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Trends in vascular surgery activity: results from an 18-year period (from 2005 to 2022) and need for specialists by 2035

Tendencias en la actividad de cirugía vascular: resultados en un periodo de 18 años (de 2005 a 2022) y necesidad de especialistas para 2035

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Abstract

Introduction: human resource planning for health is extremely important to adequately respond to the challenges of the specialty and thus assess both our activity and the vascular medical workforce.

Objectives: to identify trends in diagnosis, procedures and costs of the specialty of Angiology and Vascular Surgery in Spain over a period of 18 years and analyze the number of specialists needed with a time horizon set in 2035.

Methods: we conducted a retrospective, observational, population-based study to analyze the activity of vascular surgery services in Spain and a cross-sectional study to analyze the current situation of the workforce in said services.

Material: annual activity data in vascular surgery departments from 2005 through 2022 from the national Minimum Basic Data Set (MBDS) available at https://pestadistico.inteligenciadegestion.sanidad.gob.es/PUBLICOSNS were analyzed, as well as the APR (All refined patient costs) cost data, available since 2016. Age- and sex-adjusted crude incidence rates were calculated for all diagnoses and procedures. Generalized linear models (GLM) were used to estimate trends. A survey was conducted among SEACV members and an estimate was made based on headcounts (number of vascular surgeons) and full-time equivalents (FTE) of vascular surgeons.

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Abstract

Results: between 2005 and 2022, the adjusted rate of diagnoses increased from 102.5 (95 % CI, 101.5-103.4) per 100,000 inhabitants in 2005 up to 237.1 per 100,000 inhabitants (95 % CI, 235.7-238.4) in 2022. The annual linear trend of the estimated total diagnosis rate shows a similar increase in all groups, with no interaction effect by sex or age (IRR, 1.02, 95 % CI, 1.01-1.04, $p = 0.001$). The adjusted rate of procedures increased from 215.4 (95 % CI, 214-216.8) per 100,000 inhabitants in 2005 up to 521.7 (95 % CI, 519.7-523.7) in 2022. 2022. The annual linear trend in the estimated total procedure rate was higher in < 65 years ($p = 0.001$), with no interaction effect by sex: IRR, 1.05 (95 % CI, 1.04-1.07) in men and 1.07 (95 % CI, 1.05-1.1) in women, while in > 65 years, IRR, 1.01 (95 % CI, 0.99-1.03) and 1.03 (95 % CI, 1.01-1.05) respectively. The mean APR cost in 2016 was €4,200.44 vs €4,867.43 in 2022. The estimated annual increase adjusted for age and sex was 133.36 (95 % CI, -2.6-269.3, $p = 0.054$). The growth in demand for stroke specialists between 2023-2035 (based on a system dynamics model) will be 45 %. From the current 985 up to the 1,430 that will be needed in 2035 according to the trends defined in diagnoses and procedures. Compared to a 19.6 % growth in supply for the same period up to the 1,169 estimated for 2035.

Conclusions: this nationwide study shows that there is an upward trend in the incidence of vascular disease. There are very few studies worldwide that perform calculations in FTE, despite being the international recommendation. There is a difference in the calculation of the needs for vascular surgeons depending on whether the calculation is made one way or another, with FTE being a more complete—also a more complex—form of calculation.

Keywords:
Vascular diagnostic incidence. Vascular procedures incidence. APR-costs.

Resumen

Introducción: la planificación de los recursos humanos para la salud es extremadamente importante para responder adecuadamente a los desafíos de la especialidad y valorar así tanto nuestra actividad como la fuerza laboral médica vascular.

Objetivos: identificar las tendencias en diagnóstico, procedimientos y costes de la especialidad de angiología y cirugía vascular en España durante un periodo de tiempo de 18 años y analizar el número de especialistas necesarios con horizonte temporal en 2035.

Métodos: estudio observacional retrospectivo de base poblacional para analizar la actividad de los servicios de cirugía vascular en España y un estudio transversal para analizar la situación actual de la fuerza laboral en dichos servicios.

Material: se analizaron los datos anuales de actividad en los departamentos de cirugía vascular entre 2005 y 2022 del Conjunto Mínimo Básico de Datos (CMBD) nacional disponibles en https://pestadistico.inteligenciadegestion.sanidad.gob.es/PUBLICOSNS, así como los datos de costes TAE (todos los costes refinados del paciente) disponibles desde 2016. Se calcularon las tasas brutas de incidencia ajustadas por edad y sexo para todos los diagnósticos y procedimientos. Se utilizaron modelos lineales generalizados (GLM) para estimar las tendencias. Se realizó una encuesta a los socios de SEACV y una estimación según headcounts (número de cirujanos vasculares) y según equivalentes a tiempo completo (ETC) de cirujanos vasculares.

Resultados: entre 2005 y 2022 la tasa ajustada de diagnósticos aumentó de 102,5 (IC 95 %: 101,5-103,4) por cada 100 000 habitantes en 2005 a 237,1 por cada 100 000 habitantes (IC 95 %: 235,7-238,4) en 2022. La tendencia lineal anual de la tasa total de diagnóstico estimada muestra un aumento similar en todos los grupos, sin efecto de interacción por sexo o edad (TIR = 1,02; IC 95 %: 1,01-1,04, $p = 0,001$). La tasa ajustada de procedimientos aumentó de 215,4 (IC 95 %: 214-216,8) por cada 100 000 habitantes en 2005 a 521,7 (IC 95 %: 519,7-523,7) en 2022. La tendencia lineal anual estimada en la tasa total de procedimientos fue superior en < 65 años ($p = 0,001$), sin efecto de interacción por sexo: TIR = 1,05 (IC 95 %: 1,04-1,07) en hombres y 1,07 (IC 95 %: 1,05-1,1) en mujeres, mientras que en > 65 años, TIR = 1,01 (IC 95 %: 0,99-1,03) y 1,03 (IC 95 %: 1,01-1,05), respectivamente. La media de costes TAE en 2016 fue de 4200,44 euros y en 2022 fue de 4867,43 euros. El incremento anual estimado ajustado por edad y sexo fue de 133,36 (IC 95 %: -2,6-269,3, $p = 0,054$).

El crecimiento de la demanda de médicos especialistas en ACV entre 2023 y 2035 (realizado mediante un modelo de dinámica de sistemas) será de un 45 %: desde los 985 actuales a los 1430 necesarios en 2035, según las tendencias definidas en diagnósticos y procedimientos, frente a un crecimiento de la oferta del 19,6 % en el mismo periodo, hasta los 1169 que se estiman para 2035.

Conclusiones: este estudio a nivel nacional muestra que existe una tendencia al alza en la incidencia de la patología vascular. Existen muy pocos estudios a nivel mundial que realicen los cálculos en ETC, pese a ser la recomendación internacional. Hay una diferencia en el cálculo de las necesidades de cirujanos vasculares según se realice el cálculo de una forma u otra. Los ETC son una forma más completa, aunque más compleja de cálculo.

Palabras clave:
Arco Incidencia en el diagnóstico vascular. Incidencia en procedimientos vasculares. Costes APR.

INTRODUCTION

The planning of human resources for health is a complex and multifactorial task of utmost importance. It is necessary to adjust productivity profiles, estimate epidemiological trends, and respond to organizational parameters for health management and organization by geographic area (1,2). Despite its complexity, such planning is fundamental for formulating policies and supporting decision-making for stakeholders, at the right moment, regarding factors or elements affecting the supply and demand of human talent in health (3).

The vascular surgery workforce is an integral component of any health care system. However, the demand for vascular disease care has imposed a heavy burden on this system. For this reason, it is necessary to adequately respond to the challenges of our specialty and thus assess the vascular medical workforce.

It is essential to consider, among other factors, the incidence of vascular disease, mortality rates by sex and age, the supply of medical residents (MIR) by sex and age, the number of vascular surgeons, the net migration balance of vascular surgeons by sex and age, and the retirement of surgeons by sex and age. All these variables are included in the system dynamics model (3). This simulation model requires all these variables to create dynamic inflows and outflows.

The primary endpoint of this study is to analyze trends in diagnoses and procedures within vascular and angiology services in Spain over an extended 18-year period (2005–2022) to identify trends in future specialist needs.

Secondary endpoints are to analyze the costs in Spain of patients treated in vascular surgery services from 2016 to 2022 and to assess productivity by applying two main workforce evaluation methods: the number of surgeons (headcount) and full-time equivalent (FTE; the conversion from headcount to FTE is based on microdata from an ad hoc survey), adjusting the system dynamics model to make projections for 2035.

MATERIAL AND METHODS

Study type

To address the clinical and economic objectives, we conducted a retrospective, observational, population-based study. To evaluate the current situation of vascular surgeons, we then conducted a cross-sectional study. For productivity projections for 2035, a system dynamics simulation model was applied.

Data sources

For the retrospective study, the minimum basic dataset (MBDS) from the Spanish national hospital discharge information system was used for the period between 2015 and 2022. This database is created by coding hospital discharge reports. Data must be provided by all Spanish hospitals, both public and private, and it is estimated to cover 98 % of the Spanish population (4). For the study period (2005–2022), it contains data on approximately 60 million hospital discharges (5). In addition to demographic data (age, sex, and place of residence), the MBDS includes the diagnosis that led to hospital admission (primary diagnosis) as well as any surgical procedure performed (4). Data collected are coded according to the International Classification of Diseases, Ninth Revision (ICD-9-CM/PCS) from 2005 through 2016, and ICD-10-CM/PCS from 2016 through 2022. Our data include the number of diagnoses, procedures, and costs in total, by sex, and by age group (< 64 and > 64 years) for the activity of 108 vascular and angiology services. Population rates were calculated using demographic data by sex and age group provided by the national census (Instituto Nacional de Estadística de España, INE) (6). We included major vascular diseases and some comprehensive diagnoses not specific to vascular surgery but with an impact on it, recorded as the primary diagnosis. Costs were estimated using data from the analytical accounting system for a representative sample of Spanish public hospitals and include all operating costs (7). In 2016, the National Health System (SNS) published cost weights for both the AP-DRG (All Patient-Diagnosis Related Group) v.27 and APR-DRG (All Patient Refined-Diagnosis Related Group) v.32 systems. APR-DRG costs represent a more refined classification of hospital case complexity, providing information on disease severity, patient mortality risk, and their impact on service costs (8).

The productivity analysis required three phases: phase 1: A survey was distributed digitally to 898 active vascular surgeons in Spain from December 2022 through March 1st, 2023.

The survey consisted of 3 parts to explore and clarify microdata: part 1: Demographic questions; part 2: Questions about the scope, location, and dedication to professional practice, type of hospital, working hours, workload, clinical activity, and subspecialization (items necessary to calculate FTE); part 3: More subjective questions on improving health care distribution and the regional distribution of vascular surgeons in Spain. Survey data were processed into an analytical database.

Phase 2: Projections for vascular surgeon needs from 2023 to 2035 were made using a demographic simulation model through system dynamics (9-11) (Tables I and II). Phase 3: These projections were compared to demand in 2 magnitudes: headcount and FTE.

Statistical method

The crude and age-sex-adjusted rate per 100,000 inhabitants (h) was calculated using the direct method. The direct adjustment method for differences between populations involves calculating general rates that would result if all populations had the same standard distribution rather than differing distributions. The standardized rate is defined as a weighted average of the stratum-specific rates, with weights taken from the standard distribution. To estimate the number of diagnoses, procedures, and costs shaping the workforce in angiology and vascular surgery in Spain up to 2035, multivariate Poisson regression predictive models were adjusted to estimate the annual linear trend of age- and sex-adjusted rates of diagnoses and procedures. These models included the number of diagnoses and procedures as dependent variables, year, sex, and age group (< 64 and > 64 years) as predictor variables, and population data as the exposure variable. To estimate the annual linear trend in age-sex-adjusted costs (APR-costs), multivariate linear regression predictive models were used, including year, sex, and age group as predictor variables. All models incorporated first-level interaction with the year. The linear trend, expressed as the incidence rate ratio (IRR), was estimated for the total sample and by sex and age group,

Table I. Parameters for the specialist supply model for vascular specialists in Spain 2023-2035

Variable	Value at *t* = 2023	Projection at *t* = 2035	Source
Stock, gender, and age	Spanish Society of Angiology and Vascular Surgery (SEACV)	Dynamic	Database of the Spanish Society of Angiology and Vascular Surgery
Specialist training positions (MIR), gender, and age	Specialty positions in the 2022-2023 call for applications	Annual growth equal to the average of the last three calls	Ministry of Health
Mortality rate by gender and age	INE	INE Projections https://www.ine.es/jaxiT3/Tabla.htm?t=36774&L=0	National Statistics Institute (INE)
Exit – Retirement from clinical activity by gender and age	SEACV Survey 2022	Constant percentage equal to 2023	SEACV Survey 2022
Net migration balance by gender and age	https://stats.oecd.org/index.aspx?DataSetCode=HEALTH_WFMI#	Average of the last 3 available years	OECD

Table II. Variables to estimate productivity

Productivity Items
Weekly hours in public hospital
Weekly hours in private hospital or clinic
Weekly hours in private consultation
Reduction in work hours or working hours: maternity/ paternity, leave, research, etc.
Reduction in work hours or working hours: other reasons
On-call shifts (24 hours, 17 hours, and mixed)
Dedication to clinical activity

with a 95 % confidence interval (95 % CI). Predictions from 2022 to 2035 were made using the standardized rate for 2022 and the linear trend estimated from the adjusted models. A *p*-value of < 0.05 was considered statistically significant. Statistical analysis was performed using STATA 17 software.

For the statistical analysis of the cross-sectional study, frequencies and counts were calculated to describe the distribution of qualitative data, while means and standard deviations were calculated to describe the distribution of quantitative data. In univariate analysis, associations between qualitative data were analyzed using the chi-square test. To compare the distribution of quantitative variables in two independent samples, the Student's t-test was performed. Spearman's correlation coefficient was calculated to analyze associations between two quantitative variables. Statistical significance was defined as $p < 0.01$.

RESULTS

The annual age-adjusted diagnosis rate in vascular surgery departments increased from 102.5 per 100,000 inhabitants (h) (95 % CI, 101.5–103.4) in 2005 up to 237.1 per 100,000 h (95 % CI, 235.7–238.4) in 2022 (Fig. 1). Similar trends were observed by sex and age group (Table III).

The adjusted surgery rate reported in vascular surgery departments increased from 215.4 per 100,000 h (95 % CI, 214–216.8) in 2005 up to 521.7 per 100,000 h (95 % CI, 519.7–523.7) in 2022 (Fig. 2). Similar trends were seen in both men and women but were higher in individuals aged < 64 years vs those aged > 64 years (Table III).

The annual linear trend in the total diagnosis rate estimated with Poisson models showed a similar increase across all groups, with no interaction effect by sex or age (IRR, 1.02; 95 % CI, 1.01–1.04, $p = 0.001$) (Table III).

The annual linear trend in the total procedure rate estimated with Poisson models was higher in the < 64-year age group ($p = 0.001$), with no interaction effect by sex: IRR, 1.05 (95 % CI, 1.04–1.07) in men and 1.07 (95 % CI, 1.05–1.10) in women. In the > 64-year age group, IRR was 1.01 (95 % CI, 0.99–1.03) for men and 1.03 (95 % CI, 1.01–1.05) for women (Table III).

Regarding the average cost per case under the refined DRG system (which includes detailed information on patient severity, mortality risk, and cost impact), it was €4,200.44 in 2016 (the average annual cost per discharge in vascular departments) and increased up to €4,867.43 in 2022 (Fig. 3).

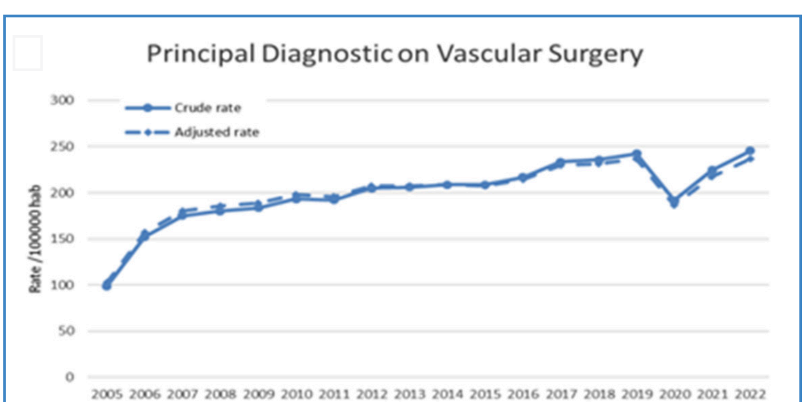

Figure 1. *Progression of diagnoses in vascular surgery departments from 2005 to 2022.*

Table III. Adjusted and non-adjusted ratios of diagnoses and procedures

	Model including age. years. gender. without interaction effect				Model including age. years. gender. with first-level interaction effect						
	Estimates				Estimates					*p* of the interaction effect	
	Linear trend	*p*	95 % CI		Group	Linear trend	*p*	95 % CI		Genre*	Age*
Diagnoses	1.02	*< 0.001*	1.01	1.04	*Men. 0-64 years*	1.03	*0.002*	1.01	1.05	0.973	0.187
					Men. > 64	1.01	0.147	0.99	1.04		
					Woman. 0-64 years	1.03	*0.005*	1.01	1.05		
					Woman. > 64 years	1.01	0.244	0.99	1.04		
Procedures	1.04	*< 0.001*	1.03	1.05	*Men. 0-64 years*	1.05	*< 0.001*	1.04	1.07	0.062	*< 0.001*
					Men. > 64 years	1.01	0.190	0.99	1.03		
					Woman. 0-64 years	1.07	*< 0.001*	1.05	1.10		
					Woman. > 64 years	1.03	*0.002*	1.01	1.05		

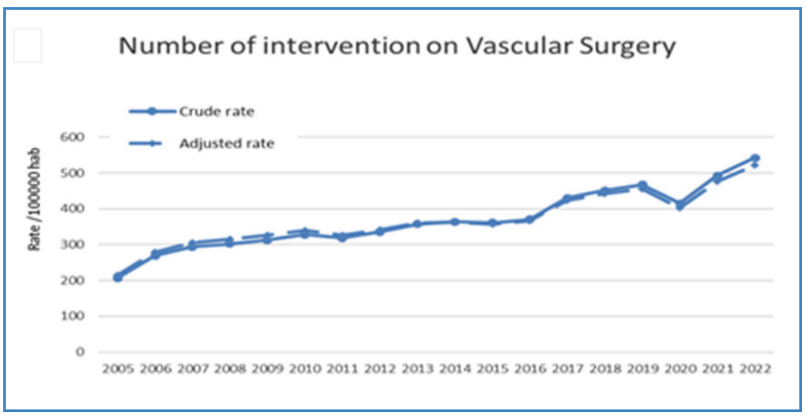

Figure 2. *Progression of procedures in vascular surgery departments from 2005 to 2022.*

For predictions to 2035, the projected case rate is expected to reach 285.7 per 100,000 h diagnostic cases in 2030 and 321.1 per 100,000 h diagnostic cases in 2035. The procedure rate in 2030 is projected to be 697.9 per 100,000 h and 837 per 100,000 h in 2035 (Table IV).

The projected average cost for the general population is expected to reach €6,334.70 in 2030 and €7,251.58 in 2035, adjusted for age and sex.

Regarding survey results (Table V), there was a 34 % response rate among members, of whom 84 % work in the public sector and 60 % in the private sector. Additionally, 36.8 % balance their work between both sectors.

The average number of weekly working hours (excluding on-call shifts) is approximately 41.5 hours (SD = 10), ranging from a minimum of 6 to a maximum of 60 hours per week (Table V).

There are no statistically significant differences in weekly workload based on gender ($p = 0.61$). Weekly workload excluding on-call shifts is also similar across age groups. However, it decreases significantly on average starting at age 56, supporting the general notion that workload reduces with increasing age (Table V).

Between 10 % and 12 % of vascular surgeons perform at least one on-call shift per month. Including these shifts, the average monthly workload rises to 178 hours (95 % CI, 171–184), which equates to an average of 44.5 hours per week (95 % CI, 42.7–46) vs 41.7 hours per week without on-call shifts.

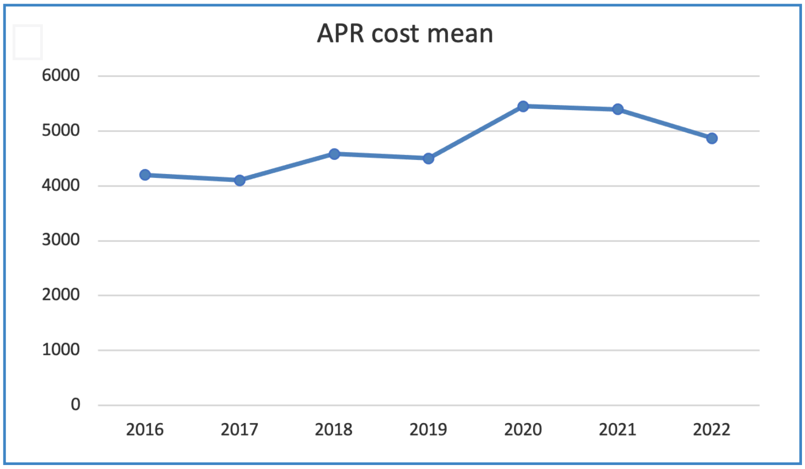

Figure 3. *Cost progression from 2016 to 2022*

Table IV. Prediction of diagnoses and procedures

	Adjusted ratio /100.000 inhabitants			Predictions / 100,000 inhabitants		
	2005	2019	2022	2025	2030	2035
Diagnoses	102.5. 95 % CI: 101.5-103.4	237. 95 % CI: 235.6-238.4	237.1. 95 % CI: 235.7-238.4	254.3	285.7	321.1
Procedures	215.4. 95 % CI: 214-216.8	455.2. 95 % CI: 453.3-457.1	521.7. 95 % CI: 519.7-523.7	581.8	697.9	837.0

Table V. Summary of the survey

	Total (*n* = 306)	Male (*n* = 185)	Female (*n* = 121)	*p*-value	≤ 55 years (*n* = 227)	> 55 years (*n* = 79)	*p*-value	Mean (SD)
Weekly workload (hours)								
Mean	40.8	41.1	40.4	0.605	42.0	37.4	0.013	40.8 (11.4)
SD	11.4	13.4	7.6		9.7	14.8		11.4 (11.4)
At least 1 on-call per month (17 or 24 hours)								
n	39	25	14	0.618	36	3	0.006	39 (n)
%	12.7 %	13.5 %	11.6 %		15.9 %	3.8 %		12.7 % (%)
Monthly workload (hours)								
Mean	178.9	180.7	176.2	0.54	187.9	153.2	< 0.001	178.9 (66.7)
SD	66.7	75.6	51.2		64.6	66.4		66.7 (66.7)
Clinical activity %								
Mean	85.3	81.6	90.8	< 0.001	88.8	75.6	< 0.001	85.3 (17.2)
SD	17.2	19.2	11.9		13.2	22.8		17.2 (17.2)
Teaching activity %								
Mean	2.7	3.9	1.1	< 0.001	2.1	4.7	< 0.001	2.7 (5.4)
SD	5.4	6.5	2.6		4.6	7.0		5.4 (5.4)
Management activity %								
Mean	8.1	10.8	4.1	< 0.001	5.2	16.2	< 0.001	8.1 (13.7)
SD	13.7	15.7	8.7		10.6	17.7		13.7 (13.7)
Research activity %								
Mean	3.8	3.7	4.0	0.771	3.9	3.6	0.703	3.8 (6.1)
SD	6.1	5.2	7.3		6.5	5.1		6.1 (6.1)

Including on-call shifts, there are still no statistically significant differences between men and women. Regarding the relationship between workload and age, there is a significant negative correlation: as age increases, work dedication decreases. Differences are particularly noticeable after age 55, with significant differences in on-call shifts as well ($p < 0.01$) (Table V).

In terms of annual workload, the average number of hours is 2136.1 hours (95 % CI, 2059–2212). No significant differences were found by gender ($p > 0.01$). However, annual workload decreases significantly after age 50.

The final component for calculating full-time equivalent productivity (FTE) is adjusting the annual net working hours dedicated to patient care versus management, teaching, research, or other activities. On average, 85 % of working hours are dedicated to patient care. 28 % of vascular surgeons dedicate 100 % of their time to patient care, while 43 % dedicate 90 % or more of their time to these activities (Table V).

Data show that women systematically dedicate between 5 % and 13 % more of their working hours to patient care than men (women: 95 % CI, 85–88 %; men: 95 % CI, 80–83 %; $p < 0.01$).

For management activities, men dedicate on average 8 % to 13 % more of their time to these tasks vs women (ranging from 2.4 % up to 5.7 %). A significant negative correlation ($p < 0.01$) is observed between age and patient care activities (Table V), particularly for men, with pronounced effects after age 55.

To calculate the FTE productivity indicator, outliers were removed by excluding the top and bottom 5 % of data. For a contractual working time of 35 hours per week (1575 hours annually), the average FTE is 135.9, representing a 35.9 % higher workload than contractual norms.

Our quantitative demand prediction model is based on official population structure data from the Spanish National Institute of Statistics (INE). In 2022, Spain had a population of 47,936,043, of which 51 % were women. Demographic indicators for 2021 showed a life expectancy at birth of 85.83 years for women and 80.27 years for men (placing Spain at the top of Europe by this measure). In the same year, the natural population growth was negative (-2.37), with a very low fertility rate of 1.19 children per woman, the lowest in the European Union. The population aged 0–14 years represented only 13.89 %, and 1 in 5 inhabitants was over 65 years old.

Following the COVID-19 pandemic, the INE updated its official population projections for 2022–2070. These projections estimate that Spain's total population will surpass 51 million by 2035. This population growth is expected to result in a 7.4 % increase in the demand for vascular surgery specialists between 2022 and 2035.

Considering these data and the system dynamics of inflow and outflow, the number of vascular surgery specialists is projected to increase from 985 professionals in 2022 to 1058 needed by 2035.

For a contractual workload of 1695 hours annually (37.5 hours weekly), the average FTE is 126.8, indicating that the average vascular surgeon works 26.8 % more than the standard annual workload.

Women have a lower productivity indicator (FTE = 121) vs men (FTE = 131), but the differences are not statistically significant. The highest productivity indicator is reached between ages 41 and 55 (FTE = 134 for men and 126 for women). There are no statistically significant differences in productivity between those working exclusively in the public or private sector. Specialists working solely in the public sector have an average FTE of 116.9, while those in the private sector average 115.6. Those with dual practice achieve an average FTE of 140.1.

Results are shown in Table VI, showing the FTE conversions for men and women.

Table VII shows the difference between supply and demand based on gross supply (headcounts) and productivity-adjusted supply (FTE). Although in both cases there is a surplus, the differences are substantial. Consequently, the decisions that may arise in human resource planning—such as promoting or reducing the number of training positions for medical specialists and other labor policies—could vary significantly depending on the context.

Table VI. Current status and projection of vascular surgeons according to FTE, geadcounts, gender, and age

	2023	2028	2035
Specialists (heads) in vascular surgery	977	1067	1169
Ratio of heads per 100,000 inhabitants	2.06	2.28	2.62
Specialists (FTE) in vascular surgery	1241	1351	1482
Ratio of FTE per 100,000 inhabitants	2.60	2.72	2.87
Percentage of women	45.40 %	47.30 %	51.30 %
Percentage over 50 years old	35.80 %	33.20 %	24.50 %
Percentage 60 years and older	11.50 %	10.70 %	9.60 %

Table VII. Calculation of the supply and demand of vascular surgeons in headcounts and FTE

Year	Supply FTE	Supply headcounts	Demand	% Deficit (-) / Surplus (+) over Supply Headcounts	% Deficit (-) / Surplus (+) over Supply FTE
2023	1240	978	937	4.2 %	24.4 %
2024	1264	997	944	5.3 %	25.3 %
2025	1287	1015	952	6.2 %	26.0 %
2026	1309	1033	959	7.1 %	26.8 %
2027	1332	1050	966	8.0 %	27.5 %
2028	1353	1067	973	8.8 %	28.1 %
2029	1374	1084	979	9.7 %	28.8 %
2030	1395	1100	985	10.4 %	29.4 %
2031	1414	1115	990	11.2 %	30.0 %
2032	1433	1130	995	11.9 %	30.5 %
2033	1450	1144	999	12.6 %	31.1 %
2034	1467	1157	1003	13.3 %	31.6 %
2035	1482	1169	1006	13.9 %	32.1 %

DISCUSSION

The primary endpoint was to evaluate historical trends in vascular diagnoses and procedures to identify future specialist needs and project these trends for the year 2035 in Spain.

As far as we know, this is the first study to assess trends in the rates of vascular diagnoses and procedures and the first in vascular surgery to calculate productivity in terms of FTE. Main Findings

Trends in diagnoses: the incidence of vascular diagnoses increased by 134.6 per 100,000 hours (from 102.5 up to 237.1) between 2005 and 2022, with similar patterns observed across age and gender (2.31× increase).

Trends in procedures: the adjusted rate of reported surgical procedures in vascular surgery departments increased by 306.3 per 100,000 hours (from 215.4 to 521.7) over the same period. Trends were consistent across genders and age groups (2.42× increase). The growth in procedures exceeds that of diagnoses due to multiple interventions for the same patient.

Future projections: Based on these trends, the projected diagnostic rate for 2035 is more than triple the baseline rate, with a procedural rate forecasted at 837 per 100,000 hours (3.9× increase).

Economic implications: This increase in vascular diseases would drive costs from €4,200.44 in 2016 up to €7,251.58 in 2035.

These findings have significant economic implications for Spain's national health system and private health insurers, providing a foundation for long-term planning within the specialty.

The global rate of procedures was higher in individuals over 64 years for both sexes (men > 64 years had an IRR of 1.01; women, 1.03). However, a greater increase in procedures was observed in individuals under 64 years (IRR for men: 1.05; women: 1.07, $p < 0.001$). This may be linked to rising cardiovascular risk factors in younger populations. Among younger women, it could also be attributed to an increase in venous procedures, warranting further study on specific diagnoses and procedures.

One of the secondary endpoints is to analyze productivity using two main workforce analysis methods: the headcount approach measures the number of health care professionals available to provide services but does not consider working hours (part-time contracts or actual working hours) or vacations, which may vary across countries and professionals. Therefore, headcount measurements only reveal the maximum potential capacity of a given health care system.

In the European Union, healthcare workforce planning activities are conducted under the authority of member states. Nevertheless, an international comparison of headcount data (the number of currently practicing professionals) and FTE (adjusted for working hours) is beneficial to understanding the different healthcare workforce contexts across countries (14).

Despite the importance of the FTE indicator, there is currently no international agreement on its calculation method and usage (15). The formulas recommended by the OECD could reduce the diversity in FTE calculation methods, as they are accepted as comparable approaches and provide support to countries lacking FTE data.

The OECD-recommended formulas could help countries improve their FTE data calculations, thereby providing more comprehensive international reports.

FTE estimates could support a deeper understanding of human resource planning and improve monitoring activities at the national level.

For these reasons, we conducted the first FTE study following OECD recommendations to gain a more detailed understanding of the current situation of vascular surgeons in Spain and to help explore future challenges.

Our study reveals the gap between supply and demand based on gross supply and productivity-adjusted supply. While both scenarios indicate a surplus, the differences are substantial, and the planning decisions for human resources (HR), such as promoting or reducing the number of specialist training positions and other labor policies, could vary significantly depending on the context.

Based on the ad hoc survey—and without being the primary focus of our study—it is shown that there are no statistically significant differences in weekly workload by gender ($p = 0.61$), despite this being a constant reference hypothesis in conversions from aggregate data (1).

Similarly, once on-call duties are included, there are no statistically significant differences between men and women. This is important because such differences are often presumed (1), but in this specialty, they have not been empirically confirmed, even considering on-call shifts.

Our study has some limitations: Although we calculated the future number of physicians based on headcounts and converted this into FTE, the precise proportion of full-time and part-time physicians and variations in individual contributions to angiology and vascular surgery need to be analyzed separately. The method is logical, simple, and consistent with professional ethics. However, it has some drawbacks, one of which is the need to update data to reflect changes over time.

Changes in technology and clinical practice styles likely also require their own adjustments, making it crucial to anticipate the implications of adopting emerging technologies (e-health and innovative treatments, including new devices or outpatient surgeries).

The involvement and rise of other specialties in vascular disease may also affect future outcomes in angiology and vascular surgery activities.

Studies like this are crucial to guiding future strategies aimed at offering an integrated and well-distributed vascular surgery service system nationwide.

Other limitations to consider include: while the data were sourced from the Ministry of Health and cover more than 98 % of the population (4), some patients may not be included. Additionally, caution is warranted regarding the results derived from modeling and prediction systems. Regarding modeling systems, they require current data to project future outcomes. This means that at present, vascular surgeons are working at 126 % capacity (i.e., productivity exceeds 100 %, likely due to the current shortage of surgeons). Including such data in the modeling system implies that future professionals will be required to maintain the same workload.

Finally, this research will provide valuable information to authorities to implement necessary changes and will facilitate the decision-making process for future generations of medical students when choosing their specialty.

CONCLUSIONS

By 2035, a 35 % increase in diagnoses and a 60 % increase in procedures are expected, resulting in a 56 % rise in costs vs 2022.

Regarding productivity calculations, vascular surgeons currently work between 26.8 % and 35.9 % more than the standard workweek. There are no differences by gender, although differences are observed by age.

With these data (growth in diagnoses and procedures) and productivity figures, the projection of vascular surgeons for 2035 suggests a slight surplus, with differences depending on whether calculations are made using headcounts or FTE.

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