

openheart Adult congenital heart disease training in Europe: current status, disparities and potential solutions

Colin J McMahon ^{1,2}, Inga Voges,³ Petra Jenkins,⁴ Margarita Brida ^{5,6}, Annemien E van der Bosch,⁷ Mikael Dellborg,⁸ Ruth Heying,⁹ Jörg I Stein,¹⁰ Borislav Georgiev,¹¹ Senka Mesihovic-Dinarevic,¹² Katja Prokšelj ^{13,14}, Gylfi Oskarsson,¹⁵ Alexandra Frogoudaki ¹⁶, Tefvik Karagöz,¹⁷ Antonis Jossif,¹⁸ Gabriela Doros,¹⁹ Dorte Nielsen,^{20,21} Mikko Jalanko,²² Inmaculada Sanchez Perez,²³ Sílvia Alvares,²⁴ Mette-Elise Estensen,²⁵ Andreas Petropoulos,^{26,27} Raili Tagen,²⁸ Lina Gumbienė,^{29,30} Ina Michel-Behnke,³¹ Peter Olejnik,³² Paul F Clift,³³ Skaiste Sendzikaite,³⁴ Dimpna C Albert-Brotons,³⁵ Mark Rhodes,³⁶ Olli Pitkänen,³⁷ Pier Paolo Bassareo ³⁸, Michael A Gatzoulis,⁵ Kevin Walsh,³⁹ Ornella Milanese,⁴⁰ Magalie Ladouceur ^{41,42}, Massimo Chessa ⁴³, Werner Budts ⁴⁴

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For numbered affiliations see end of article.

Correspondence to
Dr Colin J McMahon;
cmcmahon992004@yahoo.com

ABSTRACT

Objectives This study aimed to determine the status of training of adult congenital heart disease (ACHD) cardiologists in Europe.

Methods A questionnaire was sent to ACHD cardiologists from 34 European countries.

Results Representatives from 31 of 34 countries (91%) responded. ACHD cardiology was recognised by the respective ministry of Health in two countries (7%) as a subspecialty. Two countries (7%) have formally recognised ACHD training programmes, 15 (48%) have informal (neither accredited nor certified) training and 14 (45%) have very limited or no programme. Twenty-five countries (81%) described training ACHD doctors 'on the job'. The median number of ACHD centres per country was 4 (range 0–28), median number of ACHD surgical centres was 3 (0–26) and the median number of ACHD training centres was 2 (range 0–28). An established exit examination in ACHD was conducted in only one country (3%) and formal certification provided by two countries (7%). ACHD cardiologist number versus gross domestic product Pearson correlation coefficient=0.789 ($p<0.001$).

Conclusion Formal or accredited training in ACHD is rare among European countries. Many countries have very limited or no training and resort to 'train people on the job'. Few countries provide either an exit examination or certification. Efforts to harmonise training and establish standards in exit examination and certification may improve training and consequently promote the alignment of high-quality patient care.

INTRODUCTION

Although there have been massive strides in congenital cardiac care over several decades, there remains a clear lack of standardisation and governance of training structures for congenital cardiology in Europe.^{1,2} Having

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ High-quality training is important to ensure congenital cardiologists have the competencies to provide high-quality patient care.
- ⇒ In the USA, there is a standardised training for adult congenital heart disease (ACHD) trainees under the umbrella of the American Board of Internal Medicine with a well-established board examination.
- ⇒ In Europe, although there is high variation in the organisation, exit examination and certification of paediatric cardiology training, the landscape for ACHD remains unknown.

WHAT THIS STUDY ADDS

- ⇒ There is marked variation in the organisation, exit examination and certification of ACHD training across Europe.
- ⇒ Only 2 countries (7%) have formally recognised ACHD training programmes, 15 (48%) have informal training and 14 (45%) have very limited or no training programme. Most countries (25 (81%)) reported training ACHD doctors 'on the job'.
- ⇒ Exit examination in ACHD was conducted in only one country (3%) and formal certification provided by two countries (7%).

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Several solutions are proposed, including harmonising training, standardising an exit examination and providing certification, which may help mitigate training variation, thereby promoting aligning high-quality patient care.

recently highlighted the deficiencies in training of paediatric cardiologists across Europe and the need for a standardised

Table 1 Organisation of adult CHD training in Europe

Country	Accredited/ recognised*	Formal/ informal	Centres† total/training/surgical	Training on job	Exit exam	Certification
Austria	No	Informal	4/4/4	Yes	No	No
Azerbaijan	No	Informal	1/1/1	Yes	No	No
Belgium	No	Informal	4/4/4	Yes	No	No
Bosnia Herzegovina	No	Informal	3/3/3	Yes	No	No
Bulgaria	No	None	2/1/1	Yes	No	No
Cyprus	No	None	1/0/1	Yes	No	No
Czechia	No	Informal	3/3/3	Yes	No	No
Croatia	No	None	1/0/1	Yes	No	No
Denmark	No	Informal	3/3/1	Yes	No	No
Estonia	No	None	1/1/1	Yes	No	No
Finland	No	Informal	5/1/1	Yes	No	No
France	No	Informal	11/3/7	–	No	No
Germany	Yes	Formal	28/28/26	–	Yes	EMAH
Greece	No	None	8/1/5	Yes	No	No
Iceland	No	None	0/0/0	Yes	No	No
Ireland	No	Informal	1/1/1	–	No	No
Italy	No	Informal	7/3/7	Yes	No	No
Latvia	No	None	1/0/1	Yes	No	No
Lithuania	No	Informal	1/1/1	Yes	No	No
Netherlands	No	Informal	5/5/4	Yes	No	No
Norway	No	Informal	2/2/1	Yes	No	No
Poland	No	None	5/0/3	Yes	No	No
Romania	No	None	0/0/5	Yes	No	No
Slovenia	No	None	1/1/1	Yes	No	No
Slovakia	No	None	–	–	No	No
Spain	No	Informal	24/9/13	Yes	No	No
Sweden	No	Informal	7/2/2	Yes	No	No
Switzerland	No	Informal	7/3/4	–	No	No
Turkey	No	None	5/5/5	Yes	No	No
UK	Yes	Formal	11/11/11	–	No	CCT

*Recognised by Ministry of Health of that country.

†Centres: total ACHD cardiology centres in country (excluding private practice departments)/training centres/surgical centres. ACHD, adult CHD; CCT, certificate of completion of training; CHD, congenital heart disease; EMAH, Zusatzbezeichnung Spezielle Kardiologie für Erwachsene mit angeborenen Herzfehlern.

curriculum and exit examination/certification, we must turn our attention to the status of training in adult congenital heart disease (ACHD).^{1–4} It is important to question what would represent a uniform standard against which training could be benchmarked across Europe. This should encourage quality, make equivalence more apparent and offer ACHD trainees to remain in Europe for their training, mitigating high staff turnover.⁵

The number of patients transitioning from paediatric to adult congenital services is increasing each year.^{6–8} In several countries, ACHD has now evolved as its own distinct speciality with several guidelines on

management.^{6–12} ACHD training requirements in the USA are relatively standardised under the umbrella of the American Board of Internal Medicine (ABIM) with several guidelines endorsed by the American College of Cardiology and also the Canadian Cardiac Society.^{12–15} In the USA, there is a well-established board certification examination for ACHD to ameliorate gaps in training.¹³

Although some previous reports have studied and made recommendations for training of ACHD in Europe, there are limited data available on the structure and governance of ACHD training currently

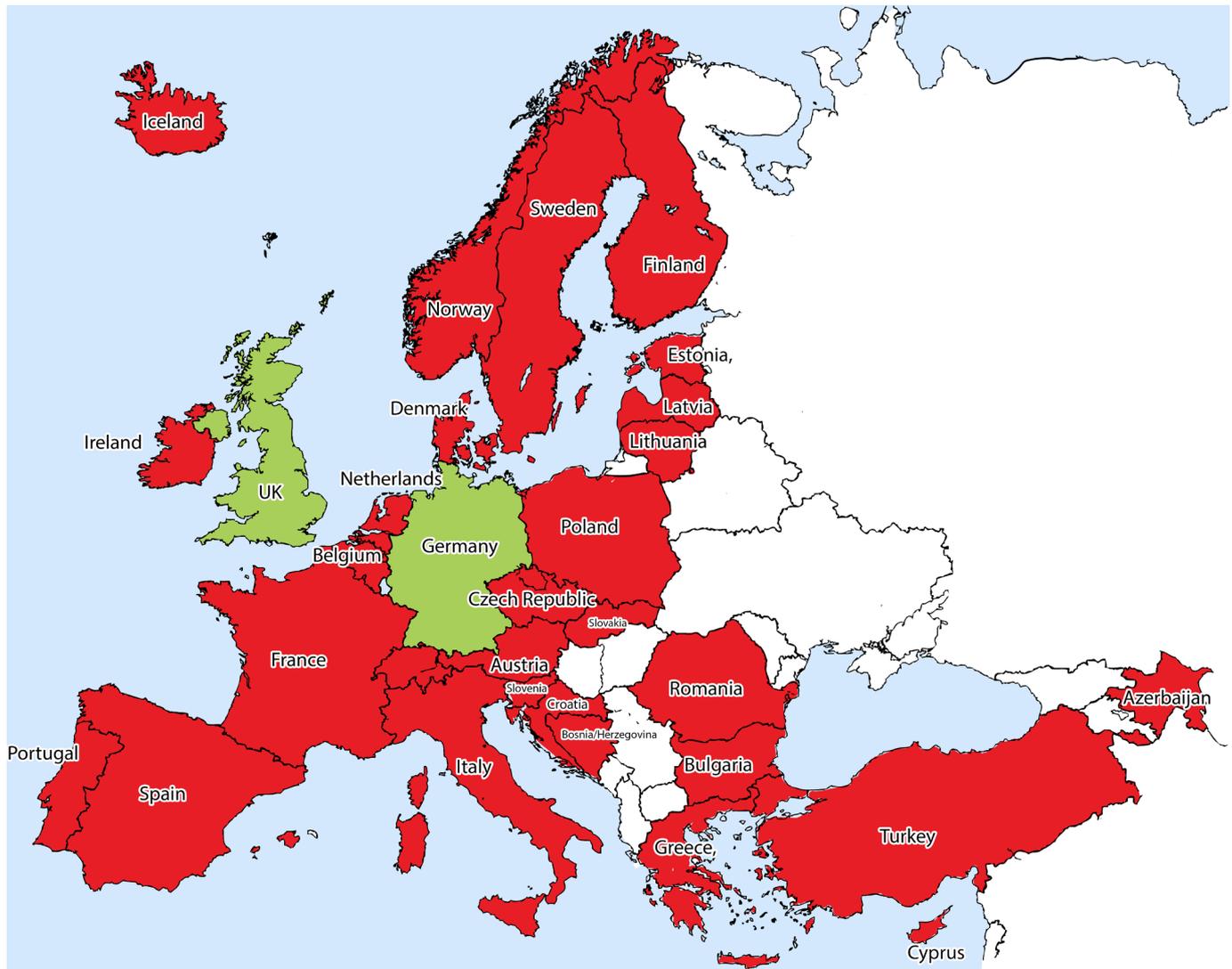


Figure 1 ACHD cardiology subspecialty recognition by governmental ministries of health across 31 AEPC countries. Green represents countries whose Ministry of Health recognise ACHD cardiology as a distinct subspecialty. Red represents countries whose Ministry of Health do not recognise ACHD cardiology subspecialty. White represents a country which did not participate in the study. ACHD, adult congenital heart disease; AEPC, Association of European Paediatric and Congenital Cardiology.

available.^{16–21} It is unknown which countries have an exit examination or certification. This study aimed to shed light on the current state of training of ACHD cardiologists, numbers of ACHD cardiologists per population for each European country, to elucidate which countries provide exit examinations and certification. The overarching aim is to encourage standardisation and provision of high-quality training, thereby promoting an equitable provision of high-quality expertise and healthcare to ACHD patients across Europe.

METHODS AND MATERIALS

Structured questionnaire and selection of countries

In September 2022, a structured questionnaire was prepared based on a previously conducted study.² The questionnaire was reviewed with focus on completeness and clarity of the questions, length of time to complete

the questionnaire and finally validated by Educational Committee of the Association of European Paediatric and Congenital Cardiology (AEPC). Questions were formulated to delineate the current training for all ACHD cardiologists throughout different training centres in Europe. Representative ACHD cardiologists from each country registered with the AEPC or identified through the AEPC Working Group on ACHD were invited by email to take part in the study. If the cardiologist declined to participate with repeated requests, the national AEPC delegate was asked then to nominate or recommend a substitute participant. If that person refused to participate after repeated efforts, then we deemed the country non-participatory. This study built on our previous training study² by expanding the ACHD survey to 34 countries, extensively characterising training in those countries and offering bespoke solutions to training deficits.

Table 2 ACHD cardiologists per million population and GDP in 31 European countries

Country	Population (million)	ACHD cardiologists*	ACHD cardiologist per million population	Nominal GDP† (billion dollars)
Austria	9.05	8	0.89	479.815
Azerbaijan	10.01	8	0.80	73.369
Belgium	11.63	15	1.29	609.887
Bosnia/Herzegovina	3.26	5	1.53	23.358
Bulgaria	6.91	0	–	89.533
Cyprus	1.21	3	2.48	27.726
Croatia	4.04	2	0.50	69.459
Czechia	10.72	3	0.28	296.238
Denmark	5.81	12	2.16	399.100
Estonia	1.32	2	1.52	37.202
Finland	5.55	9	1.62	297.617
France	65.4	25	0.38	2936.702
Germany	83.9	250	2.98	4256.540
Greece	10.38	11	1.06	222.770
Iceland	0.34	0	–	27.865
Ireland (ROI)	5.0	4	0.8	516.146
Italy	60.38	23	0.38	2058.330
Lithuania	2.69	3	1.12	69.782
Latvia	1.87	1.5	0.8	40.266
Netherlands	17.16	30	1.75	1013.595
Norway	5.45	8	1.47	541.938
Poland	37.8	16	0.42	699.559
Portugal	10.17	8	0.77	251.915
Romania	19.13	10	0.52	312.492
Slovenia	2.08	3	1.44	63.647
Slovakia	5.46	4	0.73	118.434
Spain	46.77	54	1.15	1435.56
Sweden	10.15	12	1.18	621.241
Switzerland	8.7	20	2.30	841.969
Turkey	85.09	12	0.14	692.380
UK	67.89	55.5	0.82	3376.003
Total	615.32 m (total) 0.34–85.09 (r)	9 (median) 0–250 (range)	0.81 p/m (median) (0.14–2.98) (r)	312.492 (median) 23.3–4256.54 (r)

Czechia Czech Republic. Data collated on October 2021.

*ACHD cardiologist number includes those working in academic hospital settings. Small scattered private practice cardiologists were not included.

†Nominal GDP 2022 (<https://www.statista.com/statistics/685925/gdp-of-european-countries/>).

ACHD, adult congenital heart disease; GDP, gross domestic product; r, range; ROI, Republic of Ireland.

The questionnaire (online supplemental appendix 1) detailed the number of training programmes, number of ACHD congenital cardiology trainees, trainee characteristics, curriculum, rotations, entry criteria, exit criteria and qualifications. Open-ended questions probed for strengths and weaknesses of current programmes. We asked the local cardiologist the number of ACHD patients, ACHD cardiologists and their estimation of the

‘ideal’ required number of ACHD cardiologists for their respective country.

Definitions

‘Formal accredited or recognised training’ is defined as a nationally recognised (or accredited) structured training programme of sufficient standard to complete basic ACHD training to function as an independent ACHD cardiologist.

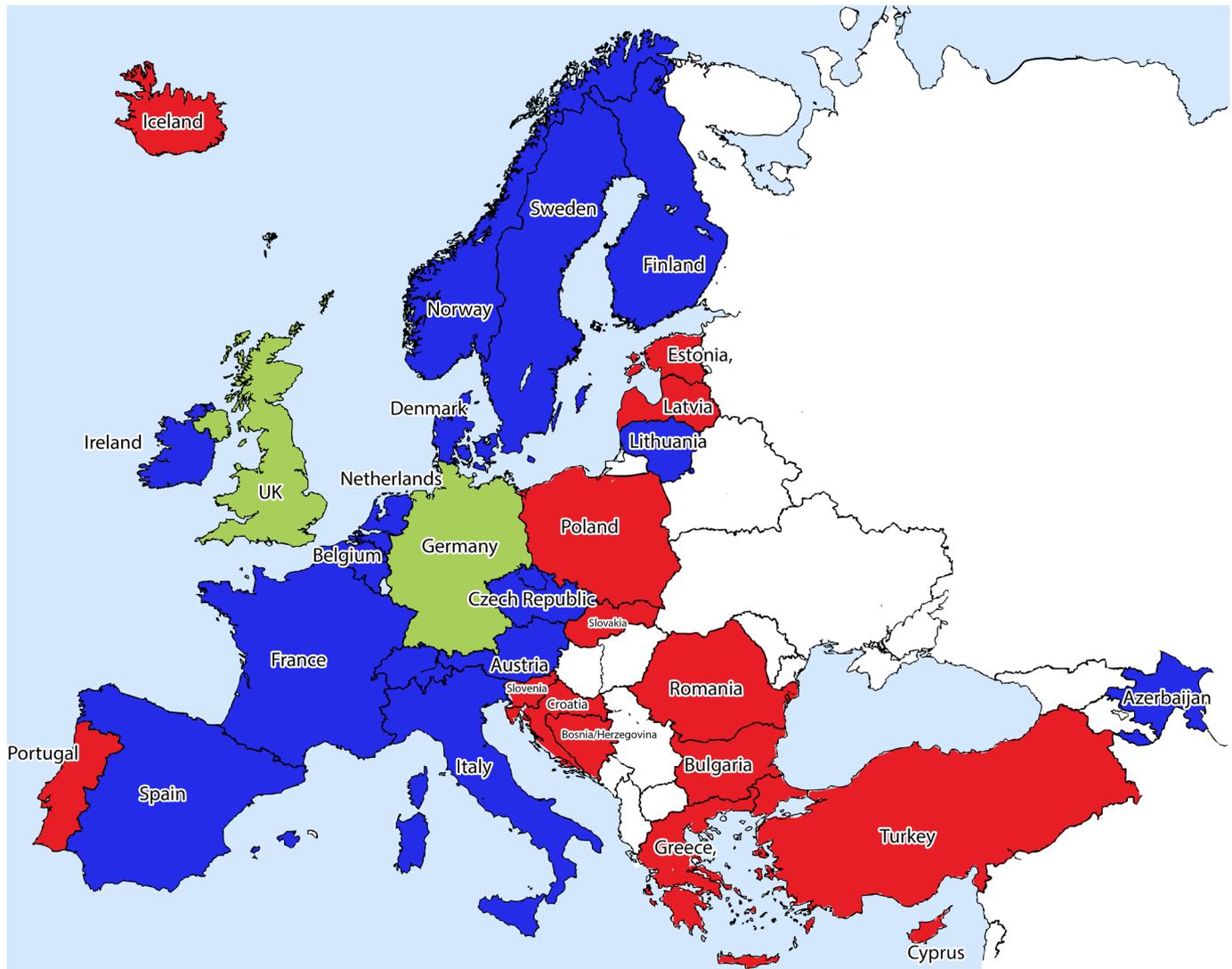


Figure 2 ACHD training programme status across 31 AEPCC countries. Green represents a country with a formally recognised or accredited ACHD cardiology training programme. Blue represents a country with informal ACHD cardiology training programme. Red represents a country with very limited or no ACHD cardiology training programme. White represents a country which did not participate in the study. ACHD, adult congenital heart disease; AEPCC, Association of European Paediatric and Congenital Cardiology.

‘Informal training’ is defined as a programme being of sufficient standard to function independently as a consultant ACHD cardiologist. Of note, the training is not formally recognised (or accredited) irrespective of recognition by the Department of Health in that country.

‘ACHD cardiologist’ is defined as a medical doctor who fully completed ACHD cardiology training was appointed to a public hospital or clinic and actively delivered care as a specialist to adolescents or adults with congenital heart disease.

‘ACHD centre’ is defined as an established public clinic in a hospital caring for ACHD patients. ‘ACHD surgical centre’ was an established public hospital which provided surgical interventions for ACHD.

‘Competency-based medical education’ encapsulates education which focuses on fulfilling critical competencies the trainee must acquire to meet the

healthcare needs of their patients (eg, the Canadian Medical Education Directive for Specialists.²²

‘Gross domestic product’ (GDP) is the total value of all goods and services that are produced within a country’s borders during a specific time (2022 in this paper) (<https://www.statista.com/statistics/685925/gdp-of-european-countries/>).

Statistical analysis

Data were expressed as number (n), percentage (%), and median (minimum–maximum range). Median was chosen because most data refer to whole numbers and/or were asymmetrically distributed. Reporting minimum maximum range was preferred to make the outliers visible for the readers. Mainly descriptive statistics were applied. Population data were expressed against a number of ACHD cardiologists. GDP that can be used to compare the economic performance of different countries was

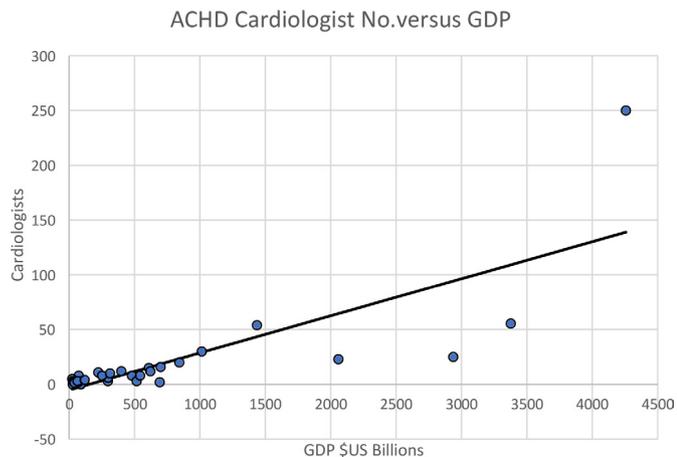


Figure 3 Relationship of total number of ACHD cardiologists and gross domestic product (GDP) in Europe. ACHD, adult congenital heart disease.

correlated with the number of ACHD cardiologist to check whether the number of ACHD cardiologists would also be subject to economic prosperity. Pearson correlation statistics were applied. Statistical tests were two sided and a $p < 0.05$ was considered to be statistically significant. Software packages that were used: Microsoft Office 365 and IBM SPSS Statistics V.28.0.

RESULTS

Characteristics of the participating countries

Representatives from 31 out of 34 countries invited (91%) responded. Hungary, Serbia and Ukraine did not respond. ACHD cardiology was reported as recognised as a distinct specialty by the respective department of Health in two countries (7%) (table 1, figure 1).

Median number of ACHD patients per country was 18 687 (range 100–300 000). The median age of transition was 18 years (range 16–23 years age).

The median number of practising ACHD cardiologists was 9 (range 0–250) (table 2). The median estimated ‘required number’ of ACHD cardiologists was 15 (range 3–400). Twenty-seven (87%) countries reported a shortage of ACHD cardiologists.

The number of ACHD centres per country is presented in table 1. Looking at the distribution of centres, there was one ACHD cardiology centre per 2.69 million population (range 0.66–8.63 million), one ACHD training centre per 3.43 million population (range 0.66–21.8 million) and one ACHD surgical centre per 3.57 million population (range 1.25–9.34 million population). Paediatric and ACHD services were in the same centre in 6 countries, in separate centres in 20 and there was a mixture of both services in 5 countries. Nine countries reported ACHD patients remaining under care of paediatric cardiologists. Eighteen countries reported multiple hospitals caring for patients with ACHD.

ACHD training programmes in Europe

According to the countries that replied, two (7%) have formally accredited or recognised ACHD training programmes: Germany and the UK (online supplemental appendix 2). Fifteen (48%) have informal (not accredited or certified) training and 14 (45%) have very limited or no programme (figure 2). Twenty-five countries (81%) described training ACHD doctors ‘on the job’. The degree of informal training varies markedly with several countries reporting adult or paediatric trained cardiologists gravitating to ACHD care and ‘training on the job’ to take care of patients. Several countries reported very limited or no training programme (Bulgaria, Bosnia/Herzegovina, Croatia, Cyprus, Estonia, Greece, Iceland, Latvia, Poland, Portugal, Romania, Slovakia, Slovenia, Turkey) and scattered or very disorganised services with doctors having to emigrate to train in larger European centres. The broad variation in European training programmes is presented in table 1. The median number of training programmes per country was 2 (range 0–28). Approximately two-thirds allowed entry from either paediatric or adult cardiology. One-third required mandatory adult cardiology training. Only two countries (7%) matched training posts with the need for consultant ACHD cardiologists.

The median number of ACHD fellows per training programme was 1 (range 0–3), and median duration of training was 1.75 years (range 1–5 years). Only two countries (7%) match training posts with postgraduate consultant cardiology posts. ACHD cardiologist number relation to nominal GDP correlation coefficient=0.789 ($p < 0.001$) (figure 3).

Designed curriculum for ACHD training

Responses indicated that only six (19%) countries had a specifically designed curriculum, which was a written document in five countries (16%). The competencies expected of each trainee were delineated in five (16%) of these documents.

Structure of training

The answers of the questionnaire documented that in 4 countries (13%) there was both a national and local training director and in 12 countries there was a local fellowship director (39%). There was a specific design to training with increasing complexity of training through fellowship in eight countries. However, several respondents reported common challenges of training including lack of ACHD facilities, training structure and time to train (online supplemental appendix 3).

Breakdown of training exposure

Training in the countries surveyed included outpatient care (77%), inpatient care (88%), intensive care unit (50%), echocardiography (88%), cardiac catheterisation (67%), electrophysiology (40%), heart failure/transplantation/pulmonary hypertension (50%), advanced imaging (MRI/CT) (54%), preventive cardiology (40%) and pregnancy care (50%).

Table 3 Cardiovascular research during ACHD cardiology training among 31 European countries

Any research component in training	14 (45%)
Formal research part to training	8 (26%)
Dedicated research time	2 (6%)
Median (range) research time (months)	3 (2–12)
Formal research methodology training (statistics, design, evaluate paper etc)	6 (19%)
Higher degree (PhD)	7 (23%)
Separate to training period	7 (23%)
Research outputs	
Complete project	3 (10%)
Submit International Journal	3 (10%)
Accept Peer Review Journal	3 (10%)

ACHD, adult congenital heart disease.

Exit examination and certification

Although only one country (3%) provided an exit examination, other countries provided regular assessments including work-based assessments, multisource feedback, consultant reviews and an ‘annual review of competence progression’ (eg, UK).

Only two countries (7%), Germany and the UK reported their country providing graduating trainees with formal certification/recognition of training in ACHD after completion of training (Zusatzbezeichnung Spezielle Kardiologie für Erwachsene mit angeborenen Herzfehlern and Certificate of Completion of Training)²³ (online supplemental appendix 2).

Cardiovascular research during ACHD training

Fourteen respondents (45%) reported some form of research was encouraged during ACHD training (table 3). Only four respondents (13%) reported a dedicated formal time for research (median of 3 months, range 2–12 months). The majority of respondents (21/31, 68%) reported neither no dedicated time nor informal time dedicated to research.

ACHD trainee travel to other destination countries

Twenty-five respondents (81%) reported their trainees travel abroad for further training (table 4). The indications for travel abroad included limited training in their country (n=13), no subspecialist training (n=9), research (n=10) and to gain wider experience (n=15).

Training in transition care

In only 10 (32%) countries trainees received training on transition to adult services.

Regression on GDP

ACHD cardiologist number versus GDP correlation coefficient=0.789 (p<0.001) (figure 3).

Table 4 Foreign destinations for training by ACHD trainees from 31 AEPC countries

Trainees travel abroad	25 (81%)
Destination training countries	
Europe	25
USA	16
Canada	18
Australia	10
Reasons foreign training	
No training at home	13
No subspecialist training	9
Research opportunities	10
Wider experience	15

ACHD, adult congenital heart disease; AEPC, Association of European Paediatric and Congenital Cardiology.

Reception to improving governance, assessment and certification

All 31 (100%) respondents said they would welcome the introduction of an ACHD logbook. Twenty-nine (94%) respondents would welcome an exit examination and 30 (97%) would welcome the introduction of certification of completion of training.

Feedback on the questionnaire

Online supplemental appendix 4 summarises the feedback to this survey and lists suggestions on what to focus and how to proceed.

DISCUSSION

This study reports a marked variation in training of ACHD fellows across Europe. Formal accredited or formally recognised training only occurs in a tiny minority of countries, clearly reflecting the significant potential for improvement in consistency of training and certification. Establishing a common curriculum with a single common examination set to a certain recognised level would be a start to improve consistency in training.

Each European country possesses a unique culture, language and often marked disparities in terms of resources and GDP. Such disparities are reflected in the wide variation in training patterns of ACHD cardiologists, not dissimilar to ACHD reports from the USA.^{14 15} This study demonstrated very few structured formalised training programmes, several with informal training (always without exit examination) and several with no formal training (usually but not necessarily in smaller countries with limited resources, eg, even resource replete countries such as Norway and Switzerland have limited training frameworks). Despite such a wide range of training programmes, many ACHD cardiologists are still ‘trained on the job’.

An unexpected finding from this study was the discovery that ACHD is recognised as a distinct specialty in only two countries (Germany and UK), thereby compromising the



Figure 4 Strategies for improving the education and training of adult congenital heart disease cardiologists in Europe. These include subspecialty recognition by each country's Ministry of Health (1), standardisation of curriculum development for ACHD across Europe (2), develop a common exit examination (3) and certification for ACHD (4), develop partnerships between larger and smaller countries/centres to promote ACHD training (5), ongoing collaboration between ESC and AEPC organisations to foster these initiatives (6), greater communication and collaboration through online meetings (7), greater research collaboration between ACHD centres in Europe (8), increased funding support for education and training of ACHD specialists (9). ACHD, adult congenital heart disease; AEPC, Association of European Paediatric and Congenital Cardiology.

ability to develop a training framework in countries where ACHD specialty is not officially recognised. Furthermore in the UK, the Specialist Advisory Committee and the GMC both fail to recognise the specialty even though the Ministry of Health recognises it. A majority of countries had not even applied for subspecialist recognition. Some delegates reported that the Ministry of Health was tentative to provide recognition, even when requested, which may be related to funding issues. Similar findings were mentioned in the recently reported European paediatric cardiology study, which are stark findings when one considers that paediatric cardiology was recognised back in 1957 by the American Academy of Pediatrics and that board examination for paediatric cardiology certification and training programmes were established in 1961 and for ACHD by the ABIM in 2015 in the USA.^{7 20}

Our aim in training ACHD cardiologists should be to provide them with the key competencies to be safe to work as independent doctors providing high-quality care to

patients in their country. Such training can prove stressful for trainees even in well-structured programmes, hence it is critically important that the training provided be of high-quality and relatively standardised across Europe.²⁴ Creative solutions in reducing stress may include novel instructional techniques (eg, echocardiography bootcamp or simulation), which can be easily incorporated into training at an early stage to allay some of these pressures on trainees.²⁵ As well as matching training to the eventual daily roles of the cardiologist, ensuring those same cardiologists maintain their level of competence in line with evolving practice and innovation remains important.

Proposed solutions

The findings from this study highlight the continuing question of how we can improve ACHD training support for countries with limited resources. We propose the following initiatives (figure 4):

- ▶ To support colleague countries lobbying their national department of Health for formal recognition of subspecialty status of ACHD. This is fundamental to providing a framework for training. Funding streams may need to be accessed to enable greater ACHD training and service development for some economically disadvantaged countries, given the recently reported disparities in resources.²⁶
- ▶ To harmonise the ACHD curriculum across Europe. This can replicate other specialties such as the Respiratory Medicine group (HERMES).²⁷
- ▶ To recommend standard ACHD fellowship duration (18 months to 2 years), rotations and expected levels of entrustment. We should direct our focus to high-quality training rather than simply counting the numbers of procedures. A logbook could record the quality of studies performed by the trainee. Recognising levels of entrustment provides an excellent model previously described for paediatric cardiology trainees.²
- ▶ Most larger countries can offer basic level core ACHD fellowship training.
- ▶ Foster collaborations between smaller countries with limited training support and larger better resourced countries with a track record in training ACHD cardiologists. Potential hubs of training, some partly in situ already, could be established between different countries. For example, a Nordic block (cumulative population exceeding 27 million) for training in ACHD cardiology similar to that proposed for paediatric cardiology.² Alternatively, trainees from smaller countries with limited resources could benefit from an exchange programme undertaking elective periods (similar to the Erasmus secondary school scholarship) at larger better resourced ACHD centres to supplement their training.
- ▶ AEPC and European Society of Cardiology (ESC) as European governing structures can foster the development of such partnerships.
- ▶ Provide a common exit knowledge based ACHD assessment and certification which would facilitate transfer of professional qualifications across different countries.
- ▶ The AEPC education group and the ESC can collaborate further and offer courses to educate trainers in instructional design and novel learning techniques.
- ▶ Encourage broader adoption of novel strategies including online learning, for example, webinars ('Heart University', 'Heartbeats' webinars, 'Congenital Heart Academy' and 'World University for Paediatric and Congenital Heart Surgery').²⁸
- ▶ AEPC and ESC can host educational sessions, for example, webinars²⁹ and specific sessions at research meetings.
- ▶ Support ACHD research collaboration across Europe³⁰ and promote research into training of ACHD cardiologists. Funding sources should be explored to invest in the education and training of ACHD specialists.

These proposals will require dialogue and planning involving official working groups under the AEPC and ESC umbrella. This paper should not be just a box-ticking exercise but an impetus for implementation of real change and learning benefits for ACHD trainees.

Where to now?

Reflecting on the sobering results of this study, we must go further and ask the question should all European ACHD cardiologists be specifically formally trained in this area or do we wish to continue the current practice of having non-specialist cardiologists practising in this field? In 2023, surely the time has come to expect the ACHD field to be respected as its own entity, with proper expectations of training and certification standards. Universal training standards have been advocated by other European groups (Harmonisation of Education in Respiratory Medicine for European Specialists, hermes.ersnet.org) demonstrating improved standards of knowledge.²⁷ How ACHD training centres of excellence would be developed remains to be decided. However, it would seem logical if ACHD trainees receive structured high-quality training that this expertise would reach and benefit ACHD patients. USA and Canada launched already in 2015 an urgent call 'to strengthen and standardise ACHD training to meet the increasing workforce requirements of this population'³¹ and they started to develop structured training programmes stating that 'advanced physician training for ACHD in the past 10 years, have begun to improve disease outcomes'.³²

Limitations of the study

Despite a high participation rate in this study, some countries' ACHD physicians could not be enrolled. Not every respondent was able to provide a complete data set for all the studied variables. We relied on each respondent to provide accurate data for their country including the number of patients and ACHD cardiologists. Most countries do not have a national registry of every ACHD patient so the number of ACHD patients were estimated by the respondents. There clearly is the potential for bias and possible error as this is somewhat subjective process. However, in an effort to ensure data accuracy, we requested the respondent from each country to carefully review the finalised paper. Statistics relating to the ratio of patients to ACHD cardiologists may be estimated as the exact number of ACHD cardiologists may be difficult to measure for every country. Also survival of congenital cardiac patients to adulthood may vary between countries, directly impacting the potential need for ACHD cardiologists. The differentiation between informal training and 'training on the job' can prove a challenge and there are nuances in training in specific countries. Small private practice institutions were not included in this study.

CONCLUSION

In conclusion, ACHD cardiology education and training varies markedly across Europe. This paper not only maps the training landscape but proposes initiatives towards

a more standardised and organised approach, with the aim of promoting better trained ACHD cardiologists. Through collaboration to support pan European solutions which can be implemented and sustained, we can promote excellence in ACHD training. Hopefully better trained doctors will facilitate increased ACHD expertise improving patient care across the entire continent.

Author affiliations

- ¹Children's Health Ireland at Crumlin, Crumlin, Ireland
- ²University College Dublin School of Medicine, Dublin, Ireland
- ³Kiel University, Kiel, Germany
- ⁴Liverpool Heart and Chest Hospital NHS Foundation Trust, Liverpool, UK
- ⁵Adult Congenital Heart Centre and Centre for Pulmonary Hypertension, Royal Brompton Hospital, London, UK
- ⁶Medical Rehabilitation, University of Rijeka Faculty of Medicine, Rijeka, Croatia
- ⁷Cardiology, Erasmus MC, Rotterdam, The Netherlands
- ⁸Cardiology, Sahlgrenska University Hospital, Gothenburg, Sweden
- ⁹Department Paediatric Cardiology Department of Cardiovascular Sciences, Catholic University Leuven, Leuven, Belgium
- ¹⁰Department of Paediatric Cardiology, Medical University Innsbruck, Innsbruck, Austria
- ¹¹Cardiology, National Heart Hospital, Sofia, Bulgaria
- ¹²University of Mostar, Mostar, Bosnia and Herzegovina
- ¹³Department of cardiology, University of Ljubljana Faculty of Medicine, Ljubljana, Slovenia
- ¹⁴Faculty of Medicine, University of Ljubljana, Ljubljana, Slovenia
- ¹⁵University of Iceland, Reykjavik, Iceland
- ¹⁶Second Cardiology Department, Attikon University Hospital, Athens, Greece
- ¹⁷Department of Paediatric Cardiology, Hacettepe University Ihsan Dogramaci Children's Hospital, Ankara, Turkey
- ¹⁸Paedi Center for Specialized Pediatrics, Strovolos, Cyprus
- ¹⁹Paediatric Cardiology, Louis Turcanu Emergency Children Hospital, Timisoara, Romania
- ²⁰Department of Clinical Medicine, Aarhus University, Aarhus, Denmark
- ²¹Department of Cardiology, Aarhus University Hospital, Aarhus, Denmark
- ²²Heart and Lung Centre, HYKS sairaanhoitopiiri, Helsinki, Finland
- ²³Department of Paediatric Cardiology, University Hospital Ramón y Cajal, Madrid, Spain
- ²⁴Pediatric Cardiology Department, Oporto Medical Center, Porto, Portugal
- ²⁵Department of Cardiology, Rikshospitalet, Oslo, Norway
- ²⁶Ped. Cardiology, Merkezi klinika, Baku, Azerbaijan
- ²⁷Pediatrics, Azerbaijan Tibb Universiteti Nariman Narimanov, Baku, Azerbaijan
- ²⁸Department of Cardiac Surgery, Tartu University Hospital, Tartu, Estonia
- ²⁹Clinic of Cardiac and Vascular Diseases, Vilniaus universitetas Medicinos fakultetas, Vilnius, Lithuania
- ³⁰Centre of Cardiology and Angiology, Vilniaus Universiteto ligonines Santariskiu Klinikos, Vilnius, Lithuania
- ³¹Department of Pediatrics and Adolescent Medicine, Medical University of Vienna, Vienna, Austria
- ³²Department of Pediatric Cardiology, Comenius University, Bratislava, Slovakia
- ³³Grown Up Congenital Heart Disease Unit, Queen Elizabeth Hospital, Birmingham, UK
- ³⁴Vilnius University, Vilnius, Lithuania
- ³⁵King Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia
- ³⁶Leeds Beckett University, Leeds, UK
- ³⁷Divisions of Pediatric Cardiology, Children's Hospital/Helsinki University Hospital, Helsinki, Finland
- ³⁸Mater Misericordiae Hospital, Dublin 7, Ireland
- ³⁹Heart House, Mater Misericordiae Hospital, Dublin, Ireland
- ⁴⁰Padua University Hospital, Padova, Italy
- ⁴¹Cardiology, Hopital Europeen Georges Pompidou, Paris, France
- ⁴²Pediatric Cardiology, Hopital universitaire Necker-Enfants malades, Paris, France
- ⁴³Pediatric Cardiology Department and GUCH Unit, Policlinico San Donato, San Donato Milanese, Italy
- ⁴⁴Department of Cardiology, University Hospital Gasthuisberg, Leuven, Belgium

Twitter Magalie Ladouceur @Mag_Ladouceur

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ORCID iDs

Colin J McMahon <http://orcid.org/0000-0003-0337-9338>
 Margarita Brida <http://orcid.org/0000-0001-8754-8156>
 Katja Prokšelj <http://orcid.org/0000-0003-1301-632X>
 Alexandra Frogoudaki <http://orcid.org/0000-0001-8381-8200>
 Pier Paolo Bassareo <http://orcid.org/0000-0002-8374-0260>
 Magalie Ladouceur <http://orcid.org/0000-0002-4325-3521>
 Massimo Chessa <http://orcid.org/0000-0001-7432-4815>
 Werner Budts <http://orcid.org/0000-0001-5850-5413>

REFERENCES

- McMahon CJ, Tretter JT, Redington AN, et al. Medical education and training in congenital cardiology: current global status and future developments in training in a post COVID-19 world. *Cardiol Young* 2021;1:1–13.
- McMahon CJ, Heying R, Budts W, et al. Paediatric and adult congenital cardiology education and training in Europe. *Cardiol Young* 2022;32:1966–83.
- Heying R, Albert DC, Voges I, et al. Association for European paediatric and congenital cardiology recommendations for basic training in paediatric and congenital cardiology. *Cardiol Young* 2020;30:1572–87.
- Gatzoulis MA. Adult congenital heart disease: education, education, education. *Nat Clin Pract Cardiovasc Med* 2006;3:2–3.
- Crossland DS, Ferguson R, Magee A, et al. Consultant staffing in UK congenital cardiac services: a 10-year survey of leavers and joiners. *Open Heart* 2021;8:e001723.
- Moons P, Bratt E-L, De Backer J, et al. Transition to adulthood and transfer to adult care of adolescents with congenital heart disease: a global consensus statement of the ESC association of cardiovascular nursing and allied professions (ACNAP), the ESC working group on adult congenital heart disease (WG ACHD), the association for European paediatric and congenital cardiology (AEPC), the pan-African society of cardiology (PASCAR), the Asia-Pacific pediatric cardiac society (APPCS), the inter-American society of cardiology (IASC), the cardiac society of Australia and New Zealand (CSANZ), the International society for adult congenital heart disease (ISACHD), the world heart foundation (WHF), the European congenital heart disease organisation (ECHDO), and the global Alliance for rheumatic and congenital hearts (global ARCH). *Eur Heart J* 2021;42:4213–23.
- Patel MS, Kogon BE. Care of the adult congenital heart disease patient in the United States: a summary of the current system. *Pediatr Cardiol* 2010;31:511–4.
- Kempny A, Fernández-Jiménez R, Tutarel O, et al. Meeting the challenge: the evolving landscape of adult congenital heart disease. *Int J Cardiol* 2013;168:5182–9.
- Egidy Assenza G, Krieger EV, Baumgartner H, et al. AHA/ACC vs ESC guidelines for management of adults with congenital heart disease: JACC guideline comparison. *J Am Coll Cardiol* 2021;78:1904–18.
- Baumgartner H, De Backer J, Babu-Narayan SV, et al. 2020 ESC guidelines for the management of adult congenital heart disease. *Eur Heart J* 2021;42:563–645.
- Stout KK, Daniels CJ, Aboulhosn JA, et al. 2018 AHA/ACC guideline for the management of adults with congenital heart disease: a report of the American college of cardiology/American heart association task force on clinical practice guidelines. *J Am Coll Cardiol* 2019;73:1494–563.
- Marelli A, Beaulacquesne L, Colman J, et al. Canadian cardiovascular society 2022 guidelines for cardiovascular interventions in adults with congenital heart disease. *Can J Cardiol* 2022;38:862–96.
- Ephrem G, Alshawabkeh L. Contemporary ACHD training and the reality of the field in the United States. *Int J Cardiol* 2019;277:85–9.
- Gurvitz MZ, Chang RK, Ramos FJ, et al. Variations in adult congenital heart disease training in adult and pediatric cardiology fellowship programs. *J Am Coll Cardiol* 2005;46:893–8.
- Gurvitz M, Valente AM, Broberg C, et al. Prevalence and predictors of gaps in care among adult congenital heart disease patients: HEART-ACHD (the health, education, and access research trial). *J Am Coll Cardiol* 2013;61:2180–4.
- Baumgartner H, Budts W, Chessa M, et al. Recommendations for organization of care for adults with congenital heart disease and for training in the Subspecialty of 'grown-up congenital heart disease' in Europe: a position paper of the working group on grown-up congenital heart disease of the European society of cardiology. *Eur Heart J* 2014;35:686–90.
- Hess J, Bauer U, de Haan F, et al. Recommendations for adult and paediatric cardiologists on obtaining additional qualification in "adults with congenital heart disease. *Int J Cardiol* 2011;149:186–91.
- Acar P. How best to train doctors in adult congenital heart disease? *Arch Cardiovasc Dis* 2017;110:277–80.
- Chessa M, Baumgartner H, Michel-Behnke I, et al. ESC working group position paper: transcatheter adult congenital heart disease interventions: organization of care – recommendations from a joint working group of the European society of cardiology (ESC), European association of pediatric and congenital cardiology (AEPC), and the European association of percutaneous cardiac intervention (EAPCI). *Eur Heart J* 2019;40:1043–8.
- Narang A, Velagapudi P, Rajagopalan B, et al. A new educational framework to improve lifelong learning for cardiologists. *J Am Coll Cardiol* 2018;71:454–62.
- Gabriel HM, Baumgartner H, Gamillscheg A, et al. Empfehlungen Zur Struktur der Betreuung von Erwachsenen MIT Angeborenen Herzfehlern (EMAH Patienten) in Österreich – update 2011. *Wien Klin Wochenschr* 2013;125:755–8.
- LoGiudice AB, Sibbald M, Monteiro S, et al. Intrinsic or invisible? An audit of Canmeds roles in Entrustable professional activities. *Acad Med* 2022;97:1213–8.
- Hess J, Bauer U, de Haan F, et al. Empfehlungen Für Erwachsenen- und Kinderkardiologen Zum Erwerb der Zusatz-Qualifikation „Erwachsene MIT Angeborenen Herzfehlern“ (EMAH). *Clin Res Cardiol Suppl* 2007;2:19–26.
- Horst JP, Michel M, Kubicki R, et al. National survey on training in pediatric cardiology by the "Junges forum" of the DGPK. *Thorac Cardiovasc Surg* 2020;68:e1–8.
- Ceresnak SR, Axelrod DM, Sacks LD, et al. Advances in pediatric cardiology bootcamp: boot camp training promotes fellowship readiness and enables retention of knowledge. *Pediatr Cardiol* 2017;38:631–40.
- Brida M, Šimkova I, Jovović L, et al. European society of cardiology working group on adult congenital heart disease and study group for adult congenital heart care in central and South Eastern European countries consensus paper: current status, provision gaps and investment required. *Eur J Heart Fail* 2021;23:445–53.
- Loddenkemper R, Séverin T, Haslam PL. European curriculum recommendations for training in adult respiratory medicine: crossing boundaries with HERMES. *Eur Respir J* 2008;32:538–40.
- Tretter JT, Windram J, Faulkner T, et al. Heart University: a new online educational forum in paediatric and adult congenital cardiac care. the future of virtual learning in a post-pandemic world? *Cardiol Young* 2020;30:560–7.
- McMahon CJ, Tretter JT, Faulkner T, et al. Are E-learning Webinars the future of medical education? An exploratory study of a disruptive innovation in the COVID-19 era. *Cardiol Young* 2021;31:734–43.
- Orwat MI, Kempny A, Bauer U, et al. The importance of national and international collaboration in adult congenital heart disease: a network analysis of research output. *Int J Cardiol* 2015;195:155–62.
- Nguyen LT, Maul TM, Hinds M, et al. Current and future status of adult congenital training in North America. *Am J Cardiol* 2015;115:1151–3.
- Liu A, Diller G-P, Moons P, et al. Changing epidemiology of congenital heart disease: effect on outcomes and quality of care in adults. *Nat Rev Cardiol* 2023;20:126–37.