Rheumatology International (2025) 45:129
https://doi.org/10.1007/s00296-025-05861-z

Rheumatology
INTERNATIONAL

OBSERVATIONAL RESEARCH

RhePort 1.3 enhances early identification of inflammatory rheumatic diseases: a prospective study in German rheumatology settings

Cay-Benedict von der Decken[1,2,3,4] · Stefan Kleinert[1,5,6] · Matthias Englbrecht[7] · Kirsten Karberg[1,8] · Georg Gauler[1,9] · Monika Ronneberger[6] · Praxedis Rapp[6] · Florian Schuch[6] · Joerg Wendler[6] · Susanna Späthling-Mestekemper[1,10] · Christoph Kuhn[1,11] · Wolfgang Vorbrüggen[1,4] · Martin Welcker[1,12] · Peter Bartz-Bazzanella[1,2,4]

Received: 7 January 2025 / Accepted: 29 March 2025

Abstract

More efficient means of identifying patients with inflammatory rheumatic diseases (IRDs) could allow earlier diagnosis and treatment. The objective of this study was to evaluate the characteristics of a revised version of an online patient questionnaire-based self-referral tool, RhePort 1.3. This prospective study included adult patients with musculoskeletal complaints presenting for a first rheumatology visit at German RheumaDatenRhePort (RHADAR) rheumatology network centers. All patients completed the RhePort 1.3 questionnaire on patient characteristics and symptoms. Data from RhePort 1.3 were compared with historical data from previous versions. Of 614 patients, 225 (36.6%) were diagnosed with an IRD by a rheumatologist and 164/225 IRD patients (72.9%) had a RhePort 1.3 score > 1, the cut-off point used to determine the need for rheumatologic evaluation. A score > 1 was associated with an approximately two-fold higher IRD risk (odds ratio [95% confidence interval] of 1.98 [1.39, 2.83] vs ≤ 1) and had good sensitivity (73%) and moderate specificity (42%). Among patients referred through a standard referral pathway (n = 283), RhePort 1.3 scores > 1 in addition to physician referral were associated with increases in rheumatology-diagnosed IRD rates from 33.2% (physician referral only) to 45.7%. RhePort 1.3 had higher accuracy than earlier versions (54% vs 35%). We conclude that modest changes to the RhePort questionnaire resulted in increased accuracy. A score > 1 was associated with a doubled risk for an IRD and higher IRD rates in physician-referred patients. These data suggest that RhePort has the potential to streamline the rheumatologist's workload and improve resource use. Further modifications are required to improve specificity.

Keywords Rheumatology · Rheumatic diseases · Workload · Referral and consultation · Online system · Surveys and questionnaires

Introduction

Early identification of inflammatory rheumatic disorders (IRDs) allows prompt treatment and has the potential to improve long-term outcomes [1–5]. However, recent studies suggest that there are often substantial delays between symptom onset and rheumatology appointments [6–8], including a German study in which the median time between musculoskeletal symptom onset and a rheumatology appointment was 30 weeks [9]. Delay in access to a rheumatologist is strongly correlated with delay in early treatment, resulting in worse long-term outcomes [5].

There are currently a number of barriers to timely diagnosis and treatment of IRDs [10]. In particular, the time to rheumatology care may be impacted by patients with musculoskeletal complaints related to non-inflammatory conditions, such as osteoarthritis. Recent studies indicate that approximately 25% of primary care consultations involve musculoskeletal symptoms [11, 12], and that both general practitioners (GPs) and patients have difficulty in distinguishing inflammatory and non-inflammatory conditions [10, 13]. As a result, many of these patients are referred

Congress presentation Some of the data from this manuscript were presented at the American College of Rheumatology (ACR) Convergence 2024 (https://acrabstracts.org/abstract/a-prospective-study-on-early-diagnosis-of-inflammatory-rheumatic-diseases-using-an-enhanced-online-questionnaire-system-rheport-1-3/).

Extended author information available on the last page of the article

Published online: 28 April 2025

to rheumatologists, but most do not have an IRD. Among GP referrals to rheumatologists, only about 25% to 40% of patients are subsequently diagnosed with an IRD [14–16]. Another important factor that influences waiting periods for rheumatology consultations is the number of rheumatologists in a given area. Many countries [17, 18], including Germany [19, 20], are experiencing a shortage of rheumatologists, especially in more rural areas.

The use of patient questionnaires has the potential to allow prioritization of early rheumatology visits for patients with a higher probability of an IRD and reduce the burden on rheumatologists and the healthcare system. A number of triage approaches and questionnaires have been developed to allow more efficient prioritization of IRDs [21], but none has yet shown optimal specificity and sensitivity for clinical use.

The online RhePort questionnaire-based self-referral tool [22] has shown utility as a decision support system in patients being seen for their first rheumatology consultation at rheumatology clinics in Germany [23–25]. An earlier version of RhePort was well-accepted among patients [24] but did not have sufficient diagnostic accuracy for use in prioritizing rheumatology appointments [23]. The aim of this study was to evaluate the performance of an updated version of RhePort, RhePort 1.3, as a referral tool for patients with musculoskeletal complaints. An effective referral tool has the potential to streamline rheumatology care and facilitate early diagnosis, which may improve long-term outcomes.

Methods

Study design and participants

This non-interventional, cross-sectional, prospective study utilized pseudonymized electronic health record (EHR) data from adult patients (≥ 18 years) in the RheumaDatenRhePort (RHADAR) GbR (A Network of Rheumatologists) database [26, 27]. The RHADAR database includes clinical data, patient-reported outcomes, and laboratory data from patients seen at five German clinical rheumatology sites. For the RhePort 1.3 patient cohort, all included patients had completed the RhePort 1.3 clinical questionnaire (described below) prior to an initial rheumatology consultation and had subsequently received a diagnosis or exclusion of an IRD from a rheumatologist. Patients were either referred by GPs or other physicians or were self-referred based on a RhePort 1.3 score > 1.0, the score used by RHADAR rheumatology practices to indicate the need for a rheumatology consultation. Patients included in this study completed the RhePort 1.3 questionnaire between May 23, 2022 and November 30, 2023. Data for comparisons with previous versions (RhePort 1.1/1.2) were obtained from patients who completed the questionnaire between April 1, 2016 and February 28, 2021.

Ethical approval for the RhePort questionnaire and resulting analyses was obtained from the Ethics Committee of Ärztekammer Nordrhein (number 2015228; September 1, 2015; amendment approved August 8, 2021, number 2021312) and the study was conducted in compliance with the Declaration of Helsinki. All patients provided written informed consent.

RhePort questionnaire-based self-referral tool

RhePort.de [22] is a rheumatology-specific online platform that promotes cooperative collaboration between physicians and patients and contains the RhePort 1.3 questionnaire [23–25]. RhePort.de was developed by nine clinicians who are now part of the RheumaDatenRhePort (RHADAR) GbR (A Network of Rheumatologists) group [22]. The goal of RhePort.de is to advance the early detection and treatment of IRDs. In addition to the RhePort 1.3 patient questionnaire, the site features information on rheumatologic disorders and appointment scheduling functions. Referring physicians can register their patients for RhePort via a special channel, or patients can access the site directly without a referral. The questionnaire is available as a web-based version for the public and provided in an app version on a tablet for patients at rheumatology centers. An English translation of the questionnaire can be found in Supplementary materials (Section S1). The full questionnaire and possible answers can be accessed at https://rheport.de/RhePortS1.aspx.

RhePort 1.3 is the third version of the questionnaire to be developed. The previous version of RhePort (RhePort 1.2) was a 23-item questionnaire concerning patient data, complaints, and symptoms (complemented by pictures of affected joints) that took approximately 8.5 min to complete [23]. Entering lab results was optional. Responses to these questions provided a weighted sum score from which a background algorithm calculated the probability of an IRD (sum scores ≥ 1 indicate increased probability of an IRD; higher scores suggest a more urgent need for a rheumatology appointment) [23–25].

RhePort versions 1.0–1.2 were refined on the basis of published data [23, 25] supplemented by clinical knowledge to create RhePort 1.3, the questionnaire used in the study reported here. RhePort 1.3 contains 23 questions, with several sub-questions, and allows entry of additional relevant laboratory values (rheumatoid factor [RF], cyclic citrullinated protein antibody [anti-CCP], and HLA-B27 plus the previously included C-reactive protein [CRP] and erythrocyte sedimentation rate [ESR]) (Supplementary Section S1). In addition to the overall score for the probability of IRD, algorithmic rules were added to improve the recognition of rheumatoid arthritis (RA) and axial spondyloarthritis (axSpA) based on specific response patterns.

The full data protection policy can be found on the RhePort.de website ((https://rheport.de/RhePort18.aspx). Of note, patients only provide their email (a neutral email address is encouraged), telephone number, and zip code to allow appointments with a nearby rheumatologist. Their names are not entered into the RhePort.de system.

Statistical analysis

A study size calculation was not performed, as sample size for this exploratory study was determined by all eligible patients during the study period.

We analyzed descriptive data for patients with reported data; missing data were not imputed. For sample characterization, we used absolute and relative frequencies and means with standard deviation (SD). Predictive accuracy assessments compared with the rheumatologist's diagnosis included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive and negative likelihood ratios, odds ratio (OR), Youden index (summary measurement of a test's accuracy based on the receiver operating characteristic [ROC] curve), and overall accuracy. Values are reported with 95% confidence intervals (CIs). ROC analyses to determine the area under the curve (AUC) of RhePort 1.3 compared with chance were also performed. Statistical analyses were performed using R software (version 4.4.0) and RStudio (version 1.1.453).

Results

IRD diagnosis and patient characteristics

The RhePort 1.3 patient cohort included 614 patients who completed the questionnaire before their first rheumatology consultation. The IRD diagnosis or exclusion was determined by the consulted rheumatologist and recorded in the RHADAR database. Of these patients, 225 (36.6%) were found to have a rheumatologist-diagnosed IRD, most commonly RA (41.3% of patients with an IRD) followed by psoriatic arthritis (PsA; 16.4%) (Fig. 1). The remaining 389 patients (63.4%) did not have an IRD.

Compared with non-IRD patients, the IRD patient cohort had fewer females (53.3% vs 70.2%), a shorter symptom duration (mean [SD] of 2.6 [5.0] vs 4.1 [5.9] years), and higher RhePort 1.3 scores (mean [SD] of 2.0 [1.4] vs 1.4 [1.3]) (Table 1). As expected, patient characteristics varied by diagnosis (Table 1). Non-IRD and RA patients had the highest proportions of female patients, patients with polymyalgia rheumatica and crystal-induced arthropathy had the highest mean age, patients with axSpA and crystal-induced arthropathy had the longest symptom duration, and patients with RA, polymyalgia rheumatica, and axSpA had the highest mean RhePort 1.3 scores (Table 1).

RhePort 1.3 score and IRD diagnosis

A RhePort score > 1 is currently used in clinical practice as an indicator of need for a rheumatology consultation. Of the 225 patients with a subsequent IRD diagnosis from the rheumatologist, approximately three-quarters (n = 164 [72.9%]) had a RhePort 1.3 score > 1 (Fig. 2 and Table 2). For patients with no IRD diagnosis, 224/389 (57.6%) had a RhePort 1.3 score > 1. The proportions of both true positives and false positives decreased with increasing cut-off scores. For instance, a RhePort 1.3 score > 2.4 was recorded in 95/225 (42.2%) of patients with an IRD and 104/389 (26.7%) of patients who did not have an IRD.

The RhePort 1.3 score distribution for patients with the most common IRDs (n > 10) varied considerably but had a median > 1 for all subgroups (Fig. 3). With respect to specific IRD diagnoses, a RhePort 1.3 score > 1 was most frequently observed in patients with PsA (31/37; 83.8%) and RA (69/93; 74.2%). A score > 1 was less useful in identifying undifferentiated arthritis (7/12; 58.3%) and axSpA (13/21; 61.9%) (Table 2).

Accuracy of RhePort 1.3

Analyses of the predictive parameters of RhePort 1.3 indicated that the cut-off point of > 1 was associated with an approximately two-fold greater risk for an IRD compared with a score of ≤ 1 (OR of 1.98) (Table 3). The risk was similar for patients with a score of > 2.4 vs ≤ 2.4 (OR of 2.00), but much higher with a cut-off point of 4 (OR of 4.13 for a score of > 4 vs ≤ 4). RhePort 1.3 scores > 1 had good sensitivity (73%) with respect to identifying IRD patients, but only moderate specificity (42%) (Table 3). For the cut-off point of 2.4, these characteristics were reversed (sensitivity of 42% and specificity of 73%). As might be expected, the cut-off point of ≥ 4.0 had low sensitivity (14%) but very high specificity (96%). The accuracy rate was 54% for RhePort 1.3 scores > 1, 62% for > 2.4, and 66% for ≥ 4. Other parameters, including PPV, NPV, and likelihood ratios were consistent with sensitivity and specificity evaluations (Table 3).

ROC analysis provided a visual representation of decreases in true positive and false positive rates with higher RhePort 1.3 scores (Supplementary Fig. 1). As is typical for diagnostic tests, increasing cut-off points resulted in greater specificity, but lower sensitivity. The AUC, an overall summary of diagnostic accuracy, was 0.62 (where 1.0 is a perfectly accurate test).

A RhePort 1.3 score > 1 had similar accuracy rates for the most common specific rheumatologic diagnoses, ranging from a high of 49% for RA to a low of 43% for axSpA,

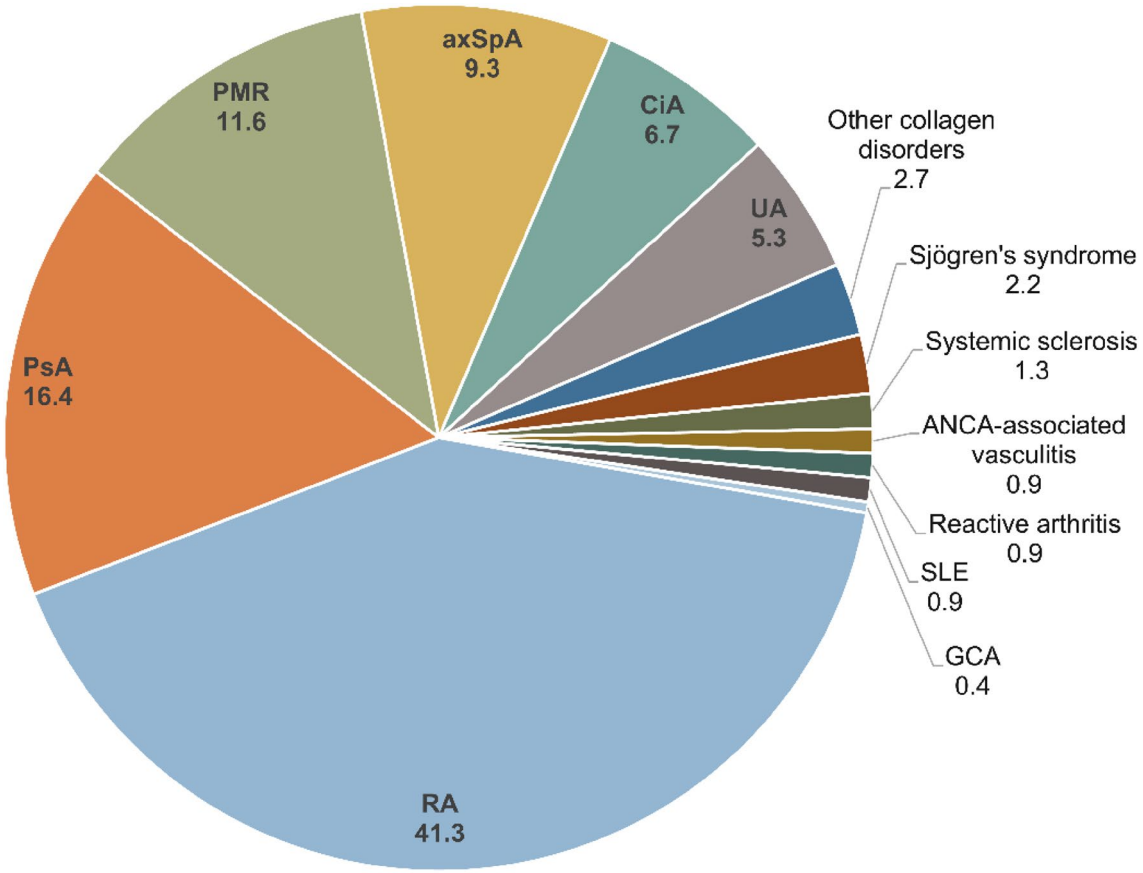

Fig. 1 Percentages of patients with specific IRD diagnoses among patients with IRDs (n = 225). *ANCA* antineutrophil cytoplasmic antibody, *axSpA* axial spondyloarthritis, *CiA* crystal-induced arthropathy, *GCA* giant cell arteritis, *IRD* inflammatory rheumatologic disorder, *PMR* polymyalgia rheumatica, *PsA* psoriatic arthritis, *RA* rheumatoid arthritis, *SLE* systemic lupus erythematosus, *UA* undifferentiated arthritis

Table 1 Patient characteristics by diagnosis (N = 614). For specific IRD diagnoses, characteristics for subgroups with at least 10 patients are shown

Diagnosis	n (%)	Female, n (%)	Age, years	Symptom duration, years[a]	RhePort 1.3 score
Non-IRD	389 (63.4%)	273 (70.2%)	50.4 (14.3)	4.1 (5.9)	1.4 (1.3)
IRD[b]	225 (36.6%)	120 (53.3%)	53.5 (16.0)	2.6 (5.0)	2.0 (1.4)
Rheumatoid arthritis	93 (41.3%)	64 (68.8%)	54.6 (15.2)	1.2 (3.1)	2.2 (1.4)
Psoriatic arthritis	37 (16.4%)	12 (32.4%)	53.4 (12.4)	3.1 (5.5)	1.7 (1.0)
Polymyalgia rheumatica	26 (11.6%)	15 (57.7%)	68.1 (8.8)	0.7 (0.8)	2.1 (1.5)
Axial spondyloarthritis	21 (9.3%)	9 (42.9%)	34.6 (10.7)	6.6 (7.7)	2.1 (1.6)
Crystal-induced arthropathy	15 (6.7%)	2 (13.3%)	62.1 (14.9)	6.6 (7.8)	1.8 (1.1)
Undifferentiated arthritis	12 (5.3%)	6 (50.0%)	49.8 (18.2)	0.9 (1.8)	1.5 (1.3)

Data are presented as mean (SD) unless otherwise specified. For specific subtypes of IRDs, n (%) data are presented as the proportion of IRD diagnoses

[a]Data were not available for 72 patients with a non-IRD diagnosis and 32 patients with an IRD diagnosis

[b]Additional IRD diagnoses included other collagen disorders (n = 6), Sjögren's syndrome (n = 5), systemic sclerosis (n = 3), ANCA-associated vasculitis (n = 2), reactive arthritis (n = 2), systemic lupus erythematosus (n = 2), and giant cell arteritis (n = 1)

ANCA antineutrophil cytoplasmic antibody, *IRD* inflammatory rheumatologic disorder, *SD* standard deviation

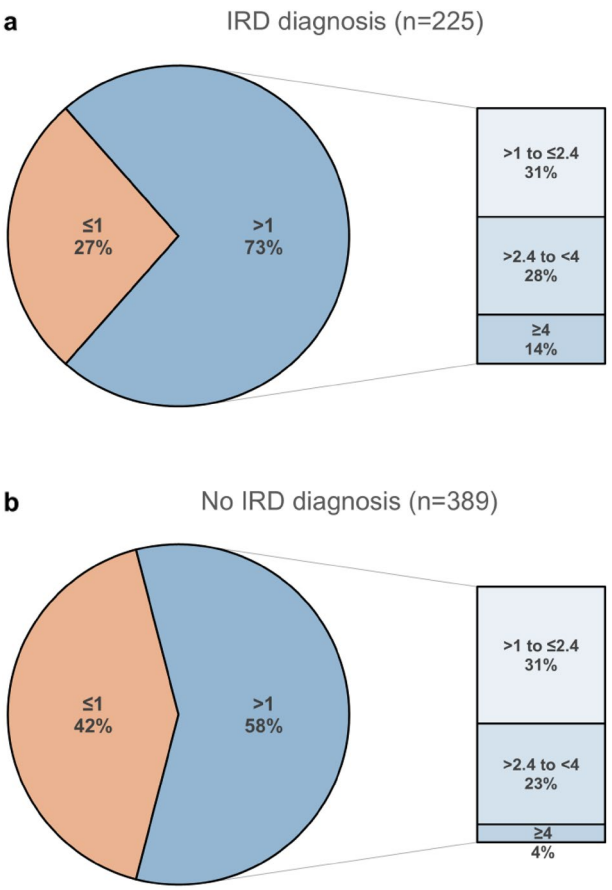

Fig. 2 RhePort 1.3 scores in patients **a** with an IRD diagnosis or **b** with a diagnosis of no IRD. *IRD* inflammatory rheumatologic disorder

crystal-induced arthropathy, and undifferentiated arthritis (Supplementary Table 1). The sensitivity of the test was highest for PsA (84%) and RA (74%) and lowest for undifferentiated arthritis (58%), while the specificity was 42% for all of the specific diagnoses evaluated (Supplementary Table 1).

RhePort 1.3 as an augmentation to standard referral

Of the 614 patients in the patient cohort, 283 (46.1%) were referred by a GP or another physician and answered the RhePort 1.3 questionnaire before their first rheumatology consultation in the waiting room, and 331 (53.9%) completed the online RhePort 1.3 questionnaire with a score > 1 and booked a rheumatology appointment through the RhePort web site. For this group of 331 self-referred patients, RhePort was recommended by a physician or non-medical contact (family, friends, self-help groups), suggested by rheumatology practices contacted for an appointment, or found independently on the internet.

Of the 283 patients who were referred to a rheumatology practice through standard procedures, 94 (33.2%) subsequently received a diagnosis of an IRD from the rheumatologist; this proportion was slightly lower than the 36.6% IRD rate in the overall patient cohort. A RhePort 1.3 score > 1 in addition to referral correctly identified 43/94 (45.7%) patients as having an IRD. Accordingly, the RhePort 1.3 score in addition to referral resulted in a 38% improvement in IRD identification. Of the 189 referred patients who did not have an IRD, 136 (72.0%) had a RhePort 1.3 score ≤ 1 and were therefore correctly identified as non-IRD.

Comparison of RhePort 1.3 with previous RhePort versions

An analysis of a cohort of 2504 patients who completed previous versions of the RhePort questionnaire (RhePort 1.1/1.2) found that 818 (32.7%) had IRDs. In this patient cohort, 2404 (96.0%) had a score > 1 and 100 (4.0%) had a score ≤ 1. Scores > 1 on RhePort 1.1/1.2 correctly identified 803/818 (98.2%) patients with an IRD but were also recorded by 1601/1686 (95.0%) of patients who did not have an IRD, resulting in high sensitivity (98% [95% CI 97, 99]) but very low specificity (5% [95% CI 4, 6]). The accuracy rate was 35% (95% CI 34, 37).

Table 2 IRD diagnoses by different RhePort 1.3 cut-offs

Rheumatologist diagnosis	n	RhePort 1.3 score, n (%)			
		≤ 1	> 1	> 2.4	≥ 4
No IRD	389	165 (42.4%)	224 (57.6%)	104 (26.7%)	15 (3.9%)
Any IRD	225	61 (27.1%)	164 (72.9%)	95 (42.2%)	32 (14.2%)
RA	93	24 (25.8%)	69 (74.2%)	48 (51.6%)	15 (16.1%)
PsA	37	6 (16.2%)	31 (83.8%)	9 (24.3%)	2 (5.4%)
PMR	26	7 (26.9%)	19 (73.1%)	10 (38.5%)	5 (19.2%)
axSpA	21	8 (38.1%)	13 (61.9%)	12 (57.1%)	4 (19.0%)
CiA	15	5 (33.3%)	10 (66.7%)	4 (26.7%)	1 (6.7%)
UA	12	5 (41.7%)	7 (58.3%)	3 (25.0%)	1 (8.3%)

axSpA axial spondyloarthritis, *CiA* crystal-induced arthropathy, *IRD* inflammatory rheumatologic disorder, *PMR* polymyalgia rheumatica, *PsA* psoriatic arthritis, *RA* rheumatoid arthritis, *UA* undifferentiated arthritis

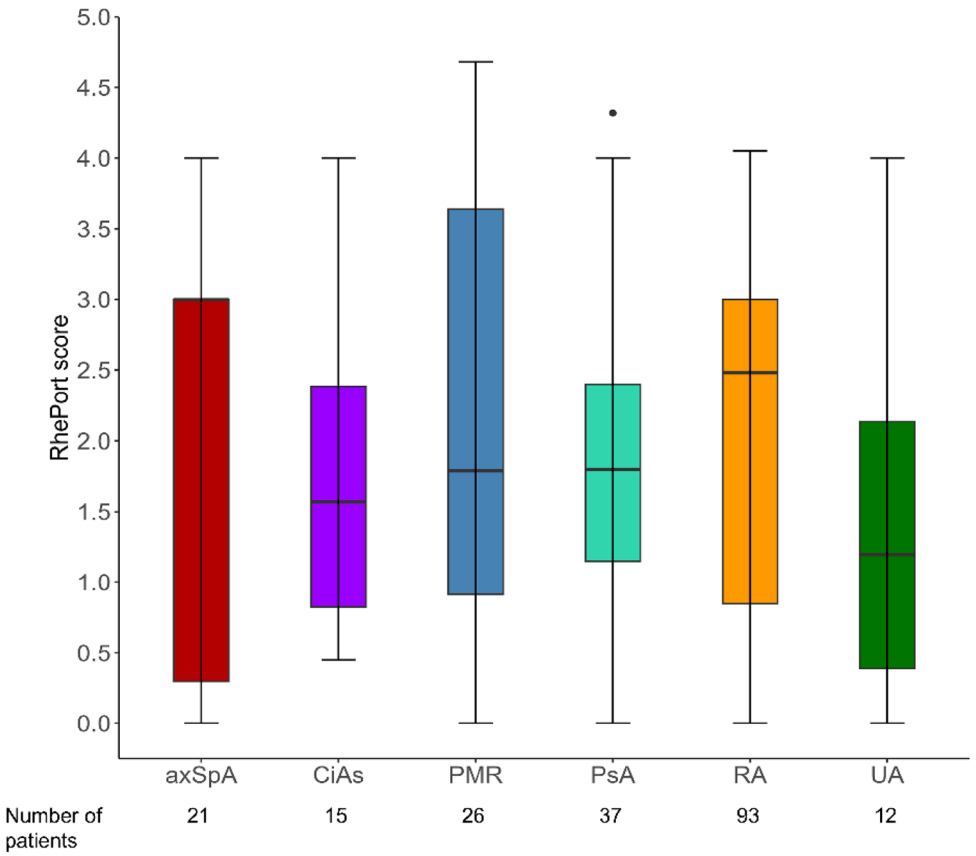

Fig. 3 Box and whisker plot of distribution of RhePort 1.3 score by IRD diagnosis. Boxes illustrate the upper quartile, median (center line), and lower quartile values. Vertical lines represent minimum and maximum values. *axSpA* axial spondyloarthritis, *CiA* crystal-induced arthropathy, *IRD* inflammatory rheumatologic disorder, *PMR* polymyalgia rheumatica, *PsA* psoriatic arthritis, *RA* rheumatoid arthritis, *UA* undifferentiated arthritis

Table 3 Predictive accuracy of different cut-off points of RhePort 1.3

Parameter	RhePort 1.3 cut-off score for IRD		
	> 1	> 2.4	> 4
Odds ratio	1.98 (1.39, 2.83) vs ≤ 1	2.00 (1.42, 2.83) vs ≤ 2.4	4.13 (2.19, 7.82) vs ≤ 4
Sensitivity (%)	73 (66, 78)	42 (36, 49)	14 (10, 20)
Specificity (%)	42 (37, 48)	73 (69, 78)	96 (94, 98)
PPV (%)	42 (37, 47)	48 (41, 55)	68 (53, 80)
NPV (%)	73 (67, 79)	69 (64, 73)	66 (62, 70)
LR +	1.27 (1.13, 1.42)	1.58 (1.26, 1.98)	3.69 (2.04, 6.66)
LR −	0.64 (0.50, 0.82)	0.79 (0.69, 0.90)	0.89 (0.84, 0.94)
Youden index	0.15 (0.08, 0.23)	0.15 (0.08, 0.23)	0.10 (0.05, 0.15)
Accuracy rate (%)	54 (50, 58)	62 (58, 66)	66 (62, 70)

Data are presented as value (95% CI)

CI confidence interval, *IRD* inflammatory rheumatologic disorder, *LR* likelihood ratio, *NPV* negative predictive value, *PPV* positive predictive value

Discussion

Our analyses of RhePort 1.3, an updated version of a patient questionnaire-based self-referral tool, indicate that it has utility as an aid in identifying patients with a greater need for rheumatology referral. In the patient cohort evaluated here, which reflects patients seen in daily rheumatology practices, a RhePort 1.3 score > 1 was associated with a two-fold increase in risk of an IRD (OR of 1.98) compared with scores ≤ 1. From the perspective of a rheumatologist with limited time slots available, the doubled IRD likelihood associated with a RhePort score > 1 has the potential to improve prioritization practices and decrease delays in seeing and treating patients with IRDs. Further support for the utility of RhePort was found in our analysis of patients

with a physician referral plus a RhePort 1.3 score > 1. The rate of rheumatologist-diagnosed IRDs in this subpopulation was 46% compared with 33% among all physician referrals, a 38% improvement. The 46% IRD rate observed in patients with a physician referral plus a RhePort 1.3 score > 1 is higher than most other rates of IRD diagnoses reported in patients referred by GPs [14–16], suggesting that the simple addition of a requirement for a RhePort 1.3 score > 1 to physician referrals could help triage rheumatology appointments and reduce the rheumatologist's workload related to conditions that can be treated in primary care. To the best of our knowledge, this is the first report to show that a patient questionnaire can augment normal rheumatology referral patterns in the overall population of patients presenting with musculoskeletal symptoms.

RhePort was developed to offer patients an additional option for securing an initial consultation with a rheumatologist, particularly for those who lack a referral or face challenges in obtaining an appointment following a referral from their general practitioner. It provides a rapid assessment of patient's symptoms and is well accepted by patients [24]. In addition to having the potential to improve time to IRD diagnosis, the RhePort web portal also optimizes resource utilization. The online system automatically assigns an initial consultation appointment with a rheumatologist to patients with RhePort score > 1 [22]. This scheduling feature is especially important for patients who encounter difficulties achieving a timely rheumatology consultation. A preliminary study found that use of the RhePort web site for facilitating rheumatology appointments in patients with an urgent need reduced the burden on rheumatology center administrative and medical staff compared with doctor-to-doctor referrals [28].

Although the 73% sensitivity finding for RhePort 1.3 scores > 1 supports its ability to accurately categorize most patients with IRD, the 42% specificity highlights the fact that false positives are relatively frequent. An ROC AUC ≥ 0.7 is generally considered acceptable for diagnostic tests [29], and the RhePort 1.3 AUC was 0.62, which falls slightly below that level. Although it is not yet the ideal questionnaire-based self-referral tool, our data show that RhePort 1.3 in its current form nonetheless has the potential to enhance the efficiency and optimize the utilization of the rheumatologist's time by prioritizing appropriate patients, in contrast to the standard referral process. Improvements gained over the previous RhePort version indicate that this questionnaire can improve its performance by further refinement to optimize its potential in supporting patients and rheumatologists.

In comparisons of RhePort 1.3 with previous versions of RhePort (1.1/1.2), both cohorts had similar rates of rheumatologist-diagnosed IRDs (36.6% for the RhePort 1.3 cohort and 32.7% for the RhePort 1.1/1.2 cohort). However, RhePort 1.3 scores > 1 had much higher specificity (42% vs 5% for the earlier version) and greater accuracy (54% vs 35%). It should be noted that the results for earlier RhePort versions in the study presented here (98% sensitivity, 5% specificity, and 35% accuracy) vary from other studies of RhePort 1.2 in patients preparing for their initial rheumatology consultation, which reported a 54% sensitivity, 52% specificity, and 52% accuracy in 164 patients seen at one rheumatology center [23] and 62% sensitivity, 47% specificity, and 52% accuracy in 600 patients seen at three rheumatology centers between September 2019 and April 2021 [25]. The difference may be due to the fact that one of the three rheumatology referral centers was affiliated with a university hospital, which generally attracts patients with more severe symptoms and a higher chance of having an IRD [23]. This "pre-selection" could have potentially decreased the number of false positives and increased the specificity of RhePort 1.2 compared with the results of our RhePort 1.1/1.2 analyses, in which patients presented to community GP and rheumatology practices. The previous RhePort 1.2 study was also conducted primarily during months affected by the COVID-19 pandemic, which may have also skewed the patient population to those with more serious musculoskeletal symptoms.

Our data suggest that RhePort 1.3 is a useful tool to optimize resource utilization in rheumatology practices, but further modifications may be required to improve clinical reliability. In particular, RhePort 1.3 had a high false positive rate, which lowers overall accuracy. Accordingly, this is the point with the highest potential for improvement for future RhePort versions. One approach would be to institute mandatory entry of key laboratory markers (e.g., CRP, ESR, RF). Alternatively, inclusion of a text field for patient-reported symptom description connected to an application programming interface to harness artificial intelligence (AI) capabilities could further refine the diagnostic accuracy of RhePort. Application of machine learning to identify specific clinical characteristics associated with IRDs, such as finger joint pain, has recently been shown to improve the accuracy of RhePort [30].

In addition to RhePort, there are a number of other triage approaches and symptom checkers, some of which are AI based; a recent scoping review found 53 unique studies and noted that the number of published studies was increasing rapidly [21]. For all studies evaluating prioritization approaches, the results are highly dependent on the prevalence of IRDs in the study population [15]. Although it is difficult to compare different tools due to varying patient populations and study design, in a comparative study of RhePort 1.2 and the Ada symptom checker, which includes but is not specifically designed for rheumatologic conditions, RhePort had slightly lower diagnostic accuracy (52% vs 63% for the top disease suggestion) and the agreement between the tools was low (Cohen's kappa = 0.15) [25]. *Rheumatic?*, an online

screening tool that produces a risk score for rheumatologic disease based on medical questions, showed some utility in identifying patients with joint swelling who would develop an immune-mediated rheumatologic disease after 1 year, but the authors concluded that the scoring system required optimization [31]. In patients at risk for RA as indicated by the presence of autoantibodies, remote symptom monitoring with the digital REMOTRA questionnaire showed a specificity of 42% for the cut-off score in this study, the same as the specificity for RhePort 1.3 [32]. Two questionnaires designed to identify patients who should be referred to rheumatologists, the Rotterdam Early Arthritis Cohort (REACH) and Clinical Arthritis Rule (CARE), had AUC values of 66% and 76%, respectively [33]. However, in their current form these tools require completion by a research assistant or healthcare professional, which makes them more burdensome than an online patient-reported tool. A patient-reported questionnaire developed for recognition of early inflammatory arthritis had an AUC of 71% among patients sent to an early arthritis referral center [15]. This questionnaire includes questions on morning stiffness duration and difficulty with making a fist, items that could potentially be added to RhePort.

The common goal of all these investigations is to advance the early detection and treatment of inflammatory rheumatologic disorders. It is possible that a combination of questionnaires and tests will be required for accurate identification of IRDs. Alternatively or in addition, AI-powered algorithms and applications may allow recognition of patterns that improve IRD identification. A recent exploratory study found that the large language model ChatGPT-4 achieved higher sensitivity in the detection of IRDs than rheumatologists, but with lower specificity [34].

Limitations of this study include its observational nature. Patients arrived at the RhePort 1.3 questionnaire through different pathways and were not chosen for specific characteristics. Although this may have influenced the heterogeneity of results, it also allowed our study to reflect the types of patients referred to rheumatology centers during routine care, which is a study strength. This questionnaire was designed by a small group of expert rheumatologists but did not employ Delphi exercises to determine objectives, which may have resulted in a more rigorous development process [35]. Because of the digital nature of the questionnaire, older patients may have chosen not to participate or might have received support from younger family members. The usability of RhePort 1.3 was not assessed, but the closely related RhePort 1.1/1.2 had a score of 79.3 (out of 100) on the System Usability Scale [24]. Comparisons to previous RhePort versions (1.1/1.2) relied on data from an earlier time period and patient groups were not randomized to the previous vs current version or to other questionnaires designed to identify patients with IRD. The study was not designed to compare IRD rates in patients who completed RhePort 1.3 to those in patients who did not complete the questionnaire.

Conclusions

Efficient and accurate identification of patients at high risk for IRD has the potential to speed delivery of care and streamline the rheumatologist's workload, which could result in more rapid initiation of treatment and improved patient outcomes. A RhePort 1.3 score > 1 is associated with an approximately twofold increase in the risk of a rheumatologist-diagnosed IRD and is currently used in daily practice to help prioritize self-referred and physician-referred patients for rheumatology appointments. Future studies should focus on ways to improve the utility of RhePort 1.3, such as by instituting mandatory entry of key laboratory markers or adding text fields for patient-reported symptom descriptions that can be assessed by AI. Until more accurate methods become available, RhePort may be able to provide assistance in streamlining rheumatology care for patients with musculoskeletal complaints.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00296-025-05861-z.

Acknowledgements We thank the rheumatologists, patients, and medical staff who participated in this study and Sharon L. Cross, PhD, who provided medical writing support under the direction of the authors with funding from RheumaDatenRhePort (RHADAR) GbR (A Network of Rheumatologists).

Author contributions Study conception and design: C-BvdD, SK, MW, PB-B; data curation and formal analysis: SK, ME; investigation; C-BvdD, SK, KK, GG, MR, PR, FS, JW, SS-M, CK, WV, MW, PB-B; Visualization: ME; Supervision, C-BvdD, SK; writing-original draft: C-BvdD, SK, ME. All authors were involved in reviewing and revising the article and approving it for publication. C-BvdD, SK, and PB-B are the manuscript guarantors. All co-authors take full responsibility for the integrity and accuracy of all aspects of the work.

Funding This study, including medical writing support and Open Access publication, was funded by RheumaDatenRhePort (RHADAR) GbR (A Network of Rheumatologists), Moehrendorfer Str. 1c, 91056 Erlangen, Germany. RHADAR GbR received a grant for this study from Novartis Pharma. Novartis Pharma was not involved in data interpretation, manuscript content, final approval, or the decision to publish.

Data availability Data are available from the corresponding author upon reasonable request for a collaborative research project.

Declarations

Conflict of interest C-BvdD received travel/meeting support from AbbVie and Galapagos/Alpha sigma. SK received grants from AbbVie, Novartis, and Sparrow, and consulting and/or speaker's fees from AbbVie, Celgene, Chugai, Galapagos, Novartis, and Siemens Healthineers. ME received funding for the present study for data analysis from RHADAR GbR and also received consulting fees from AbbVie and RHADAR, speaker's fees from AbbVie, Janssen-Cilag,

Sanofi, and Swedish Orphan Biovitrum, and is on the advisory board of Chugai Pharma Germany. KK received speaker's fees from AbbVie, Galapagos, Novartis, Rheumakademie, and UCB and travel/meeting support from UCB. GG received speaker's fees from AbbVie, Galapagos, and Novartis and travel/meeting support from AbbVie and Novartis. JW received consulting and/or speaker's fees from AbbVie, Janssen-Cilag, and Novartis. SS-M received speakers fees from AbbVie, Boehringer Ingelheim, Eli Lilly, GSK, Janssen-Cilag, Novartis, and UCB. MW received consulting and/or speaker's fees from AbbVie, Fresenius, Galapagos, Lilly, and UCB and travel/meeting support from AbbVie, Galapagos, GSK, Lilly, and UCB. PB-B received speaker's fees from AbbVie, Boehringer Ingelheim, Chugai/Roche, Janssen-Cilag, Novartis, Pfizer, and UCB and travel/meeting support from AbbVie. MR, PR, FS, CK, and WV have no conflicts of interest to disclose. C-BvdD, SK, KK, GG, SS-M, CK, WV, MW, and PB-B are members of RheumaDatenRhePort (RHADAR) GbR.

Ethical approval

Ethical approval for this study was obtained from the Ethics Committee of Ärztekammer Nordrhein (number 2021387; November 11, 2021) and the study was conducted in compliance with the Declaration of Helsinki. All patients enrolled in the study provided written informed consent.

References

1. Finckh A, Liang MH, van Herckenrode CM, de Pablo P (2006) Long-term impact of early treatment on radiographic progression in rheumatoid arthritis: a meta-analysis. Arthritis Rheum 55(6):864–872. https://doi.org/10.1002/art.22353
2. Kyburz D, Gabay C, Michel BA, Finckh A, physicians of SCQM-RA (2011) The long-term impact of early treatment of rheumatoid arthritis on radiographic progression: a population-based cohort study. Rheumatology (Oxford) 50(6):1106–1110. https://doi.org/10.1093/rheumatology/keq424
3. Gwinnutt JM, Symmons DPM, MacGregor AJ, Chipping JR, Marshall T, Lunt M et al (2017) Twenty-year outcome and association between early treatment and mortality and disability in an inception cohort of patients with rheumatoid arthritis: results from the Norfolk arthritis register. Arthritis Rheumatol 69(8):1566–1575. https://doi.org/10.1002/art.40090
4. Haroon M, Gallagher P, FitzGerald O (2015) Diagnostic delay of more than 6 months contributes to poor radiographic and functional outcome in psoriatic arthritis. Ann Rheum Dis 74(6):1045–1050. https://doi.org/10.1136/annrheumdis-2013-204858
5. Albuquerque CP, Reis APMG, Vargas Santos AB, Bértolo MB, Júnior PL, Neubarth Giorgi RD et al (2023) Do it fast! Early access to specialized care improved long-term outcomes in rheumatoid arthritis: data from the REAL multicenter observational study. Adv Rheumatol 63(1):17. https://doi.org/10.1186/s42358-023-00301-7
6. Stack RJ, Nightingale P, Jinks C, Shaw K, Herron-Marx S, Horne R et al (2020) Delays between the onset of symptoms and first rheumatology consultation in patients with rheumatoid arthritis in the UK: an observational study. BMJ Open 9(3):e024361. https://doi.org/10.1136/bmjopen-2018-024361
7. Rosa JE, García MV, Luissi A, Pierini F, Sabelli M, Mollerach F, Soriano ER (2020) Rheumatoid arthritis patient's journey: delay in diagnosis and treatment. J Clin Rheumatol 26(7S Suppl 2):S148–S152. https://doi.org/10.1097/RHU.0000000000001196
8. Jain A, Joseph S, James J, James TS, Kumar K, Raza K, Greenfield S, Shenoy P (2023) Delay in diagnosis of rheumatoid arthritis: reasons and trends over a decade. Rheumatol Int 43(3):503–508. https://doi.org/10.1007/s00296-022-05187-0
9. Fuchs F, Morf H, Mohn J, Mühlensiepen F, Ignatyev Y, Bohr D et al (2023) Diagnostic delay stages and pre-diagnostic treatment in patients with suspected rheumatic diseases before special care consultation: results of a multicenter-based study. Rheumatol Int 43(3):495–502. https://doi.org/10.1007/s00296-022-05223-z
10. Saraiva L, Duarte C (2023) Barriers to the diagnosis of early inflammatory arthritis: a literature review. Open Access Rheumatol 15:11–22. https://doi.org/10.2147/oarrr.s282622
11. Haas R, Gorelik A, Busija L, O'Connor D, Pearce C, Mazza D, Buchbinder R (2023) Prevalence and characteristics of musculoskeletal complaints in primary care: an analysis from the population level and analysis reporting (POLAR) database. BMC Prim Care 24(1):40. https://doi.org/10.1186/s12875-023-01976-z
12. Keavy R, Horton R, Al-Dadah O (2023) The prevalence of musculoskeletal presentations in general practice: an epidemiological study. Fam Pract 40(1):68–74. https://doi.org/10.1093/fampra/cmac055
13. Baymler Lundberg AS, Esbensen BA, Jensen MB, Huage EM, Thurah A (2021) Facilitators and barriers in diagnosing rheumatoid arthritis as described by general practitioners: a Danish study based on focus group interviews. Scand J Prim Health Care 39(2):222–229. https://doi.org/10.1080/02813432.2021.1913925
14. Thoms BL, Bonnell LN, Tompkins B, Nevares A, Lau C (2023) Predictors of inflammatory arthritis among new rheumatology referrals: a cross-sectional study. Rheumatol Adv Pract 7(3):rkad067. https://doi.org/10.1093/rap/rkad067
15. ten Brinck RM, van Dijk BT, van Steenbergen HW, le Cessie S, Numans ME, Hider SL et al (2019) Development and validation of a clinical rule for recognition of early inflammatory arthritis. BMJ Open 8(11):e023552. https://doi.org/10.1136/bmjopen-2018-023552
16. Piovesan DM, Busato VB, da Silveira RG, do Prado AD, Molina-Bastos CG, Hickmann S et al (2021) Quality of referrals to a rheumatology service before and after implementation of a triage system with telemedicine support. Adv Rheumatol 61(1):47. https://doi.org/10.1186/s42358-021-00203-6
17. Battafarano DF, Ditmyer M, Bolster MB, Fitzgerald JD, Deal C, Bass AR et al (2018) 2015 American college of rheumatology workforce study: supply and demand projections of adult rheumatology workforce, 2015–2030. Arthritis Care Res (Hoboken) 70(4):617–626. https://doi.org/10.1002/acr.23518
18. Kulhawy-Wibe SC, Widdifield J, Lee JJY, Thorne JC, Yacyshyn EA, Batthish M et al (2022) Results From the 2020 Canadian rheumatology association's workforce and wellness survey. J Rheumatol 49(6):635–643. https://doi.org/10.3899/jrheum.210990
19. Krusche M, Sewerin P, Kleyer A, Mucke J, Vossen D, Morf H, Rheumadocs und Arbeitskreis Junge Rheumatologie (AGJR) (2019) Facharztweiterbildung quo vadis? [Specialist training quo

vadis?]. Z Rheumatol 78(8):692–697. https://doi.org/10.1007/s00393-019-00690-5
20. Kuhlmann E, Bruns L, Hoeper K, Witte T, Ernst D, Jablonka A (2022) Fachkräfteentwicklung in der Rheumatologie : Ein berufsstruktureller Überblick und gesundheitspolitischer Weckruf [Health workforce development in rheumatology : A mapping exercise and wake-up call for health policy]. Z Rheumatol 81(9):717–729. https://doi.org/10.1007/s00393-021-01012-4
21. Biln NK, Bansback N, Shojania K, Puil L, Harrison M (2024) A scoping review of triage approaches for the referral of patients with suspected inflammatory arthritis, from primary to rheumatology care. Rheumatol Int 44(11):2279–2292. https://doi.org/10.1007/s00296-024-05575-8
22. Rheumatologists' Network. www.RhePort.de. Accessed 12 September 2024.
23. Knitza J, Mohn J, Bergmann C, Kampylafka E, Hagen M, Bohr D et al (2021) Accuracy, patient-perceived usability, and acceptance of two symptom checkers (Ada and Rheport) in rheumatology: interim results from a randomized controlled crossover trial. Arthritis Res Ther 23(1):112. https://doi.org/10.1186/s13075-021-02498-8
24. Knitza J, Muehlensiepen F, Ignatyev Y, Fuchs F, Mohn J, Simon D et al (2022) Patient's perception of digital symptom assessment technologies in rheumatology: results from a multicentre study. Front Public Health 10:844669. https://doi.org/10.3389/fpubh.2022.844669
25. Knitza J, Tascilar K, Fuchs F, Mohn J, Sebastian K, Bohr D et al (2024) Diagnostic accuracy of a mobile AI-based symptom checker and a web-based self-referral tool in rheumatology: results from a multicenter randomized controlled trial. J Med Internet Res 26:e55542. https://doi.org/10.2196/55542
26. Kleinert S, Bartz-Bazzanella P, von der Decken C, Knitza J, Witte T, Fekete SP et al (2021) A real-world rheumatology registry and research consortium: the German RheumaDatenRhePort (RHADAR) Registry. J Med Internet Res. https://doi.org/10.2196/28164
27. RHADAR–RheumaDatenRheport GbR. www.rhadar.de. Accessed 12 September 2024.
28. Kleinert S, Shuch F, Wendler J, Rapp P, von der Decken C, Burigk K et al (2023) RhePORT–Efficiency in terms of human resources and patient selection–proven in everyday practice! [abstract] 2023 Deutsche Gesellschaft für Rheumatologie 51st Congress, Leipzig, Germany, August 30, 2023. https://doi.org/10.3205/23dgrh236
29. Mandrekar JN (2010) Receiver operating characteristic curve in diagnostic test assessment. J Thorac Oncol 5(9):1315–1316. https://doi.org/10.1097/jto.0b013e3181ec173d
30. Knitza J, Janousek L, Kluge F, von der Decken CB, Kleinert S, Vorbrüggen W et al (2022) Machine learning-based improvement of an online rheumatology referral and triage system. Front Med (Lausanne) 9:954056. https://doi.org/10.3389/fmed.2022.954056
31. Knevel R, Knitza J, Hensvold A, Circiumaru A, Bruce T, Evans S et al (2022) Rheumatic?-A digital diagnostic decision support tool for individuals suspecting rheumatic diseases: a multicenter pilot validation study. Front Med (Lausanne) 9:774945. https://doi.org/10.3389/fmed.2022.774945
32. Pfeuffer N, Hartmann F, Grahammer M, Simon D, Schuster L, Kuhn S et al (2025) Early detection of rheumatoid arthritis through patient empowerment by tailored digital monitoring and education: a feasibility study. Rheumatol Int 45(2):43. https://doi.org/10.1007/s00296-025-05793-8
33. van Delft ETAM, Barreto DL, van der Helm-van Mil AHM, Alves C, Hazes JMW et al (2022) Diagnostic performance and clinical utility of referral rules to identify primary care patients at risk of an inflammatory rheumatic disease. Arthritis Care Res (Hoboken) 74(12):2100–2107. https://doi.org/10.1002/acr.24789
34. Krusche M, Callhoff J, Knitza J, Ruffer N (2024) Diagnostic accuracy of a large language model in rheumatology: comparison of physician and ChatGPT-4. Rheumatol Int 44(2):303–306. https://doi.org/10.1007/s00296-023-05464-6
35. Zimba O, Gasparyan AY (2023) Designing, conducting, and reporting survey studies: a primer for researchers. J Korean Med Sci 38(48):e403. https://doi.org/10.3346/jkms.2023.38.e403

Authors and Affiliations

Cay-Benedict von der Decken[1,2,3,4] · Stefan Kleinert[1,5,6] · Matthias Englbrecht[7] · Kirsten Karberg[1,8] · Georg Gauler[1,9] · Monika Ronneberger[6] · Praxedis Rapp[6] · Florian Schuch[6] · Joerg Wendler[6] · Susanna Späthling-Mestekemper[1,10] · Christoph Kuhn[1,11] · Wolfgang Vorbrüggen[1,4] · Martin Welcker[1,12] · Peter Bartz-Bazzanella[1,2,4]

✉ Cay-Benedict von der Decken
c.vonderdecken@rhadar.de

Stefan Kleinert
s.kleinert@rhadar.de

Matthias Englbrecht
m.englbrecht@statscoach.de

Kirsten Karberg
k.karberg@rhadar.de

Georg Gauler
g.gauler@rhadar.de

Monika Ronneberger
Monika.Ronneberger@gmx.de

Praxedis Rapp
praxedis.rapp@pgrn.de

Florian Schuch
florian.schuch@pgrn.de

Joerg Wendler
joerg.wendler@pgrn.de

Susanna Späthling-Mestekemper
s.spaethling@rhadar.de

Christoph Kuhn
Kuhn.christoph@t-online.de

Wolfgang Vorbrüggen
w.vorbrueggen@rhadar.de

Martin Welcker
m.welcker@rhadar.de

Peter Bartz-Bazzanella
p.bartz-bazzanella@rhadar.de

[1] RHADAR-RheumaDatenRheport GbR, Möhrendorfer Str. 1 C, 91056 Erlangen, Germany

[2] Klinik für Internistische Rheumatologie, Rhein-Maas-Klinikum, Würselen, Germany

[3] Medizinisches Versorgungszentrum, Stolberg, Germany

[4] Verein zur Förderung Der Rheumatologie E.V, Würselen, Germany

[5] Department of Medicine II, Rheumatology/Clinical Immunology, University Hospital of Würzburg, Würzburg, Germany

[6] Praxisgemeinschaft Rheumatologie-Nephrologie, Erlangen, Germany

[7] Freelance Healthcare Data Scientist, Greven, Germany

[8] Rheumatologisches Versorgungszentrum Steglitz, Berlin, Germany

[9] Rheumatology Practice, Osnabrück, Germany

[10] Rheumapraxis, München, Germany

[11] Praxis für Rheumatologie, Karlsruhe, Germany

[12] Medizinisches Versorgungszentrum für Rheumatologie Dr. M. Welcker GmbH, Planegg, Germany