Influence of Electronic Medical Record Management Systems on the Disease Activity and Frequency of Outpatient Visits of Patients with Ankylosing Spondylitis: A Cross-Sectional Study

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Abstract

Background

To investigate the impact of an electronic medical record management system (EMRMS) on disease activity and the frequency of outpatient visits among patients with ankylosing spondylitis (AS).

Methods

We identified 652 patients with AS who were followed up for at least 1 year before and after the first Ankylosing Spondylitis Disease Activity Score (ASDAS) assessment and compared the number of outpatient visits and average visit time within 1 year before and after the initial ASDAS assessment. Finally, we analyzed 201 patients with AS who had complete data and received ≥ 3 continuous ASDAS assessments at an interval of 3 months, and we compared the results of the second and third ASDAS assessments with those of the first.

Results

The number of annual outpatient visits increased after ASDAS assessment (5.8 ± 3.4 vs. 5.4 ± 3.4, $p < 0.001$), particularly among those with a high initial disease activity. The average visit time was reduced within 1 year after ASDAS assessment (8.7 ± 3.8 vs. 9.2 ± 4.4 min, $p = 0.030$), especially among patients whose ASDAS-C-reactive protein (CRP) was < 1.3 (8.5 ± 3.3 vs. 9.2 ± 4.2 min, $p = 0.022$). Among patients who received at least three ASDAS assessments, the third ASDAS-CRP was significantly lower than the first (1.5 ± 0.8 vs. 1.6 ± 0.8, $p = 0.049$).

Conclusion

The use of an EMRMS increased the frequency of ambulatory visits among AS patients with high disease activity and reduced the visit time among those with an inactive disease. Continual ASDAS assessments may help control the disease activity of patients with AS.

Trial registration

Institutional Review Board (IRB) of Taichung Veterans General Hospital (TCVGH-IRB No.: CE20145B)

Key messages

The surveillance of ankylosing spondylitis through electronic devices influences disease activity.

Our study investigated the health-related behavior of patients with AS through the application of an electronic device that was connected to a single medical center’s laboratory database.

The protocol increased the clinic visit adherence of patients with a highly active disease and decreased the visit time of patients with a low disease activity

Introduction

Ankylosing spondylitis (AS) is a form of axial spondyloarthritis (axSpA), characterized by chronic back pain with articular and periarticular extraspinal features, including synovitis, enthesitis and dactylitis, and nonarticular features, including psoriasis, uveitis, and inflammatory bowel disease (IBD). AS presents as human leukocyte antigen (HLA) B27 positive, with elevated C-reactive protein (CRP) during the active reactive phase, and typical sacroiliitis and spinal abnormalities are shown on radiographs[1].

The mean AS prevalence per 10,000 population (from 36 eligible studies) was 0.238% in Europe, 0.167% in Asia, 0.319% in North America, 0.102% in Latin America, and 0.074% in Africa in 2014 systemic research[2]. The prevalence in Taiwan is 0.337%[3]. The risk of AS is higher in men and in individuals with a family history of AS. The guidelines of the European League Against Rheumatism recommend a range of treatment strategies for the optimal management of axSpA, including nonpharmacological treatment, pharmacological treatment, surgery, and lifestyle modifications. The primary goal of AS treatment is to attenuate inflammation for relieving pain and stiffness, preventing or delaying complications and spinal deformity, reducing extraspinal and extra-articular manifestations and comorbidities, and maintaining effective psychosocial function. These AS treatment strategies, along with regular monitoring of disease activity, are generally applied by rheumatologists. The Ankylosing Spondylitis Disease Activity Score (ASDAS) is used as a measure of disease activity in patients with AS by using clinical laboratory data and a self-administered questionnaire. The management of axSpA in Taiwan is strongly influenced by the National Health Insurance reimbursement system and local health circumstances[4]. However, rheumatologists in Taiwan are usually operating at maximum capacity, and consequently, they are unable to assess disease activity in patients with AS. Therefore, a new integrated disease surveillance strategy must be developed to monitor disease activity in patients with AS.

With advances in mobile technologies, electric health (eHealth) and smartphone applications (known as apps) have been developed to facilitate the transmission of information related to infectious diseases in numerous low-income countries, such as some nations in Africa[5]. Furthermore, smart apps have been extensively used for standard clinical evaluations and monitoring diseases and changes in the health status of patients with chronic health conditions[6], including asthma[7], obesity, diabetes[8], hypertension, cardiovascular disease[9], and multiple sclerosis[10]. Such app-based data systems ensure complete and timely data collection[11]. However, a comprehensive, high-quality, evidence-based data app for disease management in patients with AS is lacking[12].

Therefore, the purpose of this study was to investigate the effects of an interactive electronic medical record management system (EMRMS) intervention on the disease activity and frequency of outpatient visits of patients with AS in Taiwan.

Methods

Ethics

The study protocol was approved by the Institutional Review Board (IRB) of Taichung Veterans General Hospital (TCVGH-IRB No.: CE20145B). All experiments were performed in accordance with relevant guildlines and regulations. Informed consent was waived because personal information had been anonymized before analysis.

Study design

This was a single center, retrospective, cross-sectional study.

Data source

The EMRMS was established in November, 2016 to assist rheumatologists in conducting ASDAS assessments and comprehensively evaluating clinical outcomes in all patients with AS attending TCVGH. The EMRMS database contains information such as AS-related biological characteristics (C-reactive protein [CRP] level and erythrocyte sedimentation rate [ESR]), patient comorbidities, patient history, and family history. The reliability and validity of the data have been verified[13].

Patients with AS were consecutively enrolled in the TCVGH-AS cohort after they received a confirmed AS diagnosis from a TCVGH rheumatologist according to the 1984 modified New York criteria[9]. The CRP and ESR data were automatically uploaded to the TCVGH healthcare information system (HIS) to reduce human error. The information, which was collected by trained nurses, including clinical characteristics, onset age, comorbidities at presentation (hypertension, diabetes mellitus, hyperlipidemia, hepatitis B, hepatitis C, renal insufficiency, gout, coronary artery disease, stroke, periodontal disease, osteoporosis, and tuberculosis history), periarticular extraspinal features (synovitis, enthesitis, and dactylitis) and nonarticular manifestations (psoriasis, uveitis, and IBD), family history of autoimmune disease, and patient history of arthropathy, obtained through standardized questionnaires and worksheets to ensure reproducibility and adherence to good laboratory practice. The rheumatologist in charge then confirmed patients' clinical characteristics, and nurses assisted the patients with AS to complete the self-assessment questionnaires for disease evaluation. The questionnaires were completed on the TCVGH app at every 3-month outpatient visit or on blood examination days. The following measures were used: global assessment of disease activity on a numerical rating scale (NRS) of 0–10, back pain on an NRS of 0–10, duration of morning stiffness on an NRS of 0–10, and peripheral pain or swelling on an NRS of 0–10.

Definition of AS

Patients were defined as having AS if they received a diagnosis of AS (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] code 720.0) according to the modified New York criteria for AS proposed in 1984 during at least three ambulatory visits and received AS treatment concurrently.

Study participants

A total of 652 eligible patients with AS with complete baseline demographic and assessment data who received an AS diagnosis before April 17, 2020, were enrolled to investigate the changes in their health-related behaviors after EMRMS implementation. Patients with AS with (1) incomplete details related to ASDAS-CRP, ASDAS-ESR, and age of symptom onset in the assessment questionnaires, (2) their first ASDAS assessment after February 01, 2019, (3) or no outpatient visits within 1 year before or after the first assessment were excluded from this study. Of the 652 patients with AS, 201 underwent three consecutive assessments of disease activity using the EMRMS.

Outcome

The primary outcomes were the frequency and time of outpatient visits. The secondary outcome was changes in ASDAS after the EMRMS intervention.

Statistical analysis

Continuous variables are reported as means ± standard deviations, and categorical variables are reported as percentages. Differences in continuous variables were assessed for the same patient at two time points by using a paired *t* test. The ASDAS assessment measures four disease activity states: inactive, moderate, high, and very high. Disease status was evaluated on the basis of three cutoff values: 1.3, 2.1, and 3.5 units. The following cutoff values were selected to indicate improvement: a change of ≥1.1 units denoted a clinically important improvement, and a

change of ≥2.0 units denoted a major improvement. The results of a cross-validation analysis strongly supported the selected cutoff values[14-17]. Data were analyzed using SAS software (SAS Institute, Inc., Cary, NC, USA).

Results

We enrolled 652 patients with AS who were followed up for at least 1 year before and after their first ASDAS assessment (Figure 1) and compared the number of outpatient visits and average visit time within one year before and after the initial ASDAS assessment. We identified 201 AS patients who received ≥ 3 continuous ASDAS assessment with at an interval of 3 months and compared the results of the second and third ASDAS assessments with those of the first.

Basline characterisitics

The mean age of the 652 eligible patients with AS at their first assessment on the EMRMS was 43.1 ± 13.7 years, and 475 patients were men (72.9%). The AS onset age distribution was 26.8 ± 11.5 years, the disease duration was 16.4 ± 11.7 years, 430 patients were HLA-B27 positive (66%), and 203 were undergoing biologic treatment (31.1%). The most common comorbidity was hypertension (131 patients, 20.1%), the most common AS symptom was uveitis (168 patients, 25.8%), and the most common cause of arthropathy was fracture (70 patients, 10.7%; Table 1).

The mean age of the 201 eligible patients with AS and more than three consecutive assessments on the EREMS was 43.3 ± 13.4 years. In all, 148 were men (73.6%), the AS onset age distribution was 27.0 ± 11.2 years, the disease duration was 16.3 ± 11.6 years, 136 were HLA-B27 positive (67.6%), and 49 were undergoing biologic treatment (24.4%). The most common comorbidity was hypertension (131 patients, 20.1%), the most common AS symptom was uveitis (43 patients, 21.4%), and the most common cause of arthropathy was fracture (15 patients, 7.5%; Table 1).

Table 1. Baseline characteristics of eligible patients with AS obtained using the electronic medical record management system for ASDAS assessment

	Eligible AS patients, n=652	Eligible AS patients with ≥ 3 continuous assessment, n=201
Age, years (Mean ± SD)	43.1±13.7	43.3±13.4
Gender		
Female	177 (27.1)	53 (26.4)
Male	475 (72.9)	148 (73.6)
AS Age, years (Mean ± SD)	26.8±11.5	27.0±11.2
Disease duration, years (Mean ± SD)	16.4±11.7	16.3±11.6
HLA-B27 positive	430 (66.0)	136 (67.7)
Biologics therapy	203 (31.1)	49 (24.4)
Co-morbidities		
Hypertension	131 (20.1)	43 (21.4)
Diabetes mellitus	48 (7.4)	9 (4.5)
Hyperlipidemia	96 (14.7)	32 (15.9)
Hepatitis B	71 (10.9)	19 (9.5)
Hepatitis C	15 (2.3)	6 (3.0)
Renal insufficiency	21 (3.2)	4 (2.0)
Gout	29 (4.4)	6 (3.0)
Coronary artery disease	21 (3.2)	7 (3.5)
Stroke	2 (0.3)	1 (0.5)
Periodontitis	121 (18.6)	39 (19.4)
Osteoporosis	42 (6.4)	12 (6.0)
Tuberculosis history	45 (6.9)	12 (6.0)
AS symptoms		
Uveitis	168 (25.8)	53 (26.4)
Psoriasis	44 (6.7)	22 (10.9)
Crohn's disease	0 (0.0)	1 (0.5)
Ulcerative colitis	3 (0.5)	2 (1.0)
Peripheral arthritis	125 (19.2)	43 (21.4)
Enthesitis	92 (14.1)	36 (17.9)
Dactylitis	15 (2.3)	4 (2.0)
Family history		
AS-First degree relatives	119 (18.3)	30 (14.9)

AS-Secondary degree relatives	185 (28.4)	48 (23.9)
Psoriasis	27 (4.1)	10 (5.0)
Psoriatic arthritis	4 (0.6)	2 (1.0)
Uveitis	30 (4.6)	12 (6.0)
Crohn's disease	0 (0.0)	0 (0.0)
Ulcerative colitis	2 (0.3)	1 (0.5)
Rheumatoid arthritis	38 (5.8)	11 (5.5)
Systemic Lupus Erythematosus	19 (2.9)	5 (2.5)
Sicca syndrome	16 (2.5)	6 (3.0)
Past history		
Total hip replacement	25 (3.8)	4 (2.0)
Total knee replacement	4 (0.6)	1 (0.5)
Fracture	70 (10.7)	15 (7.5)
Palindromic rheumatism	7 (1.1)	1 (0.5)

Abbreviations: AS: *ankylosing spondylitis,* ASDAS, *Ankylosing Spondylitis Disease Activity Score*

Primary outcomes

After the first assessment on the EREMS within 1 year, the frequency of outpatient visits increased from 5.4 ± 3.4 to 5.8 ± 3.5 ($p < 0.001$), particularly in patients with a high disease activity (ASDAS-CRP, 5.1 ± 3.2 vs 5.9 ± 3.5, $p < 0.001$ and ASDAS-ESR, 5.4 ± 3.5 vs 6.2 ± 3.7, $p < 0.001$) and very high disease activity (ASDAS-CRP, 5.7 ± 3.4 vs 8.7 ± 4.0, $p < 0.001$ and ASDAS-ESR, 5.6 ± 3.6 vs 8.4 ± 3.9, $p = 0.002$). The duration of outpatient visits decreased from 9.2 ± 4.4 to 8.7 ± 3.8 min, ($p = 0.03$), especially in those with an inactive disease (ASDAS-CRP, 9.2 ± 4.2 vs 8.5 ± 3.3 min, $p = 0.022$; ASDAS-ESR, 9.1 ± 4.2 vs 8.4 ± 3.3 min, $p = 0.024$; Table 2).

Table 2. Frequency and time of outpatient visits before and after the first EMRMS assessment (n = 652)

Analysis population	ASDAS	Number	Frequency of outpatient visits (mean ± SD)		P value	Time of outpatient visits (minutes) (mean ± SD)		P value
			One year before assessment	One year after assessment		One year before assessment	One year after assessment	
CRP	<1.3	211	5.5±3.4	5.6±3.4	0.485	9.2±4.2	8.5±3.3	0.022
	1.3 - <2.1	245	5.4±3.4	5.6±3.4	0.311	9.3±4.8	9.0±4.4	0.278
	2.1 - 3.5	170	5.1±3.2	5.9±3.5	<0.001	8.7±4.1	8.5±3.4	0.554
	>3.5	26	5.7±3.4	8.7±4.0	<0.001	9.6±4.1	9.8±2.7	0.827
ESR	<1.3	195	5.4±3.2	5.4±3.1	0.878	9.1±4.2	8.4±3.3	0.024
	1.3 - <2.1	258	5.3±3.4	5.5±3.4	0.160	8.9±4.2	8.5±4.1	0.214
	2.1 - 3.5	174	5.4±3.5	6.2±3.7	<0.001	9.3±4.6	9.4±3.7	0.961
	>3.5	25	5.6±3.6	8.4±3.9	0.002	11.0±4.5	9.3±2.9	0.124
Total		652	5.4±3.4	5.8±3.5	<0.001	9.2±4.4	8.7±3.8	0.030

*P value from a paired *t* test

Abbreviations: ASDAS, *Ankylosing Spondylitis Disease Activity Score*; CRP, C-reactive protein*; ESR,* erythrocyte sedimentation rate

Secondary outcomes

The ASDAS-CRP and ASDAS-ESR were improved between the first and third consecutive assessment (1.6 ± 0.8, 1.5 ± 0.8, p = 0.040 and 1.6 ± 0.8, 1.5 ± 0.7, p = 0.089, respectively), but only the ASDAS-CRP reached significant difference (Table 3).

Table 3. ASDAS-CRP and ASDAS-ESR from three consecutive assessments (n = 201).

	First assessment	Second assessment	Third assessment	P-value*		
				1^{st} vs 2^{nd}	2^{nd} vs 3^{rd}	1^{st} vs 3^{rd}
ASDAS-CRP						
Mean ±SD	1.6±0.8	1.5±0.8	1.5±0.8	0.122	0.631	0.040
Q2 (Q1-Q3)	1.5 (0.9–2.1)	1.3 (0.9–1.9)	1.4 (0.8–1.9)			
ASDAS-ESR						
Mean ±SD	1.6±0.8	1.5±0.7	1.5±0.7	0.243	0.537	0.089
Q2 (Q1-Q3)	1.4 (1.1–2.0)	1.5 (1.0–2.0)	1.4 (1.0–1.9)			

*Statistical analysis was conducted using a paired *t* test

Abbreviations: ASDAS, *Ankylosing Spondylitis Disease Activity Score*; CRP, C-reactive protein*; ESR,* erythrocyte sedimentation rate

†Comorbidities were identified within 1 year before the index date.

†Three consecutive times: the earliest time was considered the first time, the second time was 84 ± 7 days, and the third time was 168 ± 7 days

Discussion

To our knowledge, several meta-analyses have assessed the effectiveness of mHealth applications for monitoring AS disease activity in multiple centers[5,6]. However, no study had explored the influence of EMRMS intervention on disease activity and time and the frequency of outpatient visits among patients with AS in a single medical center. This study demonstrated changes in the health-related behaviors of patients with AS, including increased outpatient visit frequency and decreased outpatient visit time, especially among AS patients with very high disease activity. Furthermore, ASDAS-CRP improved after the EMRMS intervention.

The study findings indicate that the proposed smartphone-based management system is a time- and cost-effective disease management tool, achieving high ASDAS and the efficient detection of inflammatory markers in a Chinese AS cohort[17,18]. Self-report ASDAS questionnaires have been applied extensively to evaluate the disease activity of patients with AS in single medical center studies[19-24]. In contrast to previous studies, the current study linked the TCVGH HIS with smartphone applications, wherein laboratory data are automatically integrated into the app and trained nurses assist patients with completing assessments through an NRS on the app for ASDAS calculation. This system has a high interrater reliability, accuracy, and precision. Optimal treatment of AS must involve shared decision-making between patients and health professionals. Through this user-friendly EMRMS, patients with AS can more thoroughly understand their disease severity, which may in turn improve their treatment adherence rates and increase clinic visits. This study comprehensively adjusted potential confounders, such as comorbidities, medications, and laboratory data. The study findings provide new insight into the use of apps for disease monitoring to reduce consultation times for individuals with a mild disease status, improve the treatment adherence rates of individuals with a severe disease status, and ameliorate AS disease activity.

Our study has some limitations. First, data were collected from a single medical center in Taiwan, which may have introduced selection bias. Second, we did not have the data of changes in disease activity and frequency of outpatient visits in AS patients who did not receive ASDAS assessment using the EMRMS. Therefore, we cannot compare our data of the VGHTC-AS cohort with those of a control group. Finally, the results may not be generalizable to the entire population of Taiwan with AS.

Conclusions

This is the first single medical center study in Taiwan to compare the treatment outcomes of patients with AS after EMRMS management. The EMRMS is an effective management system that offers satisfactory levels of usability; the data obtained are of a high quality, and the system enables a comprehensive analysis of patient function, helping patients more accurately understand their conditions and thus leading to improved patient treatment adherence. The study results may help increase outpatient visits and improve the health status of patients with AS. Further research should explore the application of EMRMSs for the management of other chronic diseases.

abbreviations

EMRMS: electronic medical record management system

AS: *Ankylosing Spondylitis*

ASDAS: *Ankylosing Spondylitis Disease Activity Score*

CRP: C-reactive protein

ESR: erythrocyte sedimentation rate

IBD: inflammatory bowel disease

HLA: human leukocyte antigen

eHealth: electric health

Declarations

Ethics approval and consent to participate: The study protocol was approved by the Institutional Review Board (IRB) of Taichung Veterans General Hospital (TCVGH-IRB No.: CE20145B).

Consent for publication: Informed consent was waived because personal information had been anonymized before analysis. Not applicable.

Data and materials availablility: The datasets generated during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests

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Authors' contributions:

PJH: original draft (equal), writing — review and editing (lead). YHC: investigation (equal), data curation (equal), methodology(equal). WNH: investigation (equal), data curation (equal). YMC: investigation (equal), formal analysis (equal). KLL: Data curation (equal), investigation(equal). TYH: investigation (equal), data curation (equal). WTH: investigation (equal), project administration (equal). CTL: investigation (equal), resources (equal). CWT: investigation (equal), software (equal). KTT: investigation (equal), software (equal). YYC: investigation (equal), supervision (equal). YDW: investigation (equal), supervision (equal). CYH: formal analysis (Lead) CWH: investigation (equal). YJC: investigation (equal). YWL: investigation (equal). YYL: resources (equal). HHC: original draft (lead), conceptualization (lead), data curation (lead), methodology (lead), project administration (lead), Validation (lead), Visualization (lead). The author(s) read and approved the final manuscript.

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Figures

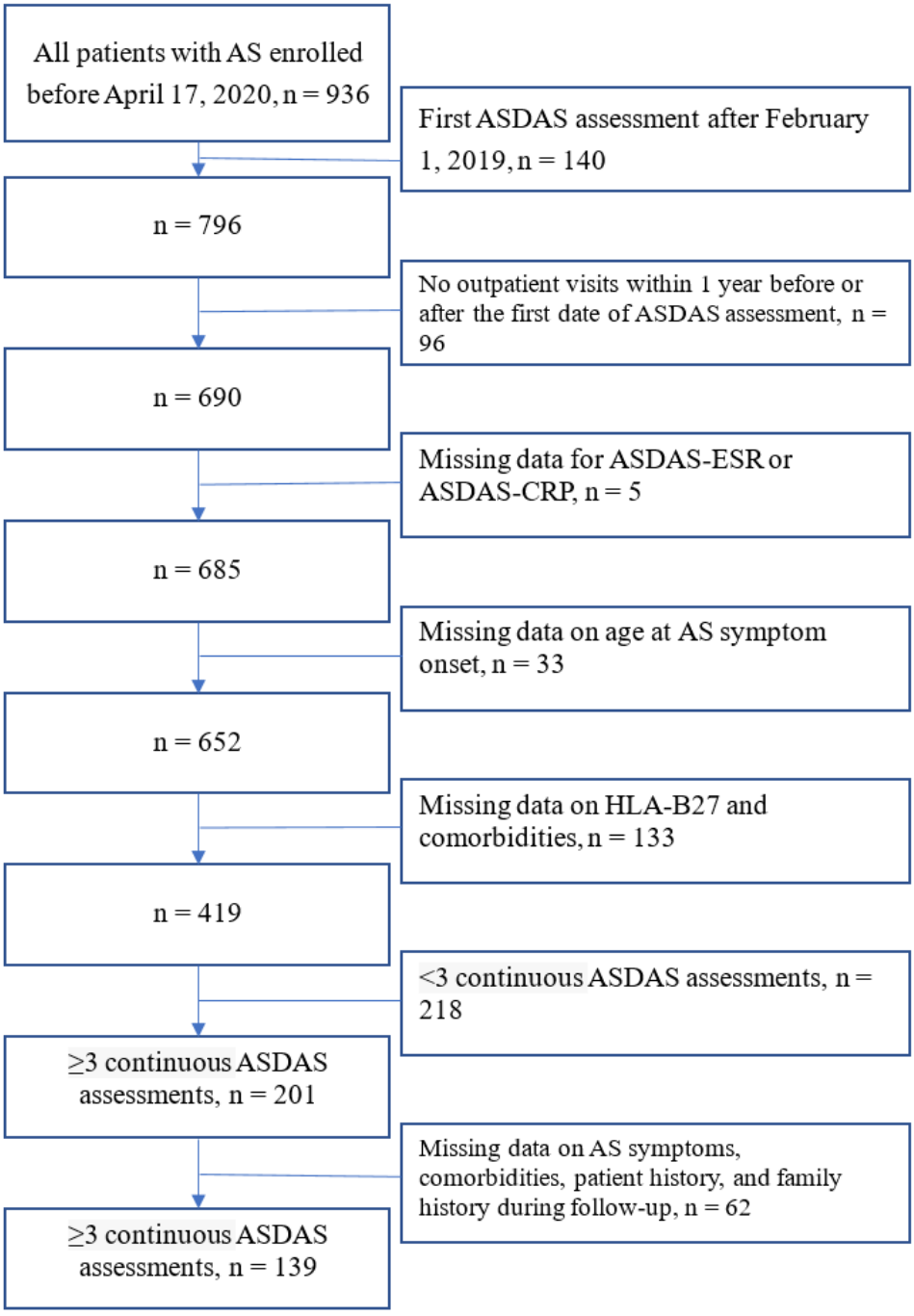

Figure 1

Flowchart of patient enrollment

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