American College of Rheumatology
Empowering Rheumatology Professionals

Arthritis Care & Research
Vol. 74, No. 3, March 2022, pp 340–348
DOI 10.1002/acr.24497

2015 American College of Rheumatology Workforce Study and Demand Projections of Pediatric Rheumatology Workforce, 2015–2030

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Objective. To describe the character and composition of the 2015 pediatric rheumatology workforce in the US, evaluate current workforce trends, and project future supply and demand of the pediatric rheumatology workforce through 2030.

Methods. The American College of Rheumatology created the workforce study group to study the rheumatology workforce. The workforce study group used primary and secondary data to create a representative workforce model. Pediatric rheumatology supply and demand was projected through 2030 using an integrated data-driven framework to capture a more realistic clinical full-time equivalent (FTE) and produce a better picture of access to care issues in pediatric rheumatology.

Results. The 2015 pediatric rheumatology workforce was estimated at 287 FTEs (300 providers), while the estimated excess demand was 95 (33%). The projected demand will continue to increase to almost 100% (n = 230) by 2030 if no changes occur in succession planning, new graduate entrants into the profession, and other factors associated with the workforce.

Conclusion. This study projects that the pediatric rheumatology workforce gap will continue to worsen significantly from the 2015 baseline, and by 2030 the demand for pediatric rheumatologists will be twice the supply. Innovative strategies are needed to increase the workforce supply and to improve access to care.

INTRODUCTION

The relative lack of pediatric rheumatologists to treat the approximately 300,000 children in the US with chronic arthritis and other rheumatic diseases has been a recognized problem for decades (1). In the late 1990s Cassidy and Athreya reported that the number of practicing pediatric rheumatologists had grown from 27 in 1976 to 178 (121 board-certified) in 1996 (2). Although the 7-fold growth of the specialty over those 20 years seemed promising, it remained concerning that more than one-third of 125 pediatric academic centers did not have a pediatric rheumatologist faculty member. In 2006, the American Board of Pediatrics (ABP) published data showing that there were 200 board-certified pediatric rheumatologists, with a clear increasing trend in the number of pediatric rheumatology fellows over 10 years (3). However, the same study demonstrated that there were only 3 pediatric rheumatologists per million children in the US, and 14 states had no practicing pediatric rheumatologists. The American College of Rheumatology (ACR) workforce study published 1 year later predicted a pediatric rheumatology deficit of 33 providers by 2025 (4). In response to these findings, a series of policy recommendations, focused on training and economics, health care delivery, and global outreach, were published to aid in increasing the pediatric rheumatology workforce (5–7). Despite these studies and policy recommendations, a significant deficit in the pediatric rheumatology workforce remains.

To understand the full extent of this workforce gap, in 2015 the ACR created the workforce study group. The purpose of the workforce study group was to evaluate the changes in the adult and pediatric workforce through 2030 and to provide potential

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No potential conflicts of interest relevant to this article were reported.

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Submitted for publication May 20, 2020; accepted in revised form October 22, 2020.

SIGNIFICANCE & INNOVATIONS

- A shortage currently exists of the US pediatric rheumatology workforce to treat children with rheumatic diseases.
- Some geographic regions in the US, especially the South and Southwest, have a severe shortage in pediatric rheumatology providers, and this gap is expected to worsen if interventions do not occur.
- The overall shortage of the workforce is predicted to worsen so that by 2030 demand for pediatric rheumatology providers will be twice the supply.
- Strategies are needed to recruit rheumatologists, physician assistants, and nurse practitioners to pediatric rheumatology and to augment the provider network.

solutions to be addressed by the ACR and other stakeholders. The goals of the pediatric arm of the workforce study group were to describe the current state of the pediatric rheumatology workforce as compared to the previous ACR workforce study (4), project a succession plan as rheumatologists near retirement, develop assumptions regarding the key factors affecting the supply of and demand for rheumatologists, create a patient-centered approach to providing quality care to all patients with rheumatic conditions, and conduct a sensitivity analysis of this workforce model to determine the potential best- and worst-case scenarios. Results from the 2015 adult rheumatology arm of this study have been published previously (8). Here we present the pediatric rheumatology workforce study findings. From these findings, we propose solutions to improve the supply of pediatric rheumatology providers.

MATERIALS AND METHODS

Workforce study group. The workforce study group was composed of a diverse membership group of volunteer rheumatology specialists, including pediatric rheumatologists. There were 5 members of the core leadership, 3 of whom are co-authors on this study (MMD, SUM, and DFB). Two of the core leaders (SUM and DFB) were adult rheumatologists and the other 3 had expertise in workforce and academic leadership. An additional 9 members belonged to the core group. The core membership group included 2 pediatric rheumatologists (co-authors LFI and MSK-G), 1 fellow in adult and pediatric rheumatology, 1 physician assistant (PA), and 1 nurse practitioner (NP). Among both groups, there were 4 division directors (2 adult, 2 pediatric) and 2 adult program directors. Group members came from a variety of geographic locations in the US. Full details of the workforce study group can be found in Appendix A of the 2015 workforce study document (9). Additional focus groups were used to ensure that members of the pediatric rheumatology workforce not represented in the workforce study group were able to provide their perspectives. The workforce study group provided input into the secondary data collection procedures, provided guidance in the primary data collection methods of ACR/Association of Rheumatology Professionals (ARP) members, identified critical factors affecting supply and demand for rheumatology services, approved the workforce study modeling process, and accepted the final workforce study findings. The University of Michigan Institutional Review Board reviewed the study and determined it to be exempt from ongoing review (exemption #2 of the 45 CFR 46.101.[b]; HUM00104523).

Data collection. A mixed-methods approach (both primary and secondary data) was used to identify and evaluate workforce issues. These issues informed the model used to help predict the future pediatric rheumatology workforce. Data were collected from many secondary sources (e.g., American Medical Association, ABP, Rheumatology Nurses Society, National Commission Certification of Physician Assistants) (9). Primary data were collected through electronic surveys distributed to the ACR membership, current rheumatology fellows-in-training, and a group of rheumatology patients identified by the Arthritis Foundation (9). These data were supplemented by data collected through pediatric focus groups and personal interviews. Volunteers were recruited through the ACR to participate in focus groups, both in-person at the ACR Annual Meeting, and via teleconference, for a total of 8 focus groups that included 5–10 participants in each group. Information from these interviews was integrated into the workforce study.

Workforce study modeling. The workforce study model was a critical focus of the workforce study group. The challenge was developing a model that would ensure translating population needs into the appropriate provider supply. The workforce study group selected an integrated workforce framework model that combined socioeconomic and epidemiologic factors along with utilization rates that incorporated the current use of health care services. The first step was to determine the number of pediatric rheumatology providers in the workforce. This step was done by reviewing the number of providers that were ABP board-certified and was supplemented by reviewing pediatric providers in the ACR website and by reviewing responses to the workforce study survey. Pediatric providers included physicians, NPs, and PAs. The next step was to define the pediatric rheumatology workforce that provided direct patient care at the time of the study (2015), defined as the clinical full-time equivalent (FTE). Because of the changing demographics and pattern trends identified, understanding the actual number of practitioners was clearly not sufficient to determine the workforce supply.

The clinical FTE, which is the ratio of units that equate to the number of practitioners seeing patients full-time, was subsequently identified, and used to provide a realistic level of effort devoted to direct patient care. For example, a clinical FTE of 0.5

(or 50%) means that a provider spends half of their time in patient care. Therefore, 2 providers with 0.5 FTE would equate to 1 clinical FTE. After careful assessment and consensus discussion among pediatric rheumatologists in the workforce, the clinical FTE definition for pediatric rheumatology used in the workforce model was 1.0 clinical FTE for physicians in nonacademic settings (approximately 5% workforce) and 0.8 clinical FTE for those working in academic settings (approximately 95% workforce). The pediatric academic FTE was unique from the adult academic FTE, which was estimated at 0.5. This was because compared to pediatric academic rheumatologists, adult academic rheumatologists spent a greater amount of time in scholarly activities and less time in patient care (8). The nonphysician providers (NPs and PAs) were defined as 0.9 clinical FTE regardless of setting.

Workforce study supply and demand assumptions. Factors influencing supply included geographic domestic patterns of population distribution and density (geographic mobility, net migration, and micropolitan statistical areas), practice setting and productivity, succession trends, sex and generational breakdown, and demographic breakdown of new graduates entering the rheumatology workforce (Table 1). The base model assumed no geographic changes over 10 years, that providers working in micropolitan statistical areas worked 15% less than those who worked outside those areas, and that on average, pediatric rheumatologists worked 55 hours per week.

Factors influencing demand included health care utilization patterns, the prevalence of disease, changes in patient demographics, and gross domestic product (GDP) per capita income

Table 1. 2015 ACR workforce study supply and demand base-model assumptions*

	Base-model assumptions
Supply factors	
Geographic	No geographic changes in the model over next 10 years
	Physicians practicing in MSAs work on average 15% fewer hours than those not working in these areas
	On average pediatric rheumatologists work 55 hours per week
Productivity (RVUs)	Pediatric subspecialties saw an increase by 8.0% for compensation per work RVU in 2013
	The work RVU changed by 6.1%, resulting in an increase in compensation of 1.0%
Succession planning	Approximately 32% of pediatric rheumatologists plan to retire in the next 5–10 years
	Approximately 80% of those who plan to retire anticipate a decrease in their patient load by 25%; therefore we factored a three-quarter FTE for those who plan to retire
Sex	In 2015, 68% were female and 32% male
	Females are reported to work 7 fewer hours each week on average
	Females treated approximately 30% fewer than their male counterpart
Full-time vs. part-time employment	Assumed 17.5% work part-time
	Part-time were then assumed to work 0.5 FTE
Practice setting	Approximately 5% nonacademic settings and 95% academic medical center
	One pediatric rheumatologist in nonacademic settings would equal 1 FTE
	One pediatric rheumatologist in an academic medical center would equal 0.8 FTE
New graduate entrants	Approximately 25 graduates annually; 3.9% do not graduate
	Approximately 42.6% are IMGs; approximately 23.9% of the IMGs will practice outside the US
	Approximately 18% will work part-time; approximately 90% of those working part-time are female
	All entering fellows are millennials
Nonphysician providers (NPs/PAs)	Approximately 25% increase in NPs and 25% increase in PAs between 2015 and 2030
Demand factors	
Aging population	Population of children expected to increase by approximately 3% between 2015 and 2030
Prevalence of disease	Females 2.5 times more likely to have rheumatic disease than males
Per capita income	Approximately 1.5% increase
Medicaid expansion	Approximately 30% by 2030 for eligible Medicaid beneficiaries

* Sources: American College of Rheumatology (ACR), 2015 (9); American College of Rheumatology Committee on Rheumatology Training and Workforce Issues, 2013 (10), US Census Bureau (15); Health Resources and Services Administration, 2016 (11); American Board of Pediatrics, 2015 (12); Association of American Medical Colleges, 2016 (13); Accreditation Council for Graduate Medical Education, 2015 (14). FTE = full-time equivalent; IMG = international medical graduate; MSA = micropolitan statistical areas; NPs = nurse practitioners; PAs = physician assistants; RVU = relative value unit.

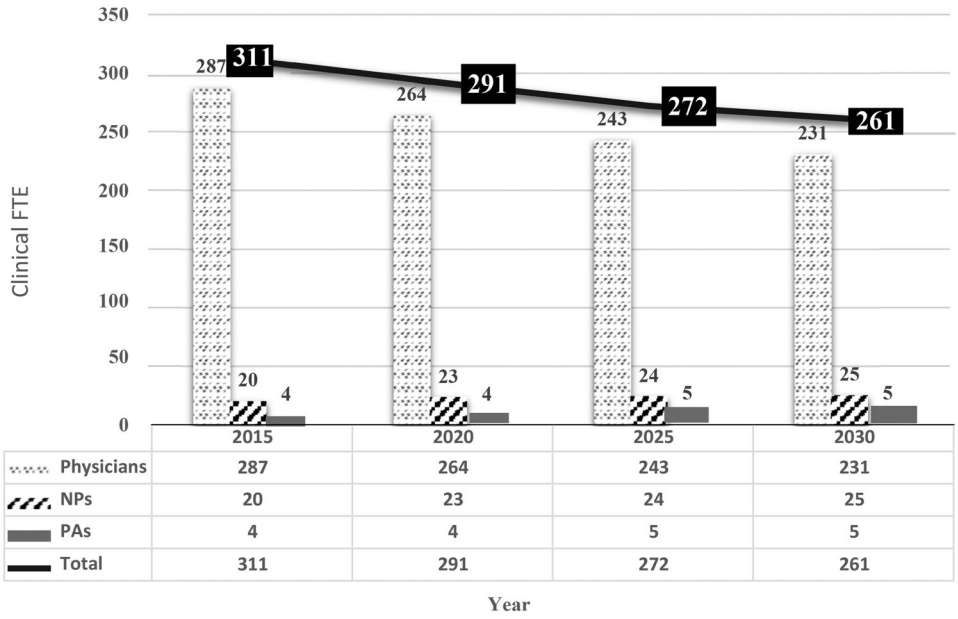


Figure 1. Projected pediatric rheumatology clinical full-time equivalent (FTE) from 2015 through 2030. NPs = nurse practitioners; PAs = physician assistants.

overall and by region (10–14). While the projected population increase in children was anticipated to be relatively small (approximately 3–4%) from 2015–2030, this change was factored in the demand model (15). While the projected effect of the aging US population was far less on pediatric rheumatology than on adult rheumatology, the cost of rheumatology care and GDP per capita income impact was also evaluated. In the 2015 workforce study, a sample of patients was queried to evaluate perceived need and access, which added a new perspective to the supply and demand modeling.

Based on the information collected, the workforce study identified shifts in the demographic breakdown (e.g., sex and

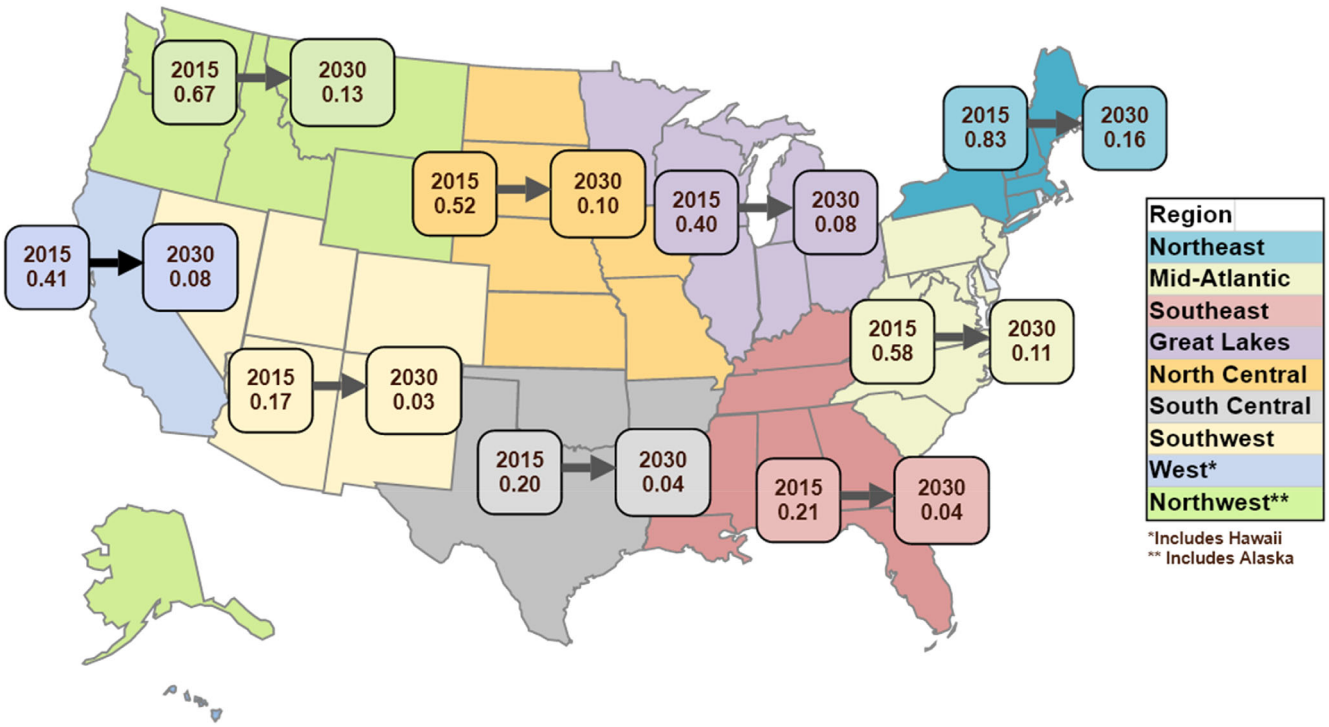
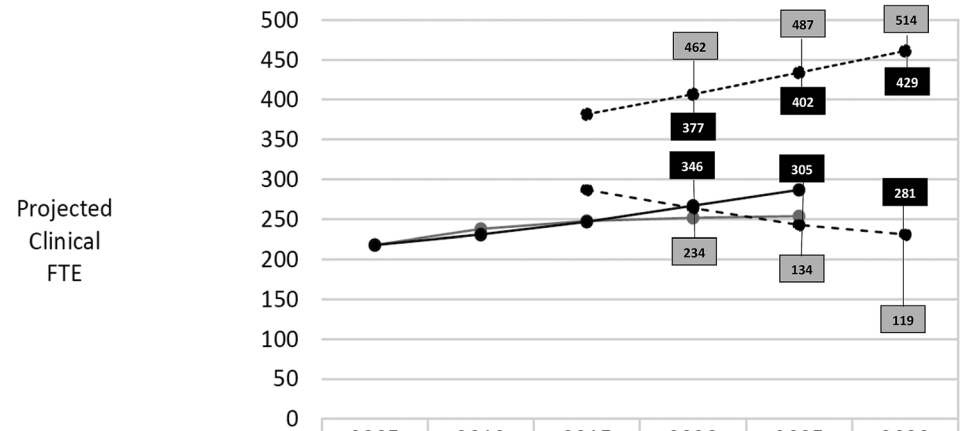


Figure 2. Pediatric rheumatology distribution rate per 100,000 children (2015 versus 2030).



	2005	2010	2015	2020	2025	2030
2005 Projected Supply	218	238	248	252	254	
2005 Projected Demand	218	231	247	267	287	
2015 Projected Supply			287	264	243	231
2015 Projected Demand			382	407	434	461

Figure 3. Projected gap between supply of rheumatologists and demand. This figure includes the previously predicted projection from the 2005 workforce study (4). FTE = full-time equivalent.

generational differences), geographic distribution trends, and practice patterns that indicated a much larger decline in the supply of pediatric rheumatology effort than projected in the 2005 workforce study (4). This decline in supply was theorized to be multifactorial, with an increased number of retiring rheumatology providers, the expansion of part-time providers in the workforce, and the increased number of rheumatology graduates seeking part-time employment. Multivariate and logistic regression with backward stepwise analysis was used to determine factors that contributed significantly to the model for pediatric rheumatology services ($F = 39.06$, $P < 0.001$; $R^2 = 0.37$). Goodness-of-fit tests were used to determine model fit.

Sensitivity testing. To address the variability in the results from the base-model, sensitivity analyses were conducted. Sensitivity testing is an analytic methodology used to build confidence in results. It allows for alternate models to be used in conjunction with a base-case model that incorporates best-estimated values of all selected parameters (16). Sensitivity testing was used to ascertain a best-case and worst-case scenario, providing an estimated range of supply for and demand of services through 2030 (see Supplementary Table 1, available on the Arthritis Care & Research website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24497/abstract). Sensitivity testing is critical to provide for a range in variability that can occur when making future projections.

RESULTS

Baseline rheumatology workforce. Pediatric rheumatology providers were defined as rheumatologists, NPs, and PAs who specialized in treating pediatric patients. Calculations were conducted based on the estimated time providers spent treating patients (referred to as clinical FTE). Figure 1 depicts the pediatric rheumatology workforce supply projections in provider clinical FTEs, including PAs and NPs, from 2015 through 2030. The projections anticipate a 16% decrease between 2015 and 2030.

Demand and supply factors. The factors that were used to assess the future demand of the pediatric rheumatology services included changes in population demographics, health care utilization patterns, practice trends, GDP per capita income, and net migration/geographic trends. Unlike the adult rheumatology workforce, aging was not a major driving force, because according to the US Census Bureau, the population of children age >18 years was not expected to increase significantly between 2014 and 2030, remaining at approximately 74 million by 2020 and 76 million by 2030 (15,17,18). Therefore, population demographics and geographic trends played less of a role in the demand in pediatric rheumatology compared to adult rheumatology. Based on GDP per capita compound growth from 2010 to 2015 and the forecasted value for 2020, an estimated compound growth for 2015–2030 would be approximately 2.5%, up 1.5% from the 2005 study (19–21). In 2015, the growth of the real GDP per capita in the US was approximately 1.5% compared to the previous year. While the GDP per capita continues to rise, the percentage of increase is expected to decrease beginning in 2018 through 2022 (22). Of the factors used to assess future supply for pediatric rheumatology specialists, 3 major drivers included workforce practice trends, access to care/geographic distribution

Table 2. Potential solutions to increase the supply of the pediatric rheumatology workforce*

Increase recruitment of physicians and nonphysician providers
Create a 2-year fellowship for pediatric rheumatologists seeking a clinical-focused career
Implement initiatives to expose more PAs and NPs to rheumatology and increase their recruitment to the field
Increase exposure to pediatric rheumatology in medical school and residency
Give financial incentives (higher salary and/or loan forgiveness)
Optimize the geographic distribution of rheumatologists to improve access to quality care
Extend the use of telemedicine
Providers have significant experience since the COVID-19 pandemic
Reduce referrals of patients with nonrheumatic diseases
Expand rheumatology training in primary care residencies and continuing medical education
Improve rheumatology quality care initiatives in primary care

* PAs = physician assistants; NPs = nurse practitioners.

of rheumatology services, and changes in the demographic breakdown of the new graduates entering the workforce (Table 1) (23–25).

Current workforce practice trends. Given the aging pediatric rheumatology workforce and taking into consideration the current low numbers of pediatric rheumatology providers in the US, succession patterns (e.g., retirement, anticipated changes in workload, etc.) are critical. Labor workforce participation rates for providers of a given age, sex, and international medical graduate status from year to year were reflected in the projections. In addition, sex and millennial workforce practice trends were also included.

Income variability and access to rheumatology workforce. Access to care was defined as physician per population and geographic trends/net migration. While the overall trends show an increase, income varies widely between demographics within the US (26). The poverty rate in the US in 2015 was approximately 15% (15). Poverty rates are persistently higher in rural and inner-city parts of the country as compared to suburban areas. Moreover, 29 states had lower median income, and 18 states had higher median income. When reviewing geographic trends of pediatric providers, there were 3 geographic areas of particular concern. The Southeast had only 0.21 providers per 100,000 children, with a projection of 0.04 per 100,000 in 2030, the South Central region had 0.2 providers per 100,000 children, with a projection of 0.04 per 100,000 in 2030, and the Southwest had 0.17 providers per 100,000, with a projection rate of only 0.03 in 2030 (Figure 2).

New graduates entering the workforce and succession planning. When considering the future supply of pediatric rheumatologists, graduating fellows who enter the workforce were an important factor in the model. The calculated number depended on available fellowship positions, the fill rate of those positions, graduation rates, and number of international medical graduates who anticipate remaining in the US. Other factors that contributed to the entering workforce calculations included sex shifts. Overall, 68% of the pediatric rheumatology workforce was female. Our model assumed that 18% of new graduates entering the workforce would work part-time and 90% of those were female. Our workforce study group survey indicated that 32% of pediatric rheumatologists planned to retire within the next 10 years. Moreover, approximately 80% of those who plan to retire anticipate a decrease in their patient load by 25%. There were approximately 25 pediatric rheumatology fellows graduating each year. Our model predicts that by 2025 there will be an overall loss between retirees and new fellow graduate entrants of 27 providers.

Supply-demand projections. The supply and demand projections of pediatric rheumatology services included NPs and PAs. Figure 1 compares the total number of rheumatology providers (physician and nonphysician) to the projected clinical FTEs of all providers from 2015 to 2030. Figure 3 shows the projected gap between supply of rheumatologists and demand. This figure includes the previously predicted projection from the 2005 workforce study (4). By 2030, the projected supply of pediatric rheumatologist clinical FTEs is 231 compared to a projected demand of 461, thus projecting a net deficit of 230 clinical FTEs.

DISCUSSION

The pediatric rheumatology workforce shortage has been a recognized problem for decades. Although pediatric rheumatology has grown substantially (10-fold) since its beginnings in the 1970s (27), the workforce is approximately 300 providers in the US, which is still a major shortage. The aim of our study was to reassess the trends in supply and demand for pediatric rheumatology care. Notably, the ABP also conducted a pediatric rheumatology workforce study (2018) (28). However, this study primarily used board-certification status as a proxy for clinically available pediatric rheumatology providers, whereas our study attempted to define clinical FTE to more accurately reflect clinically available rheumatologists. This difference is important because most pediatric rheumatologists work in academic settings, and clinical FTE in academia is typically less than that of community practice. At

the time of the workforce study, the academic clinical FTE was determined to be 0.8, based on the fact that anecdotally, most pediatric rheumatologists held clinical educator positions with 0.8 clinical FTE. However, a more recent survey conducted by the American Academy of Pediatrics in 2018 demonstrated that most pediatric rheumatologists self-reported spending only 54% of their time (0.54 FTE) in direct patient care (29). Therefore, currently, the clinical FTE may be closer to 0.5 or 0.6, resulting in an even greater workforce gap than this model predicted. Our study also estimated that approximately 30% of practicing pediatric rheumatologists will retire in the next 10 years. Supportive of this projection, data from the ABP show that approximately 35% of board certified pediatric rheumatologists are age >50 years (28).

The shortage of providers most certainly affects the quality of care of children with rheumatic diseases, as primary care providers refer children to nonrheumatologist pediatric subspecialists and adult rheumatologists (30–32). To provide the highest quality of care, children should be treated by providers with specialized training in pediatric rheumatology and who understand the unique challenges of evaluating and treating a growing child. Given the prediction of a significant workforce shortage, several strategies must be considered to address this problem, including increasing recruitment of physicians and nonphysicians into pediatric rheumatology, promoting changes in the geographical distribution of providers, extending the use of telemedicine, and improving quality of care initiatives in primary care (Table 2).

The ACR and the Childhood Arthritis and Rheumatology Research Alliance both have programs aimed to improve recruitment of pediatric residents into the specialty, and as these programs mature, they should be assessed to determine whether these interventions have been effective (33,34). There are several recognized barriers to recruiting physicians into pediatric rheumatology. These include resident debt, lack of exposure in medical school and residency, concern about being the only specialist in a state or hospital, lower salary than other pediatric specialties and length of training (3-year pediatric fellowship without the 2-year option offered as in adult rheumatology fellowship) (5,6). With only 20–30 new fellows graduating each year, substantial recruitment efforts are needed. The majority of pediatric rheumatologists work in academic institutions in which there is an expectation that academic work requires additional training. Therefore, 3-year fellowships have been the norm in pediatric subspecialties. Few pediatric rheumatologists work in community practice, so a possible solution might be to create a 2-year fellowship for physicians seeking to work in community practice and/or creating strictly clinical positions within academic institutions.

Other measures to improve supply must include recruiting and training more PAs and NPs into the pediatric rheumatology workforce; they have been effectively used to treat adult rheumatology patients (35,36). Financial incentive programs, including medical student loan debt relief are also important. Loan repayment programs have been employed to increase primary care providers in underserved areas (37). A similar loan repayment program for pediatric rheumatology has been introduced to the US Senate but to date has not moved (38).

An important aspect of the workforce supply issue is not only having too few pediatric rheumatologists but also the imbalanced geographical distribution of providers. According to the ABP, there are 9 states (Alaska, Idaho, Montana, New Hampshire, New Mexico, Oklahoma, South Dakota, West Virginia, and Wyoming) without a practicing board-certified pediatric rheumatologist. Several of these states have coverage by outreach programs from other states (28). However, an equally important problem is that several states with large populations of children (e.g., Texas) have only a few pediatric rheumatologists to treat them. Telemedicine has been considered an important possible solution to the geographic barriers to augment timely consultation, reduce patient travel costs and provide access to care, and modify medical management for diagnosed patients. Prior to the COVID-19 pandemic, few pediatric rheumatology telemedicine programs existed (39,40). However, after the COVID-19 pandemic, use of telemedicine skyrocketed across health care in the US, including pediatric rheumatology, and so we will likely see a continuation in telehealth care (41). Anecdotally, we have found patient and provider satisfaction with telemedicine, but studies are needed to optimally assess quality of care in this setting, with a particular emphasis on the quality of the joint examination in telemedicine.

More efforts are needed to reduce the demand on pediatric rheumatologists. Education for primary care providers in conducting musculoskeletal examinations and ordering of rheumatology tests may help reduce referrals of patients with nonrheumatic diseases (42,43). Such training has been successful in adult medicine (44).

A strength of this study was that it used an integrative approach to assess not only the changes in pediatric rheumatology workforce over time, but also integrated changes in the US population, economy, and geographic distribution of providers. Sensitivity testing was used to ascertain best- and worst-case scenarios to establish a range of supply and demand. Importantly, this study also included the patient's perspective on barriers to access to care, and patients reported substantial direct and indirect costs for them when trying to access this care (45). The lack of workforce supply is not limited to pediatric rheumatology; adult rheumatology and several pediatric specialties face similar workforce supply challenges (8,28,46). We believe that this study can serve as a model for assessing workforce problems in other specialties as well.

There were several limitations that are important to highlight. First, it was difficult to determine accurately the number of providers in the workforce who actually treat patients, the ratio of nonacademic and academic providers, the number of medicine/pediatric subspecialists, and how they were documented to

ensure they were not being counted twice. Second, the clinical FTE was selected based on the limited information that was available at the time and cannot be considered 100% accurate. Next, the primary data collection was conducted using the ACR membership, which may limit the generalizability to the overall rheumatology workforce. Notably, the findings from this 2015 workforce study demonstrate a significant worsening in the workforce gap compared to the 2005 study. The supply and demand model is complex, taking into account several population-level factors, in addition to direct rheumatology practice measures such as FTE and disease prevalence. Although great attention was taken in creating the model assumptions, some of the assumptions were possibly inaccurate and thus overestimated the workforce gap, in comparison to the 2005 study. However, the primary purpose of these projections is to demonstrate important trends in workforce gaps and to identify access to care concerns for pediatric rheumatology care with potential solutions for the future.

In conclusion, this ACR/ARP workforce study has demonstrated that the pediatric rheumatology workforce is not meeting demand, and projections show that this excess demand is increasing significantly. Based on our model, by 2030, we are likely to have only half the supply of pediatric rheumatology care needed to meet the demand. Innovative strategies are needed to increase the workforce supply and to improve access to care for pediatric rheumatology patients.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. Correll had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Ditmyer, Imundo, Klein-Gitelman, Monrad, Battafarano.

Acquisition of data. Ditmyer.

Analysis and interpretation of data. Correll, Ditmyer, Mehta, Monrad, Battafarano.

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