Organization of intensive cardiac care units in Europe: Results of a multinational survey

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MJ Claeys[1], F Roubille[2], G Casella[3], R Zukermann[4], N Nikolaou[5], L De Luca[6], M Gierlotka[7], Z Iakobishvili[8], H Thiele[9], M Koutouzis[10], A Sionis[11], S Monteiro[12], C Beauloye[13], C Held[14], D Tint[15], I Zakke[16], P Serpytis[17], Z Babic[18], J Belohlavev[19], A Magdy[20], M Sivagowry Rasalingam[21], K Daly[22], D Arroyo[23], M Vavlukis[24], N Radovanovic[25], E Trendafilova[26], T Marandi[27,28], C Hassenger[29,30], M Lettino[31], S Price[32] and E Bonnefoy[33]

Abstract

Background: The present survey aims to describe the intensive cardiac care unit organization and admission policies in Europe.

Methods: A total of 228 hospitals (61% academic) from 27 countries participated in this survey. In addition to the organizational aspects of the intensive cardiac care units, including classification of the intensive cardiac care unit levels, data on the admission diagnoses were gathered from consecutive patients who were admitted during a two-day period. Admission policies were evaluated by comparing illness severity with the intensive cardiac care unit level. Gross national income was used to differentiate high-income countries (n=13) from middle-income countries (n=14).

Results: A total of 98% of the hospitals had an intensive cardiac care unit: 70% had a level 1 intensive cardiac care unit, 76% had a level 2 intensive cardiac care unit, 51% had a level 3 intensive cardiac care unit, and 60% of the hospitals had more than one intensive cardiac care unit level. High-income countries tended to have more level 3 intensive cardiac care units than middle-income countries (55% versus 41%, p=0.07). A total of 5159 admissions were scored on illness severity: 63% were low severity, 24% were intermediate severity, and 12% were high severity. Patients with low illness severity were predominantly admitted to level 1 intensive cardiac care units, whereas patients

[1]Department of Cardiology, Antwerp University Hospital, Belgium
[2]Department of Cardiology, University Hospital of Montpellier, France
[3]Department of Cardiology, Ospedale Maggiore, Italy
[4]Rambam Medical Health Center, Israel
[5]Department of Cardiology, Konstantopouleio General Hospital, Greece
[6]Department of Cardiology, S. Giovanni Evangelista Hospital, Italy
[7]Department of Cardiology, University of Opole, Poland
[8]Heart Institute, Holon Medical Center, Israel
[9]Heart Center Leipzig, University Hospital, Germany
[10]Red Cross General Hospital, Greece
[11]Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Spain
[12]Coimbra University Hospital, Portugal
[13]Cliniques Universitaires Saint Luc, UCLouvain, Belgium
[14]Department of Medical Sciences, Uppsala Clinical Research Center, Sweden
[15]ICCO Clinics, Transilvania University, Romania
[16]Pauls Stradins Clinical University Hospital, Latvia
[17]Faculty of Medicine, Vilnius University, Lithuania
[18]University Hospital Centre, Sisters of Mercy, Croatia
[19]2nd Department of Medicine, Charles University, Czech Republic
[20]National Heart Institution, Egypt
[21]Department of Cardiology, Aarhus University Hospital, Denmark
[22]University College Hospital, Ireland
[23]Hôpital Cantonal Fribourg, Switzerland
[24]PHO University Clinic of Cardiology, Macedonia
[25]Clinical Center of Serbia, Emergency Center, Serbia
[26]ICCU, National Cardiology Hospital, Bulgaria
[27]North Estonia Medical Centre, Estonia
[28]Department of Cardiology, University of Tartu, Estonia
[29]Department of Cardiology, Rigshospitalet, Denmark
[30]Department of Clinical Medicine, University of Copenhagen, Denmark
[31]Division of Cardiology, San Gerardo Hospital, Italy
[32]Adult Intensive Care Unit, Royal Brompton Hospital, London
[33]Intensive Cardiac Care Unit, Hospices Civils de Lyon, France

Corresponding author:
M Claeys, Antwerp University Hospital, Dept of cardiology, Wilrijkstraat Edegem, Antwerpen, 10 2650, Belgium.
Email: marc.claeys@uantwerpen.be

with high illness severity were predominantly admitted to level 2 and 3 intensive cardiac care units. A policy mismatch was observed in 12% of the patients; some patients with high illness severity were admitted to level 1 intensive cardiac care units, which occurred more often in middle-income countries, whereas some patients with low illness severity were admitted to level 3 intensive cardiac care units, which occurred more frequently in high-income countries.
Conclusion: More than one-third of the admitted patients were considered intermediate or high risk. Although patients with higher illness severity were mostly admitted to high-level intensive cardiac care units, an admission policy mismatch was observed in 12% of the patients; this mismatch was partly related to insufficient logistic intensive cardiac care unit capacity.

Keywords
Intensive cardiac care unit, organization, acute cardiovascular care, admission policy

Introduction

Since the introduction of coronary care units in the late 1960s, the spectrum of disease cases admitted into the coronary care units has profoundly changed, with a shift from cases simply requiring specialised monitoring to critical cardiovascular disease cases associated with multi-organ failure.[1–3] As a result, the concept of coronary care units has changed into intensive cardiac care units (ICCUs), where more technologically advanced invasive support is available.[4–8] Although based on observational data, the available evidence substantiated the experience of general intensive care units (ICUs) suggesting that meaningful improvements in outcomes could be achieved through the management of patients within the specialised environment of the ICCU.[9,10]

To optimise resource use while improving outcomes, levels of acute cardiac care have been established to tailor as accurately as possible logistics and expertise to the level of acuity and illness severity.[11] A recent position paper from the Acute Cardiovascular Care Association (ACCA) defined three levels of ICCUs based upon organizational and logistic capacities.[12] Level I ICCUs are designed to manage patients with cardiovascular conditions demanding low levels of intensive care. They mainly focus on the care of patients with acute coronary syndromes, congestive heart failure without shock or complex, and non-life-threatening arrhythmias. At the other end of the spectrum, level III ICCUs are designed to care for patients who have acute cardiac conditions that are severe enough to require mechanical circulatory, renal or pulmonary support, or those patients at high risk of needing such support.

Healthcare system organization is heterogeneous throughout Europe, and it is likely that the organization of acute cardiac care also varies among different countries of Europe, possibly affecting acute cardiac care. To date, a limited amount of data is available regarding the organization of the ICCUs or the admission policies in the different European countries. All of the registries, mainly national registries, lack information about the levels of the ICCUs or about the levels of illness severity.[3,13,14] An improved understanding of how the recommendations on ICCU organization are implemented in the different countries across Europe may reveal inequalities in logistics and admission policies among European regions. This may stimulate investment in the organization of ICCUs by local authorities and may also promote research on the appropriateness and cost effectiveness of acute cardiovascular care.

Therefore, the Acute Cardiovascular Care Association of the ESC established a multinational survey to collect information on the organization of the ICCUs and admission policies in different European countries.

Methods

The ICCU survey was launched in 2017 through the existing network of national representatives of the ACCA with the goal of obtaining information about the organization of ICCUs across different European countries. The national representatives selected hospitals within their country with the intent of achieving a good mixture of small and large hospitals and academic and non-academic hospitals, and with a target of one hospital per one million habitants. A total of 228 hospitals (61% academic, 88% with percutaneous coronary intervention (PCI) facilities) from 27 countries were selected and completed the survey. The data were collected in concordance with European data privacy regulations.

An ICCU was defined as a physically and administratively distinct hospital unit dedicated to and specialised in the management of acute cardiovascular conditions. ICCUs were subdivided into three levels based upon their logistics and facilities, as described in the ACCA position paper (see Table 1). One part of the survey collected data about the level of the ICCUs. Each investigator provided the number of beds allocated to a certain ICCU level in his/her institution. Information about the criteria of the different ICCU levels was visible on the survey. In addition, information was gathered about the size of the hospital, the presence of a general ICU, the facilities for cardiac surgery and PCIs. Hospitals with <250 beds were categorised as small, whereas hospitals with >750 beds were considered large.

Table 1. Criteria for intensive cardiac care unit (ICCU) levels.

Level 1 ICCU	Level 2 ICCU	Level 3 ICCU
All non-invasive clinical parameter monitoring	**As in ICCU 1 plus:**	**As in ICCU 2 plus:**
24/7 Echocardiography and thoracic ultrasound	Ultrasound-guided central venous line insertion	Post-cardiovascular arrest treatment and therapeutic initiation
Direct current cardioversion	Pericardiocentesis	Extracorporeal life support
Non-invasive ventilation	Transvenous temporary pacing	Mechanical circulatory support
Transcutaneous temporary pacing	Mechanical ventilation (short term)	Renal replacement therapy
Chest tubes	Transoesophageal echocardiography	
Nutrition support	Right heart catheterisation	
Physiotherapy in ward	Short-term mechanical circulatory support	
	Therapeutic hypothermia initiation advisable	

The second part of the survey collected data about admission diagnoses during a two-day period (first Monday and Tuesday of the month) in the different ICCU levels. The investigator categorised all the cardiac patients admitted to the ICCUs/ICUs according to their main cardiovascular reason for admission by the use of the study-specific worksheet. The different acute cardiac conditions were classified into the following four pre-specified groups: ischaemic heart disease, heart failure, arrhythmia, and other acute cardiovascular pathologies (see Table 2). The pre-specified list of diagnoses also included information about the severity of the illness, which enabled us to qualify severity levels using the same criteria as established in the ACCA position paper. Those definitions and criteria were established by a task force of 27 experts.[12] While the information about the different ICCU levels was available on the survey, the pre-specified allocation algorithm linking illness severity to ICCU level (see Table 2) was not visible on the survey.

The policy admission index was defined as the proportion of patients with a perfect match between the level of ICCU and the level of illness severity (low severity admitted to ICCU level 1, intermediate severity to ICCU level 2 and high severity to ICCU level 3).

In addition, we also focused on two important admission mismatches. First, an ICCU level 1 mismatch was defined as an admission of a patient with high illness severity to a low (1) ICCU level, suggesting under-qualification of care. Second, an ICCU level 3 mismatch was defined as the admission of a patient with low illness severity to a high (3)

Table 2. Classification of admission diagnoses according to illness severity.

	Low severity	Intermediate severity	High severity
Ischaemic heart disease	Uncomplicated STEMI with good reperfusion Non-STE-ACS, not high risk	Complicated ACS (no reperfusion, heart failure without shock, cardiac arrest without coma) Non-STE-ACS, high risk (=requiring invasive evaluation <24 h)	Mechanical complications of ACS (VSR, papillary muscle rupture)
Heart failure	Acute HF with mainly venous congestion Acute HF with pulmonary oedema and high/normal blood pressure Chronic severe valvular disease with HF	Hypotension without cardiogenic shock (e.g. sepsis) requiring an IV vasopressor Primary PAH with right heart failure	Cardiogenic shock Acute severe valvular disease with HF (e.g. endocarditis, prosthetic valve thrombosis) HTx with (suspected) rejection and LV dysfunction
Arrhythmias	Uncomplicated AF or SVT AF/SVT with HF Acute 3rd degree AV blockage Ventricular tachy-arrhythmia without haemodynamic instability	Ventricular tachy-arrhythmia with haemodynamic instability	Cardiac arrest with coma
Other **Pulmonary embolism** **Myocarditis** **Aortic dissection post intervention**	Acute PE (not high risk) Uncomplicated myocarditis/ pericarditis Post-structural/endovascular intervention	Acute PE at high risk, requiring thrombolysis Myocarditis complicated with HF Cardiac tamponade Non-complicated type-B aortic dissection	Type-A aortic dissection

ACS: acute coronary syndrome; AF: atrial fibrillation; AV: atrio-ventricular; HF: heart failure; HTx: heart transplantation; PAH: pulmonary arterial hypertension; PE: pulmonary embolism; STE: ST segment elevation; STEMI: ST segment elevation myocardial infarction; SVT: supraventricular tachycardia; VSR: ventricular septum rupture.

Table 3. Participating hospital list.

Country	Number of participating hospitals	Number of participating ICCU hospitals per million inhabitants	Number of participating ICCU beds per million inhabitants	Number of inhabitants (million)	Per capita GNI (US$)
Italy	36	0.58	13.4	60.6	31,590[a]
Poland	33	0.87	15	38	12,680
Israel	15	1.76	38.2	8.5	36,190[a]
Germany	14	0.17	5.0	82.6	43,660[a]
Greece	13	1.2	28.5	10.7	18,960
Spain	13	0.28	7.7	46.5	27,520[a]
Portugal	12	1.16	23.3	10.3	19,850
France	11	0.16	2.8	66.9	38,950[a]
Belgium	10	0.7	11.9	11.3	41,860[a]
Sweden	9	0.9	23.7	9.9	54,630[a]
Romania	8	0.4	5.6	19.7	9470
Latvia	7	3.6	100	1.9	14,630
Lithuania	7	2.5	58.9	2.8	14,770
Croatia	5	1.2	25.6	4.1	12,110
Czechia	5	0.47	17.9	10.6	17,570
Egypt	5	0.04	2.56	95.7	3460
Denmark	4	0.7	23.7	5.7	56,730[a]
Ireland	4	0.62	14.5	4.8	53,498[a]
Switzerland	4	0.47	13.7	8.4	65,910[a]
Macedonia	3	1.4	42.8	2.1	4980
Serbia	3	0.42	7.1	7	5280
Bulgaria	2	0.28	4.2	7.1	7470
Estonia	1	0.76	7.7	1.3	17,750
Netherlands	1	0.05	3.2	17	46,310[a]
United Kingdom	1	0.01	0.9	65	42,390[a]
Hungary	1	0.1	3.1	9.8	12,570
Norway	1	0.19	8.6	5.2	82,330[a]

GNI: gross national income (2016); ICCU: intensive cardiac care unit.
[a]High income.

ICCU level, suggesting over-qualification of care and the overuse of resources.

To assess inequalities in the organization of the ICCUs among different European regions with different socio-economic statuses, gross national income (GNI) was used to differentiate high-income countries (GNI>US$20,000 per capita) from middle-income countries (GNI<US$20,000 per capita) (Table 3) (source: ESC atlas of cardiology).[15]

As the database was anonymous, no informed consent was needed.

Data analysis

We provide a descriptive analysis of the collected data. Data are presented as proportions. For the comparison between high- and middle-income countries, we used a chi-squared analysis. For all analyses, a p value <0.05 was considered statistically significant. All statistical analyses were performed using MedCalc Statistical Software version 13.0.6 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org).

Results

ICCU organization

A total of 228 hospitals (61% academic, 88% with PCI facilities, 51% with coronary artery bypass graft (CABG) facilities) from 27 countries completed the survey (Table 3). There were 49% small hospitals and 37% large hospitals. A total of 98% of the participating hospitals had an ICCU: 68% at level 1, 74% at level 2, and 49% at level 3. A total of 63% of the hospitals had more than one ICCU level, and 31% of the hospitals had three ICCU levels in the same institution. The majority (80%) of the hospitals also had a general ICU. Hospitals without an ICCU admitted acute cardiac care patients to the general ICU.

Figure 1 shows the relationship between hospital profile and the distribution of ICCU levels and ICUs. Level 1 ICCUs were predominantly present in small hospitals, while level 3 ICCUs were mainly present in large and/or academic hospitals. General ICUs were present in most of the hospitals. Level 3 ICCU was present in 78% of the hospitals with on-site cardiac surgery.

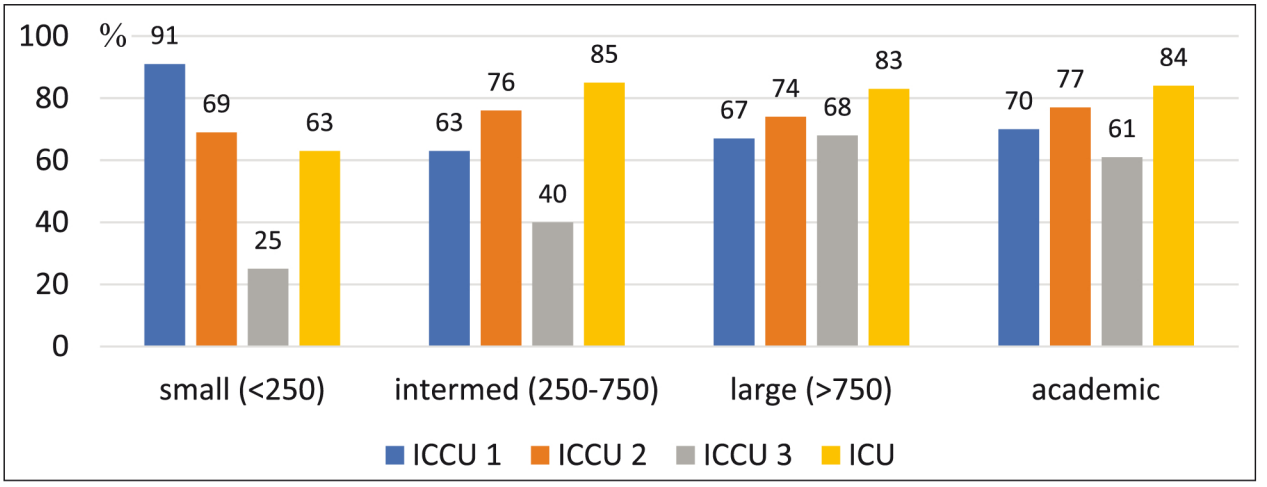

Figure 1. Bar graph showing distribution of intensive cardiac care unit (ICCU) level and intensive care units (ICUs) according to hospital profile.

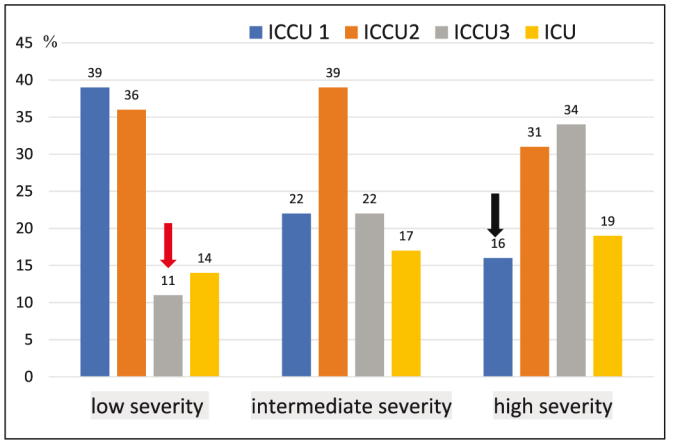

Figure 2. Bar graph showing the relationship between illness severity and intensive cardiac care unit (ICCU) levels. Level 3 ICCU mismatch is indicated by the red arrow, level 1 ICCU mismatch is indicated by the black arrow. ICU: intensive care unit.

Admission policies and ICCU levels

Information about admission diagnoses was collected from 5159 patient files during a two-day period between January–June 2018. There were 1813 admissions with ischaemic heart disease (35%), 1467 with heart failure (28%), 1121 with arrhythmia (22%), 269 with post-structural/endovascular interventions (5.2%), 182 with pulmonary embolism (3.5%), 168 with myocarditis/pericarditis/tamponade (3.2%) and 69 with aortic dissection (1.3%).

According to illness severity gradation, 3269 patients (63%) were categorised as having low illness severity, 1251 patients (24%) had intermediate illness severity and 639 (12%) had high illness severity. Heart failure was the most frequent reason for admissions with high illness severity (52%) whereas ischaemic heart disease was the most frequent reason for admission with low illness severity (32%)

Table 4 shows the relationship between illness severity level and ICCU level. Patients with low illness severity were predominantly admitted to level 1 ICCUs, whereas patients with high illness severity were predominantly admitted to level 2 and 3 ICCUs. In 1983 patients, the match between illness severity and ICCU level was perfect (policy admission index: 38.4%). A policy mismatch was observed in 12% of the patients. A total of 375 patients with low illness severity were admitted to level 3 ICCUs (level 3 ICCU mismatch, 11%, see red arrow in Figure 2). Additional analysis revealed that 47% of the 40 hospitals with level 3 ICCU mismatches had no level 1 ICCU available at their institution. In the majority of hospitals (>95%) the mismatch was present in less than five cases.

A total of 100 patients with high illness severity were admitted to level 1 ICCUs (level 1 ICCU mismatch, 15.6%, see black arrow in Figure 2). Additional analysis revealed that 58% of 26 hospitals with level 1 ICCU mismatch had no level 3 ICCU available at their institution. Although in the majority of the hospitals (>95%) the mismatch was present in less than five cases, there was one Romanian hospital with more than 30 cases of level 1 ICCU mismatch, accounting for one-third of all ICCU level 1 mismatches. In that large institution, only ICCU level 1 was available.

High- versus middle-income countries

A total of 13 countries had a GNI per capita of more than US$20,000 and were categorised as high-income countries. The other 14 countries were categorised as middle-income countries.

Table 4 compares the organizational structures and admission policies of both groups. Both groups were well balanced with regard to hospital profile, admission diagnoses and illness severity. However, high-income countries had a clear tendency for having more level 3 ICCUs or

Table 4. Comparison of high- versus middle-income countries.

	High-income country (*n*=13 countries)	Middle-income country (*n*=14 countries)	*p* Value
Number of hospitals	123	105	
Academic hospitals, %	63	59	0.6
Hospital size			0.6
Small, %	12	16	
Intermediate, %	48	50	
Large, %	40	34	
Facilities,			
PCI, %	88	89	0.85
CABG, %	53	49	0.5
ICU, %	85	76	0.06
ICCU level			
None, %	0	4	0.04
Level 1, %	72	65	0.3
Level 2, %	71	78	0.2
Level 3, %	55	42	0.06
>1 level, %	68	56	0.06
All three levels, %	33	29	0.5
Admission diagnosis			
IHD, %	34	35	0.18
HF, %	29	29	0.91
Arrhythmia, %	23	21	0.086
Illness severity			
Low, %	62	62	0.92
Intermediate, %	25	26	0.42
High, %	13	12	0.37
Admission policy			
Policy index, %	36	39	0.012
ICCU 3 mismatch, %	14	10	<0.001
ICCU 1 mismatch, %	13	18	0.077

CABG: coronary artery bypass graft; HF: heart failure; ICCU: intensive cardiac care unit; ICU: intensive care unit; IHD: ischaemic heart disease; PCI: percutaneous coronary intervention.
The policy admission index was defined as the proportion of patients with a perfect match between the level of ICCU and the level of illness severity.

more multiple ICCU levels in the same institution, and all of the hospitals had at least one ICCU department. On the other hand, in the middle-income countries, there was a relatively lower availability of general ICUs (76%) among hospitals that participated in the survey, and in some of the hospitals, there was no ICCU available (4%). With regard to admission policies, level 1 ICCU mismatches were predominantly present in the middle-income countries (18%), whereas level 3 ICCU mismatches were predominantly present in the high-income countries (14%).

Discussion

The present study is the first to describe the organizational aspects and admission policies of ICCUs across European countries. The information collected from 228 hospitals in 27 countries showed that 35% of the admissions were related to ischaemic heart disease, 28% to heart failure and 22% to arrhythmia. In two European registries (one from 2008 and one from 2014), up to 50% of patients were admitted because of ischaemic heart disease and 10–15% because of acute heart failure.[3,16] In a recent US study, ischaemic heart disease was the primary diagnosis in 25% of the ICCU admissions.[17] These observations reflect the epidemiological changes in heart disease over the last decades, with a decrease in acute ischaemic heart disease but an increase in heart failure.[14] This justifies the transformation from a coronary care unit dedicated mainly to acute coronary syndromes towards a cardiac care unit covering many different acute cardiac pathologies.[5,12] In addition, with an increasing number of comorbid medical conditions that require prolonged and technologically sophisticated invasive support, the delivery of critical care is advancing substantially in its complexity.[18] This escalation of illness severity was also visible in the present study. More than one-third of the admissions were considered intermediate-

or high-risk patients who needed a more advanced management environment.

We noted a high availability of ICCUs (>90%) across Europe, with many hospitals having more than one level of ICCU. In addition, we found a reasonable concordance between illness severity and ICCU level, indicating that a great number of the patients were admitted at the appropriate ICCU level. A perfect match, as proposed by the position paper, was present in approximately 35% of the cases. It should be stressed that a perfect match is only feasible in hospitals with three ICCU levels, which was only the case in one-third of the hospitals and which greatly depends on the size of the hospital. Information about the distribution of illness severity may help local authorities decide on how to organise the different levels of ICCUs (e.g. in terms of how many beds per ICCU level, extent of ICCU staffing/training and, above all, networks for adapted transfer) and could help to increase the cost-effectiveness of the ICCUs. In our survey, we found two kinds of admission policy mismatches. Level 3 ICCU mismatches included the admission of patients with low illness severity to high-level ICCUs. This mismatch could be partially explained by the fact that some hospitals did not have a level 1 ICCU. Another possible explanation might be related to bed capacity and occupancy of the existing level 1 ICCU, which might have diverted some 'low-risk' patients to high-level ICCUs. Additionally, economic reasons could play a role in countries where the reimbursement system favours admission in high-level ICCUs. The over-qualification of care and the overuse of resources has also been documented in a recent US report.[19] Level 1 ICCU mismatches included the admission of patients with high illness severity to low-level ICCUs, which might be clinically more relevant. One explanation is the absence of high-level ICCUs in the studied hospitals. Alternatively, some of the patients may have shown rapid stabilization after initial treatment, obviating the need to send them to a high-level ICCU. Finally, some high-risk patients arriving in a hospital without PCI/CABG facilities could have been monitored in the level 1 ICCU while waiting for a transfer to a hospital with more advanced diagnostic and therapeutic resources. It should be stressed that the current study was not designed to relate clinical outcome to the policy admission, so any clinical implication of policy mismatch should be done cautiously.

The present survey also explored potential inequalities among high- versus middle-income countries. Although the disease burden was comparable between high- and middle-income countries, there were fewer dedicated ICCUs and less advanced ICCU levels in middle-income countries than in high-income countries. This may explain the higher proportion of level 1 ICCU mismatches in the middle-income countries, as some hospitals have no appropriate high-level ICCU to manage high-risk patients. These inequalities in resources and care delivery have also been described for other cardiovascular procedures and may impact outcomes of care.[15,20] On the other hand, the increased proportion of level 3 ICCU mismatches in the high-income countries suggests some overcapacity of level 3 ICCUs in some high-income countries.

The results of this study should be considered in the context of the following limitations. As participation in this ICCU survey was voluntary, there is a risk of selection bias with an overrepresentation of hospitals with one or more ICCU levels. Also a high number of PCI centres and academic centres have favoured the presence of ICCUs in the survey. Thus, the high availability of ICCUs might be an overly optimistic view of reality, particularly in middle-income countries. Also, some ICCUs could be misclassified if the position paper criteria were not completely followed. On-site auditing was not performed, and the admission policy was based on the diagnosis made by the treating physician. In addition, as the number of prespecified diagnoses was restricted, fine tuning of the diagnosis was sometimes not possible which could have affected the illness severity allocation. To mitigate the risk of allocating the ICCU level to the illness severity, the investigator was blinded to the algorithm that we used to link different pathologies with different ICCU levels (see Table 2)

In conclusion, more than one-third of the admissions were categorised as intermediate or high risk and required a higher ICCU level, which could not be offered in some hospitals, mainly in middle-income countries. A better knowledge of the distribution of illness pathological severity may prompt the local authorities to invest in the organization of ICCU levels and may help allocate resources more efficiently.

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Conflict of interest

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