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Mapping pediatric cardiac troponin testing worldwide: results from the IFCC survey on emerging applications, standardization needs and access

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Abstract

Objectives: Limited guidance on the use and interpretation of cardiac troponin (cTn) testing in pediatric populations has restricted its broader adoption, despite the significant burden of congenital and acquired cardiac conditions in children. This survey aimed to evaluate global availability,

utilization patterns, and key challenges associated with cTn testing in laboratories and among clinicians serving pediatric patients.

Methods: The International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) Committee on Emerging Technologies in Pediatric Laboratory Medicine (C-ETPLM) conducted an electronic survey in 2025. Distributed to IFCC members and their networks over one month, the survey included 19 questions targeting both laboratory professionals and clinicians involved in pediatric care.

Results: A total of 439 responses were collected from 48 countries spanning all continents, with 330 meeting eligibility criteria. Most respondents were laboratory specialists; clinicians represented 5.8 %. Among the 58.4 % who reported offering in-house cTn testing, 65.5 % lacked pediatric-specific reference intervals. Among those providing intervals, considerable variability existed in derivation, numerical limits, and sex-specific stratification. High-sensitivity cTn assays were widely available, and at least 71 % reported turnaround times under 2 hours. Clinicians indicated a broad range of indications for cTn testing in pediatric patients. Both clinicians and laboratory professionals consistently highlighted the lack of validated pediatric reference intervals, clear clinical guidelines, and standardized testing indications as major limitations.

Conclusions: The absence of robust, outcome-based pediatric reference intervals, alongside limited clinical guidance and interpretive frameworks, remains a critical barrier to the effective and appropriate use of cardiac troponin testing in pediatric practice worldwide.

Keywords: cardiac troponin; pediatrics; reference intervals

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Introduction

Cardiac troponin testing has fundamentally transformed the diagnosis and management of cardiac disease in adult acute coronary care by enabling earlier and more accurate detection of myocardial injury, and decreased use

of invasive tests for acute coronary syndromes [1]. The widespread adoption of cardiac troponin assays has led to more rapid time to diagnosis of cardiovascular diseases, improved risk stratification, and the development of evidence-based clinical guidelines that rely heavily on cardiac troponin measurements for decision-making in acute cardiac care [2]. In adult acute care settings, adoption of high-sensitivity cardiac troponin assays has been associated with improved workflow efficiency and resource utilization, including shorter length of stay and more efficient patient disposition [3], although, its implementation and downstream clinical use are influenced not only by assay performance, but also by institutional practice, laboratory infrastructure, and local care pathways. In contrast, pediatric use remains less standardized, with important differences in disease prevalence, indications for testing, and interpretation.

Numerous surveys and observational studies have characterized the global availability and use of cardiac troponin testing in adult populations, highlighting substantial regional variation in assay availability, analytical sensitivity, and clinical implementation [4]. These data have been instrumental in guiding harmonization efforts and informing clinical practice guidelines in adult cardiology and laboratory medicine. In contrast, considerably less is known about the availability and clinical use of cardiac troponin assays in pediatric populations. Children and adolescents are affected by a broad spectrum of cardiac conditions including congenital heart diseases like tetralogy of Fallot, and acquired conditions such as myocarditis, pericarditis, cardiomyopathy, Kawasaki disease with cardiac involvement, rheumatic heart disease, as well as infection- and treatment-related cardiotoxicity. Children with congenital heart disease who survive congenital heart surgery remain at a 67-fold increased risk of mortality from congenital heart disease or cardiovascular disease, underscoring the need for ongoing surveillance [5]. Other potential indications for troponin-based monitoring in children include trauma, sepsis, hypercoagulable states, familial hypercholesterolemia, mucopolysaccharidoses, and the evaluation of chest pain to exclude ischemic etiologies, including coronary artery spasm or embolization, typically associated with drug abuse. Despite this potential for important diagnostic and prognostic value with troponin testing in these contexts, the extent to which cardiac troponin assays are available, adopted, and applied in pediatric clinical practice worldwide remains poorly characterized.

Recent literature has highlighted the unique challenges of cardiac troponin testing in pediatric practice, including heterogeneity in clinical use, uncertainty regarding appropriate decision thresholds, age-related variation in

concentrations, and the lack of standardized pediatric implementation guidance. These issues underscore the need for pediatric-specific data to inform appropriate laboratory practice and clinical interpretation [6–8].

To address this knowledge gap, the present International Federation for Clinical Chemistry and Laboratory Medicine (IFCC) Committee on Emerging Technologies in Pediatric Laboratory Medicine (C-ETPLM) survey was designed to assess the global availability and use of cardiac troponin assays in pediatric settings. We sought to gather insights into the availability, implementation, and clinical application of cardiac troponin testing for children and adolescents under 18 years of age. By evaluating current testing practices, assay accessibility, and patterns of clinical utilization across regions, this study aims to provide a comprehensive overview of pediatric cardiac troponin testing and to identify areas where further guidance, standardization, and/or education may be needed.

Methods

Questionnaire development

This electronic questionnaire was developed by the IFCC-C-ETPLM. The questions included in the survey were developed based on literature review, domain expertise, and discussion among the committee members regarding key unresolved questions in pediatric cardiac troponin implementation and interpretation. These items were intended to capture perceived gaps in current practice as well as areas considered most important for future standardization and evidence generation.

The survey was disseminated using SurveyMonkey® software (Momentive Inc., San Mateo, CA, USA). The survey consisted of 19 unique questions and employed a combination of multiple-choice and open-ended free-text response formats. The first 4 questions were designed to obtain demographic information about respondents. Question 4 was designed to assess professional practice (i.e. medical laboratory specialists or clinicians) following which the survey was tailored to the specialty. Laboratory specialists proceeded to answer questions on cardiac troponin testing practices, barriers to assay adoption and recommended research priorities (Questions 5 to 11), whereas clinicians proceeded to answer questions on the clinical indications for testing, and clinician needs and research priorities (Questions 12 to 19). The survey was open for one month to capture a defined cross-sectional snapshot of current practice while minimizing prolonged recruitment drift and duplicate circulation over time, although this

relatively short survey window may have limited participation from some regions and may have affected the breadth of responses obtained. The survey was distributed through professional and society-based channels to reach laboratories and clinicians involved in pediatric cardiac troponin testing. Respondent professional background was self-reported. Where formal verification of respondent credentials or unique institutional representation was not feasible, this was acknowledged as an inherent limitation of the survey design. Safeguards to reduce duplicate responses were applied where possible, but complete confirmation of response uniqueness across all entries was not possible.

A complete copy of the survey is provided in Supplementary Material 1.

Survey distribution

The survey was distributed between October 1st, 2025 and October 31st, 2025 to IFCC member societies and affiliated networks. Recipients were encouraged to disseminate the questionnaire broadly within their professional communities using multiple communication channels. Participation was entirely voluntary, and no personally identifiable information was collected.

Data analysis

Survey responses were exported into Microsoft Excel (Microsoft Corp., Seattle, WA, USA) for analysis. One survey item (Question 3) asked respondents to identify the primary patient population they served (pediatric only, adult only, or mixed pediatric and adult populations). Responses from participants who reported serving exclusively adult populations were excluded from subsequent analyses.

Descriptive statistics were used to summarize the data. Numerical results are presented as proportions of the total number of respondents for each question except otherwise indicated. Where available from survey responses, we expanded assay-related reporting to better distinguish high-sensitivity vs. conventional cardiac troponin methods, identify reported use of point-of-care testing, and summarize assay-related testing characteristics in tabular form. However, because the survey was designed primarily to assess global practice patterns rather than to perform a comprehensive analytical inventory of each laboratory platform, detailed assay specifications were not uniformly captured across all respondents.

Results

Survey response and participant characteristics

At the conclusion of the survey dissemination period, a total of 439 responses were received. Responses from participants who reported serving exclusively adult populations were excluded from further analysis, resulting in 330 eligible responses who served only pediatric patients (n=30) or both pediatric and adult populations (n=300).

Respondents represented 48 countries across all seven continents. Countries contributing ten or more responses included Palestine (n=124), India (n=22), Turkey (n=21), Italy (n=18), Albania (n=17), the United States of America (n=16), France (n=14), and Lebanon (n=12) (Figure 1).

With respect to practice setting, 32 % of respondents were from academic medical centers, 31 % from government or public health laboratories, 20 % from commercial laboratories, 14 % from non-academic medical centers, and 4 % from reference laboratories (Figure 2A). Laboratory specialists comprised the majority of respondents (93.3 %), while clinicians accounted for 5.8 % of respondents; 0.9 % of respondents did not indicate their professional role.

Current cardiac troponin testing practices: laboratory specialists

Most respondents reported offering in-house cardiac troponin (cTn) testing for pediatric patients (58.4 %). External testing was utilized by 35.7 % of respondents, while 5.9 % did not specify how cTn testing was provided (Figure 2B).

Among laboratories utilizing external testing (n=110), approximately half indicated plans to implement in-house pediatric cTn testing in the future (50.9 %), whereas 47.3 % did not plan to do so; 1.8 % did not specify. A small proportion of respondents (5.8 %) reported uncertainty regarding how troponin testing was performed locally (e.g., in-house vs. externally referred testing). Rather than excluding these responses *a priori*, we retained them in descriptive analyses to preserve transparency, as this may reflect real-world separation between test ordering, clinical use, and detailed laboratory workflow knowledge. However, such responses may introduce uncertainty into assay-specific interpretations and should be considered a limitation of survey-based self-report data.

An important finding of this survey was that validated pediatric specific reference intervals or decision thresholds for

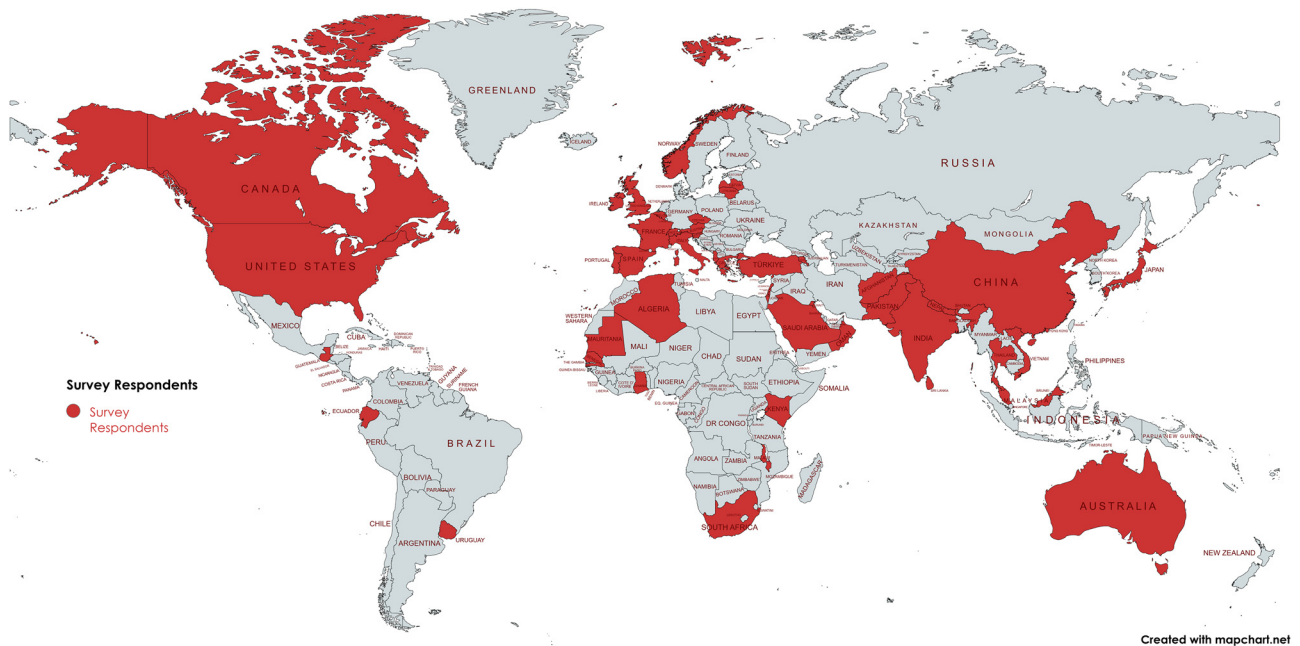


Figure 1: Laboratory specialists and clinicians from 48 countries participated in this survey. Countries are indicated in red.

cardiac troponin are not widely available for routine use and manufacturers generally provide adult-derived upper reference limits. Among the laboratories offering in-house cTn testing ($n=180$), most (65.5 %) did not provide pediatric-specific reference intervals. Among those that did provide pediatric reference intervals ($n=53$), sources included locally derived laboratory data (17.0 %), verification of manufacturer-provided reference intervals (24.5 %), and verification of literature-derived reference intervals, including databases such as CALIPER (49.0 %). Approximately half of these laboratories further stratified reference intervals by age and sex (50.9 %), while 32.0 % did not. Respondents were then asked to specify the pediatric reference intervals in use. Among the 31 responses provided, there was substantial heterogeneity, with no consistent age stratification strategies or absolute cutoff values identified.

A complete list of responses is provided in Supplementary Material 2.

Among laboratories reporting pediatric-specific reference intervals ($n=53$), most either did not include interpretive comments on pediatric cTn reports (47.0 %) or did not specify whether interpretive comments were provided (37.7 %). Only eight respondents reported including interpretive comments, citing sources such as IFCC recommendations, the universal definition of myocardial infarction, American Heart Association guidance, the 2023 European Society of Cardiology guidelines, and assay package inserts, with several noting that these interpretations were extrapolated from adult guidelines.

Analysis by institution type showed that academic medical centers and government/public health laboratories offering cTn testing for pediatric patients, either exclusively or alongside adult testing, predominantly performed testing in-house. High-sensitivity cardiac troponin (hs-cTn) assays were the preferred assay type across all institution categories for in-house testing. Turnaround times differed by institution type, with academic medical centers, commercial laboratories, and non-academic medical centers most commonly reporting results within 1 h, while government/public health laboratories more frequently reported turnaround times within 2 h (Supplementary Figure 4A–C).

Test specifications

Most respondents reported using high-sensitivity cardiac troponin assays (64.4 %), while 13.3 % used conventional assays; the remainder did not specify assay type (Figure 2c). Reported turnaround times (TAT) for cTn testing were less than 1 h for 46 % of respondents, between one and 2 h for 25 %, and greater than 2 h for 3.9 %. A total of 25 % of respondents did not provide TAT (Figure 2D).

The most frequently reported indications were infections and chest pain (each $n=6$), followed by congenital heart disease ($n=5$). Suspected myocarditis and Kawasaki disease with cardiac involvement were also commonly cited (each $n=4$). Syncope was infrequently reported ($n=1$).

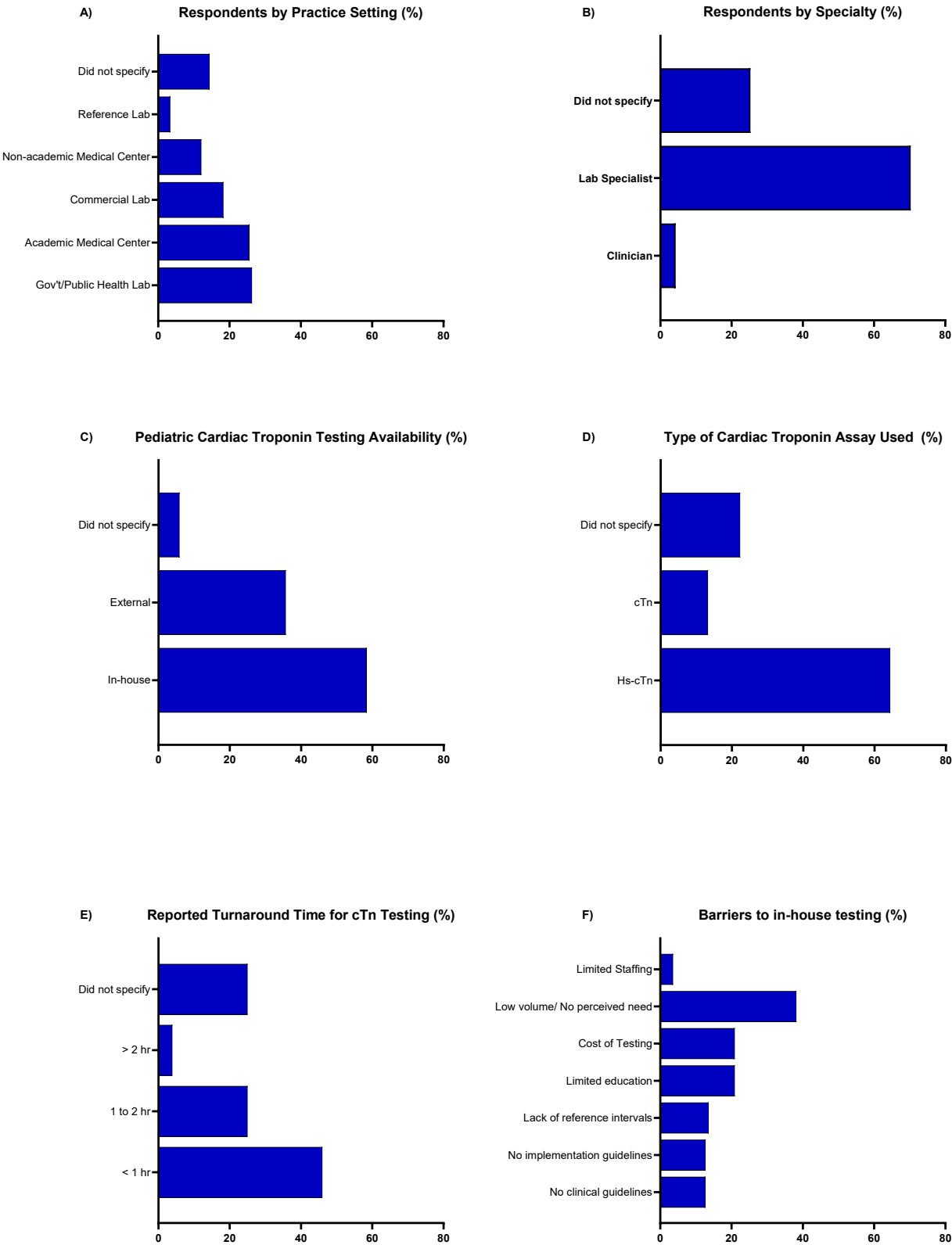


Figure 2: Distributions of respondents based on (A) practice setting, (B) troponin testing availability, (C) type of troponin assay, (D) reported TAT, and (E) barriers to in-house testing.

Table 1: Survey-reported clinical indications for cardiac troponin (cTn) testing in children and adolescents (clinicians, n=19).

Indication	Participant responses
Infections	6
Chest pain	6
Congenital heart disease	5
Suspected myocarditis	4
Kawasaki disease with cardiac involvement	4
Syncope	1

Responses to the IFCC C-ETPLM survey question on clinician-reported indications for pediatric cTn testing (clinicians, n=19). Respondents could report more than one indication; therefore, counts may sum to >19.

Collectively, these responses indicate that pediatric cTn ordering in current practice is most often associated with evaluation of acute symptoms and systemic illness, as well as underlying or suspected cardiac disease. Table 1 summarizes clinician-reported indications for pediatric cTn testing (n=19).

Challenges to adopting cardiac troponin testing

Among laboratories utilizing external cTn testing (n=110), the most commonly reported barriers to adoption included low patient sample volume or lack of perceived clinical need (n=42), cost of testing (n=23), limited education and training for healthcare providers (n=23), lack of reference intervals (n=15), absence of implementation guidelines (n=14), lack of clinical guidelines (n=14), and limited staffing (n=4).

For laboratories offering in-house cTn testing (n=180), the most frequently cited challenges were limited education and training for healthcare providers (n=53), lack of pediatric reference intervals (n=53), low patient volume or lack of perceived clinical need (n=45), lack of clinical guidelines (n=41), absence of implementation guidelines (n=33), and cost of testing (n=14) (Figure 2E).

Clinical indications for cardiac troponin testing

Clinicians (n=19) reported a range of clinical indications for requesting cTn testing in pediatric patients. The most commonly cited indications included infections (n=6), chest pain (n=6), congenital heart disease (n=5), suspected myocarditis (n=4), and Kawasaki disease with cardiac involvement (n=4). Less frequently reported indications included syncope (n=1).

Notably, there were no responses to several open-ended survey questions addressing key aspects of pediatric cTn testing. These included questions related to the existence and sources of condition-specific guidelines or protocols, challenges in interpreting cTn results in pediatric populations, the degree of collaboration between clinicians and laboratory professionals, the impact of cTn testing on clinical decision-making, the frequency of repeat testing for monitoring or confirmation, and perceived educational gaps related to cTn ordering and interpretation in pediatrics.

Recommended research questions

Despite the lack of detailed responses to these items, clinicians identified several broad areas as critical research priorities in pediatric cTn testing. These included the development of evidence-based pediatric reference intervals (n=5), optimization of sample volume requirements (n=2), evaluation of potential drug interferences (n=2), clarification of appropriate clinical indications for testing (n=1), and assessment of the overall necessity and value of cardiac biomarker testing in pediatric populations (n=1).

Laboratory specialists also had several recommendations for research questions. The majority respondents overwhelmingly agreed that advancing pediatric troponin testing requires foundational reference data, clear clinical guidance, improved interpretation frameworks, and validation of assay performance in children. Several comments were also geared towards pre-analytical and analytical issues specific to pediatrics, such as small sample volumes and microtainer collection, hemolysis, analytical interference and assay variability, and standardization across platforms. A complete list of research priorities suggestions raised by both clinicians and laboratory specialists can be found in Supplementary Material 3.

Discussion

Cardiac troponin testing is indispensable for the evaluation of acute coronary syndromes in adults, however, its role in pediatric practice is more nuanced. In children, troponin testing is used less for the assessment of acute coronary syndromes and more commonly in the evaluation of non-ischemic cardiac conditions, including myocarditis, pericarditis, as well as Kawasaki disease with cardiac involvement, and congenital heart disease [9–11]. Despite its clinical relevance in these settings, there remains a paucity of data describing the availability, utilization, and interpretation of cardiac troponin testing in

pediatric populations. The findings of this survey therefore highlight substantial gaps that must be addressed to optimize the use of cardiac troponin testing and to support the development of robust analytical and clinical guidelines for this critical population. Our survey discovered that most laboratories serving pediatric patients offer in-house cardiac troponin testing, predominantly using hs-cTn assays, satisfying the IFCC and AACC analytical specifications for cardiac troponin testing across populations with respect to limit of detection and precision [12]. And, results were reported rapidly, often within an hour. However, most laboratories do not provide pediatric-specific reference intervals. Among laboratories that do, there was no consensus regarding age or sex stratification, reference limits, or interpretive comments. Laboratories outsourcing troponin testing most often cited low pediatric testing volume as the primary barrier to in-house implementation, whereas those offering in-house testing identified limited provider education and the lack of pediatric reference intervals as major barriers to cardiac troponin testing in pediatrics. These findings align with respondents' identified priorities for future research and guidance, including the establishment of pediatric reference intervals, clarification of clinical indications, evaluation of pediatric-specific pre-analytical and analytical challenges, and development of standardized guidelines for implementation and clinical use. In fact, both laboratory professionals and clinicians acknowledged substantial uncertainty regarding appropriate use and interpretation of cTn in pediatric populations.

In this context, the clinician-reported indications in our survey (Table 1) provide a useful point of comparison with published patterns of use of pediatric cTn. A recent expert review on pediatric cTn testing concluded that the most common indications in the literature are suspicion of myo/pericarditis and traumatic chest injury, with occasional use in possible heart failure and/or myocardial ischemia [13]. Our clinician respondents most frequently reported ordering cTn for infections and chest pain, followed by congenital heart disease, suspected myocarditis and Kawasaki disease with cardiac involvement. Cardiac troponin is a well-established prognostic marker of myocardial injury and recovery following pediatric cardiac surgery and has been shown to predict prolonged hospitalization, increased need for mechanical ventilation, and mortality in children with and without underlying cardiac disease, including those presenting with trauma or poisoning [14]. Despite this prognostic utility in selected pediatric populations, the routine clinical role of cardiac troponin in children remains less clearly defined than in adults. In adult patients presenting with chest pain and symptoms suggestive of acute coronary syndrome, cardiac troponin testing is central to diagnostic decision-making and risk stratification for myocardial infarction [2]. In

contrast, myocardial infarction is exceedingly rare in children and adolescents, and pediatric chest pain is far more commonly attributable to benign or non-ischemic causes [10]. Prior studies have demonstrated that in afebrile pediatric patients or those presenting to the emergency department with normal electrocardiograms, cardiac troponin measurements offer limited diagnostic or prognostic value [4]. Besides, cardiac causes remain an insignificant contributor to chest pain in children aged six years and above [15]. This fundamental difference in disease prevalence and clinical utility likely contributes to the lower perceived value of routine in-house troponin testing for pediatric patients, as observed in this survey. For many laboratories, particularly those with low pediatric testing volumes, the combination of limited clinical demand, uncertainty regarding appropriate interpretation, and the absence of validated pediatric-specific reference intervals reduces the incentive to maintain in-house testing capabilities, leading instead to test outsourcing or restricted availability.

Key knowledge and practice gaps identified by the survey include the lack of validated pediatric cutoffs for cardiac troponin. In a recent evaluation of cardiac troponin concentrations in children and adolescents aged 1–18 years from the 1999–2004 National Health and Nutrition Examination Survey (NHANES), the defined 99th-percentile upper reference limits (URLs) differed substantially from adult-derived URLs provided by manufacturers [16]. Notably, within the pediatric population, McEvoy and colleagues proposed that a 97.5th-percentile URL for troponin I is used, as it demonstrated better statistical agreement across manufacturers compared with the 99th percentile, potentially increasing diagnostic sensitivity for pediatric cardiac disease [16]. Moreover, earlier publications revealed that while the 99th percentile pediatric URL is lower than for adults, it is an inadequate indicator of cardiac disease in children [17]. However, this recommendation has yet to be widely validated or incorporated into formal clinical practice guidelines and has not been uniformly adopted across laboratories or institutions. As proposed by Adeli and colleagues, troponin testing in pediatric clinical diagnostics may be best served by implementation of evidence-based cut-offs, known as decision limits [18]. Decision limits are not based on percentile reference intervals in healthy children. Instead, a decision limit is established for each clinical indication, based on clinical research, evidence-based for each diagnosis. Hemoglobin A1C is a highly successful example of this approach.

Consistent with these findings, results from our survey further underscore the lack of consistency in pediatric troponin reference intervals across laboratories. Among the 30 respondents who provided coherent reference interval data, marked variability was observed: some laboratories

reported age- and sex-stratified reference intervals, whereas others reported intervals stratified by neither age nor sex. This heterogeneity reflects both the absence of harmonization among troponin assays and the lack of robust, population-based pediatric reference intervals applicable across platforms as also reported in literature [19]. In contrast, reference intervals published by the CALIPER initiative specify only two age partitions and do not incorporate sex-based differences, which also stands in contrast to multiple published studies including the study by McVoy and colleagues which utilized a large pediatric cohort from the NHANES data, and demonstrated pubertal influences on cardiac troponin concentrations, resulting in higher values in adolescent males compared with female adolescents [16, 20–22]. Among survey respondents who did employ age stratification, cardiac troponin concentrations were consistently reported to be higher during infancy, with a progressive decline across childhood, findings that align with previously published pediatric studies [20, 22].

Importantly, a 2021 review by Clerico and colleagues identified the absence of validated pediatric reference intervals for cardiac troponin as a major limitation to its clinical application in pediatric practice [21]. This concern reflects the broader lack of consensus guidance on the appropriate use, reporting, and interpretation of cardiac troponin testing in children. Survey respondents similarly highlighted the absence of standardized, age- and sex-specific pediatric troponin cutoffs as a major barrier to consistent clinical interpretation, with most laboratories reporting reliance on manufacturer-provided reference intervals derived largely from adult populations and not validated in children or adolescents.

Furthermore, analytical and immunoassay interferences represent an additional challenge in cardiac troponin interpretation. Although such interferences are well recognized in troponin testing generally, their prevalence, recognition, and clinical implications may differ in pediatric settings because of differences in case mix, disease spectrum, and pre-test probability. This further complicates interpretation and reinforces the need for careful laboratory-clinical collaboration in pediatric practice.

In the absence of unified pediatric guidelines, laboratory practices vary widely. Some institutions apply adult-derived thresholds uniformly across all ages, while others adopt locally defined or literature-based pediatric cutoffs, resulting in substantial inter laboratory variability. These inconsistent practices contribute to interpretive uncertainty, heterogeneous test utilization, and variable downstream clinical decision-making, increasing the risk of diagnostic misclassification, unnecessary medical intervention, and inconsistent patient care [23].

While in adults, high-sensitivity cardiac troponin testing is now used beyond the classic emergency chest pain setting, including ambulatory care, perioperative assessment, and non-cardiac and cardiac surgical contexts the pediatric use remains less mature, with fewer standardized indications, more limited evidence-based cutoffs, and greater uncertainty regarding interpretation. This gap highlights the need for pediatric-focused implementation strategies and guidance. In the absence of robust guidelines, heterogeneity in clinical practice may partly reflect variability in reported biomarker elevation among pediatric patients with similar diagnoses. In multisystem inflammatory syndrome in children (MIS-C), patterns of cardiac biomarker elevation have been inconsistent, with reports of patients demonstrating elevations in both natriuretic peptide (NP) and troponin [24], NP alone [13], troponin alone [25], or neither biomarker [26]. Elevated troponin or NP levels have not been shown to predict left ventricular dysfunction, electrocardiographic abnormalities, or the need for inotropic support, despite the high prevalence of cardiac involvement in MIS-C [25]. NP elevation was likewise not predictive of troponin elevation, and vice versa although biomarker abnormalities generally improved with standard treatment [13]. Further, in the emergency department, elevated cardiac biomarkers were associated with increased odds of a cardiac diagnosis or MIS-C, supporting the need for further evaluation when such abnormalities are present. However, a negative high-sensitivity troponin T does not fully exclude cardiac disease, highlighting the need for additional research to develop reliable diagnostic algorithms [24]. The IFCC Committee on Clinical Applications of Cardiac Biomarkers has emphasized the need for pediatric-specific analytical and clinical considerations for cardiac troponin testing and has highlighted emerging evidence supporting alternative approaches to defining pediatric upper reference limits. In particular, the committee discussed findings from the NHANES-based study by McEvoy and colleagues, cited above, and emphasized the need for guidelines on its use in pediatrics [7]. A more recent review by Aakre et al. also concluded that the clinical use and interpretation of cTn in pediatric patients remains heterogeneous and that many current practices are driven by limited evidence and expert opinion rather than robust prospective pediatric data [24].

Collectively, these disparate recommendations and practice patterns underscore the absence of a unified, evidence-based guideline governing the use and interpretation of cardiac troponin testing in pediatric populations. Addressing this gap will require coordinated efforts among clinical societies, laboratory medicine organizations, and regulatory bodies to establish harmonized, assay-specific pediatric reference intervals and consensus-based guidance

along with decision support tools that can be consistently implemented across institutions.

Strengths and limitations of the survey

This survey provides important insights into the availability, utilization, and challenges associated with cardiac troponin testing in pediatric populations. A key strength of the study is the inclusion of perspectives from both laboratory professionals and clinicians, thereby capturing the viewpoints of the two principal stakeholder groups involved in test selection, reporting, interpretation, and clinical decision-making. In addition, the survey achieved broad international participation, with respondents representing 48 countries and a diverse range of institution types, providing a unique global perspective on current pediatric cardiac troponin testing practices. Importantly, this IFCC C-ETPLM global survey was designed not only to characterize current testing practices but also to identify gaps and areas of variability in access, implementation, reporting, interpretation, and clinical utilization. The findings demonstrate substantial heterogeneity in how pediatric cardiac troponin testing is offered and reported across laboratories and clinical settings, as well as limited and inconsistent use across several pediatric clinical indications. These results highlight important unmet needs in standardization, reference interval development, assay implementation, and clinical guidance. Collectively, the survey findings establish priorities for future research and collaborative efforts aimed at optimizing the use and interpretation of cardiac troponin testing in pediatric medicine.

Several limitations should also be acknowledged. The survey was designed to identify global gaps in access, implementation, interpretation, and clinical use of pediatric cardiac troponin testing. It was not intended as a formal assay-validation inventory, and therefore complete analytical details such as manufacturer/platform identity, specimen type, assay sensitivity, and 99th percentile upper reference limits, were not systematically assessed for all sites. This limits the extent to which assay-specific comparisons could be performed in this survey analysis and highlights an important area for future studies focused specifically on assay harmonization and pediatric reference limit standardization. Also, the survey relied on self-reported practices, and the accuracy of responses could not be independently verified.

Regional participation was uneven, which may have introduced selection bias and limits the generalizability of the findings across geographic regions. Responses were disproportionately represented by participants from Palestine, which accounted for approximately 28 % of all survey responses, whereas no other individual country

contributed more than 5 % of the total sample. Consequently, the reported practices and perceived challenges may reflect regional patterns that are not fully representative of the global pediatric troponin testing landscape.

Further, because the survey was disseminated broadly through professional society listservs, organizational communications, and professional networks rather than through a closed sampling frame of individually tracked invitees, we were unable to determine the total number of eligible participants who received the survey or calculate a true response rate. Consequently, we could not assess the characteristics of non-responders or evaluate the potential for nonresponse bias. Lastly, laboratory professionals were more heavily represented than clinicians, which may have influenced the findings and may not fully reflect the challenges, perceptions, and decision-making processes of a broader clinical audience.

Summary of outcomes

- Pediatric cardiac troponin interpretation lacks standardization, with no universally accepted clinical guidelines, decision thresholds, or harmonized reference intervals supported by robust outcome-based evidence.
- Most pediatric reference intervals are extrapolated from adult data or secondary sources, including manufacturer package inserts, despite clear biological and analytical justification for age- and sex-specific pediatric limits.
- The clinical application of troponin in children differs from adults: whereas troponin is central to acute myocardial infarction diagnosis in adults, AMI is rare in children. In pediatrics, troponin is more frequently used to evaluate inflammatory and non-ischemic cardiac conditions, such as myocarditis.
- There is an urgent need for pediatric-specific validation studies to establish appropriate interpretive frameworks, clinical decision limits, and outcome-driven guidance for cardiac troponin testing in children.

Conclusions

In conclusion, while cardiac troponin testing is increasingly accessible and analytically robust, its clinical application in children and adolescents remains poorly defined and inconsistently implemented. The findings of this survey underscore an urgent need for standardization, evidence-based guidance, and pediatric-focused research to support

the safe, consistent, and clinically meaningful use of cardiac troponin testing in pediatric populations.

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