



A bibliometric analysis of the global research in ankylosing spondyloarthritis (2008–2017)

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Abstract

The current study was to investigate the quantity and quality of researches in the field of ankylosing spondylitis, and to reveal the characteristics of worldwide productivity on this disease. This was a bibliometric study on ankylosing spondylitis using Web of Science. The numbers of papers, citations, research output normalized by population and gross domestic product, and the main active countries were analyzed. A total number of 7239 papers were published between 2008 and 2017. The yearly number of papers published during this period showed a significant increase ($p < 0.001$). North America, West Europe and East Asia were the main regions for AS papers. High-income countries contributed the greatest proportion of papers (70.49%). The research productivity from middle- and low-income countries was low (29.45%; 0.06%). The United States was the country with the greatest contributions between 2008 and 2017 (12.47%), followed by China (12.17%), Turkey (8.34%), Germany (7.82%), and the United Kingdom (5.97%). Significantly positive correlations were proved between the number of papers and population/gross domestic product ($p < 0.05$). From 2013, the number of AS publications by the authors from China exceeded those from the United States. However, China had far less total citations (7219 vs. 22,043) and average citations (8.19 vs. 24.41) than the United States. Denmark had the greatest productivity when normalized by population, followed by Norway, and Netherlands. When normalized by gross domestic product, Denmark led the top list, followed by Netherlands, and Greece. Papers from Australia showed the highest average citation (32.64), followed by Netherlands (31.63), and Germany (26.88). The current study showed a noticeable growth in global research output on ankylosing spondylitis between 2008 and 2017. High-income countries especially the United States had the greatest contributions. The contributions from middle- and low-income countries were considerably small. The number of papers published by countries was positively associated with their population and gross domestic product. Although China had exceeded the United States in the quantity of yearly AS publications, the quality of papers from China was lower compared to the United States. European countries may have better performance relative to their population and economic size.

Keywords Ankylosing spondylitis · Publications · Bibliometric analysis · Web of science

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Introduction

Ankylosing spondylitis (AS) is a chronic inflammatory disease [1, 2]. It leads to functional limitation in a large number of patients and has a great impact on their daily activities [1–3]. AS mainly affects the axial skeleton and the sacroiliac joints, and also peripheral joints and extra-articular structures [1, 3]. The prevalence of AS is 0.1–1.4% worldwide [1–3]. It is more common in men than women, and typically develops in males in their third decade of life [1, 2]. AS places a considerable economic burden on society due to crippling the people of the working population and the high drug costs of biological therapies [1]. In recent years, rapid development appears on the basic and clinical research in the field of AS [1–3]. This may be attributed to the global contributions from different countries [1–3]. However, a full view of worldwide AS research has not been investigated.

Bibliometric analysis is a widely used and well-established tool to quantitatively and qualitatively evaluate the worldwide research productivity on many fields. It is becoming a viable method to monitor the progress and patterns of different scientific fields, and also provides supporting evidence for decision making and medical policy such as increasing direct resources towards research areas that are lagging behind [4]. Bibliometric analysis has been used in many diseases and topics [5, 6]. Global research productivity in the field of AS, however, has not been published to date. This study was to analysis the quantity and quality of scientific publications related to AS using Web of Science database, and to show the characteristics of global output in the field of AS. This study may provide a holistic view on AS, and serve as an important reference for future researches.

Materials and methods

This study was performed according to similar bibliometric analyses in other subspecialty fields [5–7]. The data were obtained on November 11, 2018 from the Web of Science. This database is the world's leading database for citation and other academic impact information, and widely used in the studies on global research productivity [5–7]. The Web of Science Core Collection was selected as the data source. A topic search was performed using “Ankylosing spondylitis” as the keywords. The time period was limited from 2008 to 2017, without other restriction. Publication types were limited as original articles and reviews like previous studies [5–7]. Letter, editorial material, correction and other publication types were excluded.

Based on a mature methodology used in previous bibliometric analysis [5–7], the following information was

extracted: total publications, years, countries, and citations. When the authors were not from the same country, the country of corresponding author was considered as the country of the paper. The number of papers was further adjusted for population size and gross domestic product (GDP). The average citations were also calculated (total number of citations/the number of papers) [5–7]. Countries' research productivity were quantitatively assessed by the number of publications, and qualitatively analyzed by the number of citations. The countries were classified as high-income, upper middle-income, lower middle-income, and low-income countries according to the World Bank classification (<http://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>). The population size and GDP were obtained from the Central Intelligence Agency (<http://www.cia.gov/library/publications/the-world-factbook>).

According to previous studies [5–7], the main active countries was the countries with at least 1% of global publications on AS. The associations between the research output and population size/GDP were further analyzed. The contribution rate was calculated using the number of publications and the global output in each year. The five most active countries in the five most active journals were documented. The five most active journals in the five most active countries were listed.

The trend of yearly AS publications from the whole world and the top five countries between 2008 and 2017 were tested by regression analysis. Spearman's correlation test was used to determine the associations between the number of papers from the main active countries and their population/GDP. Statistical analyses were performed with SPSS (version 19.0, SPSS Inc., Chicago, IL, USA), and *p* value < 0.05 was considered statistically significant.

Results

A total of 10,615 papers were found using the keyword search in the 2008–2017 time period. When limited publication types were as original papers and reviews, 7239 papers from 78 countries were retrieved. There was a significant trend toward increase (from 483 to 976) in global AS-related publications per year (*p* < 0.001). The distribution of the number of papers by world countries was demonstrated in the world map, which showed that North America, West Europe and East Asia were the main regions for AS publications (Fig. 1). High-income countries produced the most papers (70.49%), followed by upper middle-income countries (26.27%), lower middle-income countries (3.18%), and low-income countries (0.06%) (Fig. 2).

The United States published the most papers (903; 12.47%), followed by China (881; 12.17%), Turkey (604;

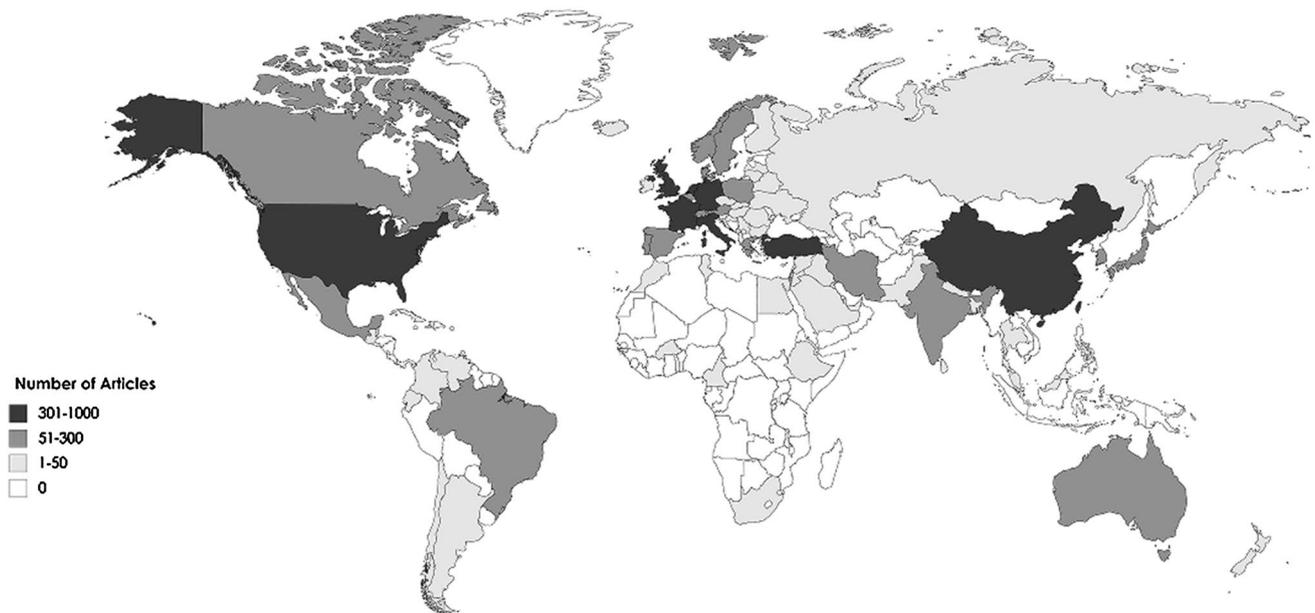
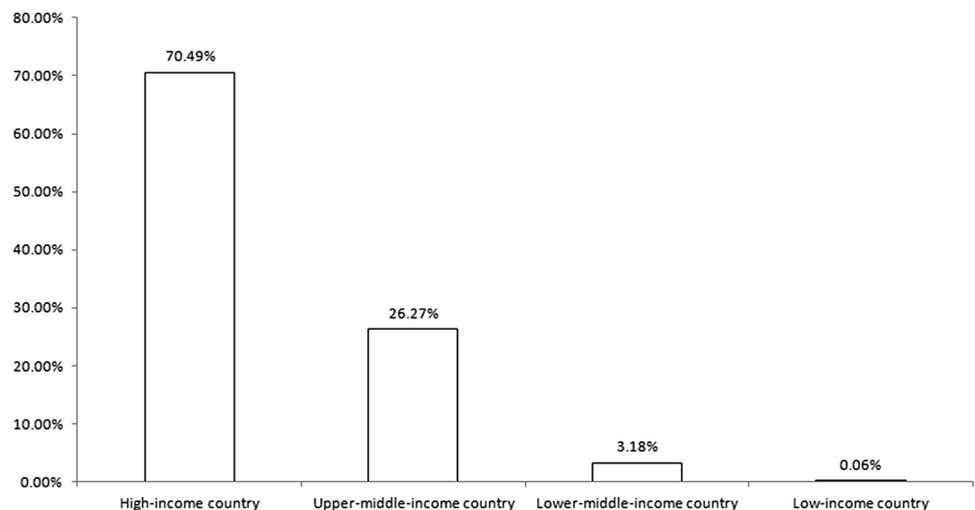


Fig. 1 The world map of global research productivity in 2008–2017

Fig. 2 Publications grouped by country classification in 2008–2017



8.34%), Germany (566; 7.82%), and the United Kingdom (432; 5.97%) (Table 1). Figure 3 shows the yearly number of papers from these top five countries during the past 10 years. Significant growth in publications on AS were demonstrated in the United States, China and Turkey ($p = 0.004$; $p < 0.001$; $p = 0.001$). China had the highest increase in the absolute number of publications, with a 6.04 times, followed by Turkey (1.68) and the United States (1.47). Germany and the United Kingdom had no obvious growth in the AS publications between 2008 and 2017 ($p = 0.458$; $p = 0.082$). From 2013, the number of AS publications by the authors from China exceeded those from the United States. However, total

citations and average citations of China were much less than those of the United States (22,043 vs. 7219; 24.41 vs. 8.19) (Table 1).

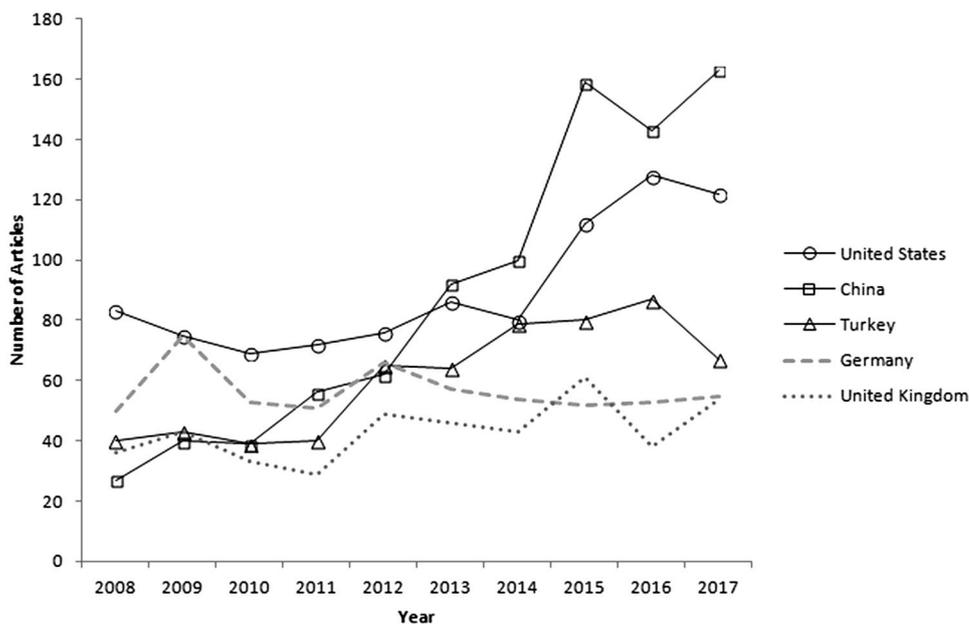
The contribution rates of the top five countries to the world were further analyzed. Table 2 shows the proportion of global contribution to the AS field from the five countries. China showed a 2.99-fold increase (from 5.59% to 16.7%) in the contribution rate ($p < 0.001$), while Germany had a decreasing contributions (from 10.35 to 5.64) to the world community on AS ($p < 0.001$). The other three countries kept steady in the contribution rate ($p > 0.05$).

There are 22 countries which were classified into the main active countries with at least 1% of the global output

Table 1 The main active countries in AS publications between 2008 and 2017

Country	<i>N</i>	%	<i>N</i> per million population	<i>N</i> per \$ 100 billion GDP	Total citation	Average citation
United States	903	12.47	2.76	4.66	22,043	24.41
China	881	12.17	0.64	3.81	7219	8.19
Turkey	604	8.34	7.47	28.32	4614	7.64
Germany	566	7.82	7.02	13.64	15,212	26.88
United Kingdom	432	5.97	6.67	15.00	10,088	23.35
Italy	402	5.55	6.47	17.43	6057	15.07
France	385	5.32	5.74	13.58	6987	18.15
Netherlands	326	4.50	19.08	35.57	10,310	31.63
Canada	275	3.80	7.72	15.59	5426	19.73
Spain	251	3.47	5.13	14.19	3247	12.94
South Korea	242	3.34	4.73	11.93	2739	11.32
Brazil	144	1.99	0.69	4.46	1287	8.94
India	126	1.74	0.10	1.33	746	5.92
Australia	124	1.71	5.34	10.04	4047	32.64
Denmark	112	1.55	19.98	39.23	2243	20.03
Belgium	106	1.46	9.22	20.06	1634	15.42
Norway	105	1.45	19.74	27.93	2095	19.95
Sweden	93	1.28	9.34	17.83	1444	15.53
Greece	86	1.19	7.99	28.71	1598	18.58
Iran	80	1.11	0.98	4.90	801	10.01
Switzerland	76	1.05	9.23	14.71	1830	24.08
Japan	73	1.01	0.58	1.35	556	7.62

N number of articles, *GDP* gross domestic product

Fig. 3 Publication trend for the five most active countries in 2008–2017

in the field of AS. These countries published the majority of total papers in the world (6392; 88.30%). The main active countries included 17 high-income countries, 4

upper middle-income countries (China, Turkey, Brazil and Iran), and 1 lower middle-income country (India). The statistical analysis showed that the number papers was

Table 2 Contribution rate of the five most active countries in the field of AS between 2008 and 2017

Year	United States (%)	China (%)	Turkey (%)	Germany (%)	United Kingdom (%)
2008	17.18	5.59	8.28	10.35	7.45
2009	12.27	6.55	7.04	12.27	7.04
2010	12.37	6.99	6.99	9.50	5.91
2011	13.00	10.11	7.22	9.21	5.23
2012	10.89	8.88	9.31	9.46	7.02
2013	12.63	13.51	9.40	8.37	6.75
2014	10.46	13.07	10.33	7.06	5.62
2015	11.58	16.44	8.27	5.38	6.31
2016	13.53	15.12	9.20	5.60	4.02
2017	12.50	16.70	6.86	5.64	5.53

significantly correlated with population size ($p = 0.025$; $r = 0.477$) and GDP ($p = 0.003$; $r = 0.597$).

When population size was considered, Denmark had the greatest productivity in the number of publications (19.98), followed by Norway (19.74), and Netherlands (19.08). When normalized by GDP, Denmark led the top list (39.23), followed by Netherlands (35.57), and Greece (28.71). With respect to the total citations, the United States ranked the first (22,043), followed by Germany (15,212), and Netherlands (10,310). However, when the average citation was calculated, Australia led the list (32.64), followed by Netherlands (31.63), and Germany (26.88).

The United States, China, Turkey, Germany and the United Kingdom were the five most active countries (Table 3). *Annals of the Rheumatic Diseases* (ARD) was the most active journal in the United States; *Rheumatology International* (RI) was the most active journal in China and Turkey; *Zeitschrift Fur Rheumatologie* was the most active journal in Germany; the journal *Rheumatology* was the most active journal in the United Kingdom.

The five most active journals involved in publishing papers on AS were ranked by the number of total papers (Table 4). *Journal of Rheumatology* (JR) ranked the first, with 374 publications and 5.17% of the world output. It was followed by ARD (338; 4.67%), *Clinical Rheumatology* (CR) (332; 4.59%), RI (295; 4.08%), and *Clinical and Experimental Rheumatology* (CER) (270; 3.73%). The five most active countries in these five most journals are documented in Table 4. Canada, Germany, Turkey, Turkey and Italy were the most active countries according to the number of publications in JR, ARD, CR, RI and CER, respectively. China was the most active country in four most active journals. The United States, Germany and Italy were the most active countries in three most active journals.

Discussion

Scientific papers are vital tools for introducing new medical information and their applications to researchers and physicians. A survey of publication activities helps to evaluate the

Table 3 The five most active journals in the five most active countries

Rank	United States	China	Turkey	Germany	United Kingdom
1	ARD (32)	RI (41)	RI (90)	<i>Zeitschrift Fur Rheumatologie</i> (71)	<i>Rheumatology</i> (45)
2	COR (31)	CR (39)	CR (44)	ARD (70)	ARD (24)
3	ACR (29)	PLoS One (35)	AR (30)	<i>Aktuelle Rheumatologie</i> (35)	JR (19)
4	JR (28)	Medicine (33)	IJRD (23)	CER (29)	CER (17)
5	CR (26)	JR (29)	TJR (19)	JR (29)	BPRCR (15)

ARD *Annals of the Rheumatic Diseases*, RI *Rheumatology International*, JR *Journal of Rheumatology*, CER *Clinical and Experimental Rheumatology*, CR *Clinical Rheumatology*, COR *Current Opinion in Rheumatology*, ACR *Arthritis Care & Research*, AR *Archives of Rheumatology*, IJRD *International Journal of Rheumatic Diseases*, TJR *Turkish Journal of Rheumatology*, BPRCR *Best Practice & Research in Clinical Rheumatology*

Table 4 The five most active countries in the five most active journals

Rank	Journal of Rheumatology	Annals of the Rheumatic Diseases	Clinical Rheumatology	Rheumatology International	Clinical and Experimental Rheumatology
1	Canada (56)	Germany (70)	Turkey (44)	Turkey (90)	Italy (54)
2	Netherlands (30)	Netherlands (57)	China (39)	China (41)	Germany (29)
3	China (29)	France (32)	United States (26)	South Korea (21)	Spain (28)
4	Germany (29)	United States (32)	Italy (25)	Spain (16)	France (21)
5	United States (28)	United Kingdom (24)	India (18)	Italy (12)	China (18)

quantity and quality of researches in certain field and provide a special insight on global research trend [5–7]. Multiple bibliometric analyses have been performed in other fields [5–7]. However, no such article has been reported in the field of AS. To our knowledge, this is the first study systematically to analyze the AS literature in a worldwide view using bibliometric method. In the present study, a rapid growth in the number of global AS papers was observed from 2008 to 2017. High-income countries produced the majority of the publications, while middle-income and low-income countries only contributed a small proportion of worldwide publications. Country's research productivity had a positive correlation with their population and GDP. China exceeding the United States ranked the first according to the quantity of yearly papers. However, there still was a long way for China to go to achieve the academic quality of the United States. Countries in Europe may perform better when population and GDP were considered.

The majority of the papers published on AS were by researchers in the United States. It is not surprising that the United States had the highest productivity, which was also proved in many other medical fields [5–7]. This finding demonstrated that the United States had the greatest influence in the field of AS. However, this study found that China had nearly similar total publications compared with the United States. This may be because China has the world's largest population and increasing research output in recent years. Most importantly, our study proved that China exceeding the United States has become the most productive country in yearly AS publications since 2013. There may have several reasons for this phenomenon. One of the most important reasons may be the increasing financial investment in the medical researches due to the rapid growth of Chinese economy [8–10]. In addition, China has an advantage in patient recruitment due to the largest population in the world [10, 11]. Lastly, Chinese researchers and physicians have much better abilities in performing and writing their works than before [8–11]. Based on this trend, with rapid progress of the country in the global communication and international collaboration, the increasing impact from China will be proved in the near future.

In addition, the United States had the highest total citations. One reason was that the United States had far more publications than any other countries. The other reason was that papers from the United States also have high citations due to the high quality. Although China has similar research output with the United States, there was still a large gap in the total citations and average citations between the two countries. Similar result was also proved in Turkey which was the third most active country. These results demonstrated that some emerging countries had a long way to go to catch up with the United States in the quality of AS researches despite they had obvious better performance than before.

It should be noted that AS is an important health problem involving global patients both in developing and developed countries. However, our study found that high-income countries produced far more articles than middle-income and low-income countries. A “10/90” divide had been reported in many fields to describe the proportion of contributions from non-high-income and high-income countries [12]. This study proved a 30/70 divide, which was not consistent with similar studies [5–7]. This may be attributed to multiple factors. First, there were five middle-income countries including China, Turkey, Brazil, Iran and India appearing in the main active countries in this study, which was more than those in the other fields [5–7]. The increasing contributions of these middle-income countries especially China and Turkey were found in this study. Second, our study proved that some high-income countries such as Germany had a significantly decreased trend for global contributions. In addition, low-income countries published few articles in the AS fields, which was similar with other fields [5–7]. This may be attributed to several reasons such as medical policies, funds, and researchers. There is a great need to change this unsatisfied status [5–7].

The correlation analysis revealed that there were significantly positive associations between the number of papers and population size and GDP. These findings suggested that the population and economy size had great influence on the development of AS researches, which were similar with previous publications [5–7]. Although the United States and China having large population and economy size led the

world research productivity, some smaller European countries such as Denmark, Norway, Netherlands and Greece were more prolific relative to their size. This may have reflected that European countries had advantages in making full use of their researchers and funds, which helped these smaller countries to have better performance than large countries [5–7].

JR, ARD, CR, RI and CER were the five most active journals. This result indicated that these journals had the great influence in the field of AS and played a critical role in the knowledge sharing of new research and applications. In addition, this study found that the journals had a trend in publishing papers from the regions where the journals were located, which was agreed with previous publications. For example, JR was published in Canada, which was the most active country in the JR; CER was published in Italy, which was the most active country in the CER. These may reflect that the fact that the authors were more likely to submit their papers to journals located in their regions [5–7].

The present study has several limitations which are similar to those mentioned in other bibliometric analysis [5–7]. Web of Science database included many non-English journals, but not all articles published in other languages were included in the database and evaluated in this study. Journals in English without impact factors were not indexed in the Web of Science, so articles published in the journals which were not included in this database could not be analyzed. The change in the use of database such as Scopus and Google Scholar may lead to different findings, which was common in the field of bibliometric analysis. We choose the Web of Science as searching source because it was the most reliable database for citations and widely used in the bibliometric analyses [5–7]. Lastly, the results may be changed when it was conducted in another time because bibliometric analysis was a cross-sectional survey. Nevertheless, considering relatively comprehensive and objective methods used, this study could still give an overall view of global research productivity in the field of AS.

Conclusion

The present study was the first to evaluate the global productivity on AS research from 2008 to 2017. The yearly number of AS publications presented a rapid increase trend during the last 10 years. However, the majority of AS researches were from high-income countries which were led by the United States, while only a small proportion of studies were published by the authors from middle- and low-income countries. The number of publications had positive correlations with countries' population and GDP. China showed increasing contributions to the world community in the field of AS. It can be expected that the number of AS publications from China will continue

to increase. However, it should be recognized that the quality of papers from China was lower compared to the United States despite China had exceeded the United States in the quantity of publications. When population and economic size were considered, several European countries may perform better.

Author contributions YM and XZ: study design, data analysis and interpretation, writing manuscript and coordination of entire study, JC and YP: data collection and analysis, interpretation and revision of manuscript, HF and BM: data collection and analysis.

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Compliance with ethical standards

Conflict of interest The authors have declared no conflicts of interest.

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