Juvenile Idiopathic Arthritis; JRA= Juvenile Rheumatoid Arthritis; ANA= Antinuclear Antibody; RF= Rheumatoid Factor; CTDs= Connective Tissue Diseases; H= Diagnosis in Hospital Discharge Records; CPs= Clinical Practices; NSAID= Non-steroidal Anti-Inflammatory Drugs; GPRD= General Practice Research Database; DMARDs= Disease-modifying Antirheumatic Drugs;
* Calculated from data provided by 2x2 tables when available.

Supplementary Appendix 6. Figure 1

Figure 1. Forest Plot: individual and pooled estimates of sensitivity and specificity across algorithms categories (reference standard: diagnosis by rheumatologist).



Supplementary Appendix 7. Figure 2

Figure 2. Forest Plot: individual and pooled estimates of PPV across algorithms categories by reference standard (left: diagnosis by rheumatologist – right: ACR/EULAR classification criteria).