

Bridging the gap: building structured pathways in paediatric and congenital cardiology education: with a focus on cardiovascular imaging

on behalf of the AEPC Education Committee and Junior Members

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Introduction: context and current gaps

Paediatric and congenital cardiology stand at a critical juncture. Advances in cardiovascular imaging, interventional cardiology, and

surgical care have dramatically improved survival and quality of life for patients with congenital heart disease (CHD). Yet, these achievements have not been matched by parallel evolution in formalized, equitable, and structured educational frameworks. Across Europe, training in paediatric and congenital cardiology remains fragmented, heterogeneous, and highly dependent on local resources, leading to significant disparities in exposure, competence development, and career progression. Imaging in particular—now central to diagnosis, intervention

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planning, and longitudinal follow-up—lacks consistent integration into early-stage training curricula, creating variability in skill acquisition and limiting cross-border mobility of young specialists.¹

Despite the growing complexity of CHD management, many trainees still rely on informal, apprenticeship-based learning with limited access to mentorship, structured curricula, or standardized assessment tools. In some regions, access to advanced imaging modalities such as cardiac magnetic resonance imaging and computed tomography (CT) is restricted, further widening the gap between centres of excellence and smaller institutions. Workforce shortages, uneven subspecialty recognition, and the absence of harmonized accreditation systems reinforce these challenges and hinder sustainable development of the specialty.^{2,3}

Within this landscape, the increasing population of adults with congenital heart disease (ACHD) adds additional pressure. As more than 90% of children with CHD now survive into adulthood, the demand for cardiologists trained along the full lifespan—from paediatric diagnosis to adult follow-up—continues to rise. However, in many countries ACHD subspecialty recognition, funding, and formal training pathways remain limited, creating inconsistencies in care delivery and exacerbating the mismatch between patient needs and specialist availability. Integrating ACHD education as a continuum of paediatric training is therefore essential, but requires robust foundational frameworks that are still lacking in several parts of Europe.⁴

The current landscape: fragmented opportunities and heterogeneous training

Across Europe and beyond, disparities persist in congenital cardiology training. Bravo-Jaimes *et al.*⁵ reported that fewer than one-third of cardiology trainees considered ACHD as a career option, citing limited training opportunities, unclear career pathways, and lack of financial or institutional support. Similarly, McMahon *et al.*⁶ found that only a minority of European countries have recognized subspecialty training in ACHD; nearly half offer only informal, non-accredited programmes. This uneven distribution of expertise perpetuates regional inequities and forces many trainees to seek education abroad, contributing to 'brain drain' phenomena. In paediatric cardiology, similar concerns have been documented: for example Cantinotti *et al.*⁷ identified major variation in training programmes, equipment and accreditation of paediatric echocardiography labs across 22 countries. McMahon *et al.*⁸ further reported that in many countries paediatric cardiology training lacks formal subspecialty recognition, contributing to regional inequities and mobility of trainees.

Other systemic factors compound these challenges. Subspecialty recognition for ACHD is lacking in many countries, limiting dedicated funding and accreditation mechanisms. Curricular content, assessment methods, and certification remain inconsistent, while structured mentorship programmes are rare. Gender disparities, work–life balance concerns, and insufficient integration of digital and imaging technologies further discourage early-career cardiologists from entering the field.^{9,10}

Education in cardiovascular imaging for congenital heart disease

Cardiovascular imaging is a cornerstone of CHD management, yet formal training in this area remains fragmented. Accurate interpretation of complex anatomy, postoperative changes, and haemodynamic patterns requires deep understanding, technical skill, and systematic exposure. Despite technological progress and the proliferation of advanced modalities—three-dimensional echocardiography, strain imaging, cardiac magnetic resonance (CMR), and CT—training opportunities remain inconsistent across centres.¹¹

Education in CHD imaging is often 'learning-by-doing,' dependent on local case volume and expert availability.⁷ While major referral centres may provide structured rotations in echo, CMR, and CT, most young trainees encounter disjointed and uncoordinated learning experiences. This variability directly affects diagnostic accuracy and clinical decision-making.¹²

Certification schemes such as the EACVI/AEPC programmes in CHD echocardiography and CMR represent important milestones but remain unevenly implemented across Europe.¹³ In many regions, imaging education still relies on local initiatives without formal integration into national curricula, limiting professional mobility and cross-border recognition of expertise.

Hands-on opportunities are also limited. Access to dedicated workstations, direct supervision, and multidisciplinary exposure to imaging–surgical correlation is inconsistent.¹⁴ Yet, imaging mastery relies on iterative, mentored practice, structured feedback, and sustained exposure to complex cases. Early and progressive integration of imaging into training curricula is therefore essential—not only to build competence but also to cultivate three-dimensional and pathophysiological thinking that underpins congenital cardiology.¹⁵

Why structured pathways matter

Structured training pathways are not merely academic ideals; they directly impact patient outcomes. Population-based analyses demonstrate that patients managed within dedicated CHD programmes experience lower mortality rates, particularly in severe disease forms.¹⁶ Similarly, surgical procedures performed by congenital specialists are associated with significantly reduced in-hospital mortality compared with those performed by non-specialists.¹⁷

Structured educational frameworks ensure consistency, quality, and patient safety by defining competencies, supervision standards, and milestones. They also sustain workforce development, mitigating burnout, and maintaining expertise during the transition from paediatric to adult care—a period marked by high risk of discontinuity and adverse events.^{18,19}

A harmonized training model encourages early exposure to the entire spectrum of CHD—from prenatal diagnosis to adult management—enhancing clinical, technical, and communicative competencies. Standardized curricula promote equitable access to knowledge, ensuring that all trainees, regardless of country or institutional resources, can achieve comparable proficiency.

Towards solutions: harmonisation, accreditation, and mentorship

Addressing disparities in paediatric cardiology education requires a coordinated, evidence-based strategy at the European level. Harmonized curricula should define shared core competencies and entrustable professional activities that transcend national boundaries.²⁰ Structured assessment tools, standardized logbooks, and transparent accreditation of training centres are vital to ensure accountability and comparability.

Training centre accreditation should be based on objective criteria, including case volume, multidisciplinary exposure, and faculty competence.²¹ Regular evaluation by professional societies such as the AEPC and the ESC ensures adherence to quality standards and alignment with evolving scientific evidence.

Mentorship represents another pillar of sustainable education. Structured mentorship programmes—particularly those fostering inclusion and career development—help mitigate isolation and support academic growth. When embedded institutionally through the AEPC Education Committee and its allied societies, mentorship becomes a systemic mechanism for continuity, diversity, and leadership.²²

Professional societies have a central role in coordinating these initiatives. By establishing consensus on training standards, accrediting

centres, and facilitating certification programmes, the AEPC and ESC can transform harmonization from aspiration into reality, ensuring equitable professional development and lifelong learning across Europe.

AEPC's comprehensive contribution to educational harmonisation

In this context, it is important to acknowledge the substantial work already undertaken by the AEPC to address many of the disparities outlined in this manuscript. Over the past years, the AEPC has significantly expanded its educational portfolio, developing a structured curriculum for paediatric and congenital cardiology, establishing the AEPC examination as a Europe-wide benchmark, and creating accreditation pathways that promote transparency and comparability across training centres. The AEPC-directed webinar series, recently evaluated and shown to provide high educational value, interactivity, and accessibility to junior members across Europe²³ represents a particularly impactful achievement. Delivered bi-weekly and aligned with AEPC training recommendations, these webinars offer equitable exposure to expert teaching across the full breadth of paediatric and congenital cardiology and cardiac surgery. Together, these initiatives demonstrate AEPC's strong commitment to reducing variability in training opportunities, supporting workforce development, and fostering a harmonized, sustainable, and modern educational ecosystem for future generations of paediatric cardiologists.

Call to action: investing in the future of congenital cardiology education

To meet the evolving needs of patients with CHD, education in paediatric and congenital cardiology must evolve from fragmented local experiences to structured, harmonized pathways grounded in equity, quality, and innovation.

Integration of cardiovascular imaging into core training curricula from early stages, supported by cross-disciplinary mentorship and accreditation, will strengthen diagnostic expertise and patient outcomes. This effort requires recognition at institutional and governmental levels—acknowledging the strategic importance of congenital cardiology within healthcare systems.

Investment in harmonized, lifelong educational frameworks represents not only a professional responsibility but also a moral imperative. The next generation of congenital cardiologists must be equipped with the tools, competencies, and collaborative mindset necessary to deliver excellence in an increasingly complex and multidisciplinary field.

AEPC's educational mission

These educational, accreditation, and digital initiatives underline AEPC's long-standing commitment to strengthening paediatric cardiology training across Europe. Through curriculum development, competency-based frameworks, and innovative e-learning strategies, the AEPC continues to build a coherent, harmonized educational ecosystem that supports both trainees and young specialists and ensures high-quality cardiovascular care for future generations.

Author contributions

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