Cardiac arrhythmia services in Africa from 2011 to 2018: the second report from the Pan African Society of Cardiology working group on cardiac arrhythmias and pacing

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Aims	Cardiac arrhythmia services are a neglected field of cardiology in Africa. To provide comprehensive contemporary information on the access and use of cardiac arrhythmia services in Africa.
Methods and results	Data on human resources, drug availability, cardiac implantable electronic devices (CIED), and ablation procedures were sought from member countries of Pan African Society of Cardiology. Data were received from 23 out of 31 countries. In most countries, healthcare services are primarily supported by household incomes. Vitamin K antagonists (VKAs), digoxin, and amiodarone were available in all countries, while the availability of other drugs varied widely. Non-VKA oral anticoagulants (NOACs) were unequally present in the African markets, while International Normalized Ratio monitoring was challenging. Four countries (18%) did not provide pacemaker implantations while, where available, the implantation and operator rates were 2.79 and 0.772 per million population, respectively. The countries with the highest pacemaker implantation rate/million population in descending order were Tunisia, Mauritius, South Africa, Algeria, and Morocco. Implantable cardioverter-defibrillator and cardiac resynchronization therapy (CRT) were performed in 15 (65%) and 12 (52%) countries, respectively. Reconditioned CIED were used in 5 (22%) countries. Electrophysiology was performed in 8 (35%) countries, but complex ablations only in countries from the Maghreb and South Africa. Marked variation in costs of CIED that severely mismatched the

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gross domestic product per capita was observed in Africa. From the first report, three countries have started performing simple ablations.

Conclusion   The access to arrhythmia treatments varied widely in Africa where hundreds of millions of people remain at risk of dying from heart block. Increased economic and human resources as well as infrastructures are the critical targets for improving arrhythmia services in Africa.

Keywords   Cardiac arrhythmias • Drug therapy • Cardiac implantable electronic devices • Electrophysiology • Ablation • Africa • Cardiac Arrhythmia Service

What's new?

- Non-Vitamin K antagonists oral anticoagulants (NOACs) were hardly available in the African market, none of countries having edoxaban and only 17% of countries used all three other NOACs (apixaban, dabigatran, and rivaroxaban).
- Apart from digoxin and amiodarone which are available in all countries, flecainide (80%), sotalol (75%), propafenone (22%), quinidine (17%), and mexiletine (4%) are unequally afforded.
- About 20% of countries did not implant pacemakers, leaving hundreds of millions of people without access to the treatment for heart blocks.
- There was a serious mismatch between the costs of cardiac implantable electronic devices and of invasive procedures, and the gross domestic product per capita of most African nations.
- Since the first PASCAR survey released 2 years ago, there has been small but promising increase in the number of countries that are able to implant pacemakers and perform cardiac ablations.

Introduction

In the 1960s, 'tropical' cardiology was limited to as the management of hypertension and rheumatic heart disease. Since then, the number of cardiologists and the utilization of conventional cardiac imaging techniques have become more available in Africa, uncovering a profound burden of other cardiac disorders, such as cardiac arrhythmias. However, the high cost of medical equipment and the requirement of highly skilled experts to treat complex arrhythmias, in conjunction with inadequate public health policies, underlie why patients with arrhythmias in Africa experience a high morbidity and mortality.[1] This neglected field of cardiology in the vast majority of African countries motivated an initiative taken by the Pan-African Society of Cardiology (PASCAR) to address reports on cardiac arrhythmia services in Africa. The reports are based to an extent on the successful template developed by the European Heart Rhythm Association (EHRA) White Book Project.[2] Regular statistic reports on the use of drugs, cardiac implantable electronic devices (CIEDs), and ablation techniques in Africa will help determine the heterogeneity in the access to cardiac arrhythmia treatment and identify potential targets to improve patient management. In 2017, the first report described invasive arrhythmia treatment from 2011 to 2016 in 31 countries.[3] In 2018, these data were complemented by a survey of diagnostic work-up available, as well as the use of anticoagulation and antiarrhythmic.[4] This second report will add 2 years to the follow-up period to help understand if progress has been made and in which countries.

Methodology

The Pan-African Society of Cardiology (PASCAR) is the scientific organization bringing together all African cardiac societies. However, not all 53 African nations have a national cardiac society and not all existing societies actively participate in PASCAR activities. Nevertheless, the vast majority of countries regularly participate in PASCAR survey and trials. For the present survey, within 3 weeks, one or two cardiologists from 31 countries had been contacted, of whom 23 countries provided data (*Figure 1*). The scientific committee of the PASCAR task force on cardiac arrhythmias designed a questionnaire on the availability of human resources (pacemaker operators and electrophysiologists), anticoagulants and antiarrhythmic drugs, facilities to perform CIED, and ablation procedures. Information on healthcare systems, demographics, economics, and vital status have also been collected. These data have been sent to investigators from member countries through an electronic survey. Answers were centralized by an administrator of the survey. Data on implantation rates were cross-checked by device manufacturers and local distributors who were provided information of CIED sales. Reports on demographic, socio-economic and financial, and vital statistics came from worldometers[5] and World Bank database.[5]

All the statistical analyses performed were done with SAS JMP 13.2.1. Mean, median diagrams, and tables were used as appropriate to describe some results. A simple linear regression was used to assess the association between device implantation rates and the cost of procedures divided by the gross domestic product (GDP) per capita. The rates were standardized by the population in the corresponding country, and implantation rates were presented per million of population. A probability of 0.05 was used as a threshold to decide of the statistical significance.

Demographic, financial and economic, governance and vital statistics

As summarized in *Table 1*, the demographic, financial and economic profiles, and vital statistics of the 23 African countries surveyed vary

Figure 1 Participating countries in the second PASCAR report on arrhythmias from 2011 to 2018.
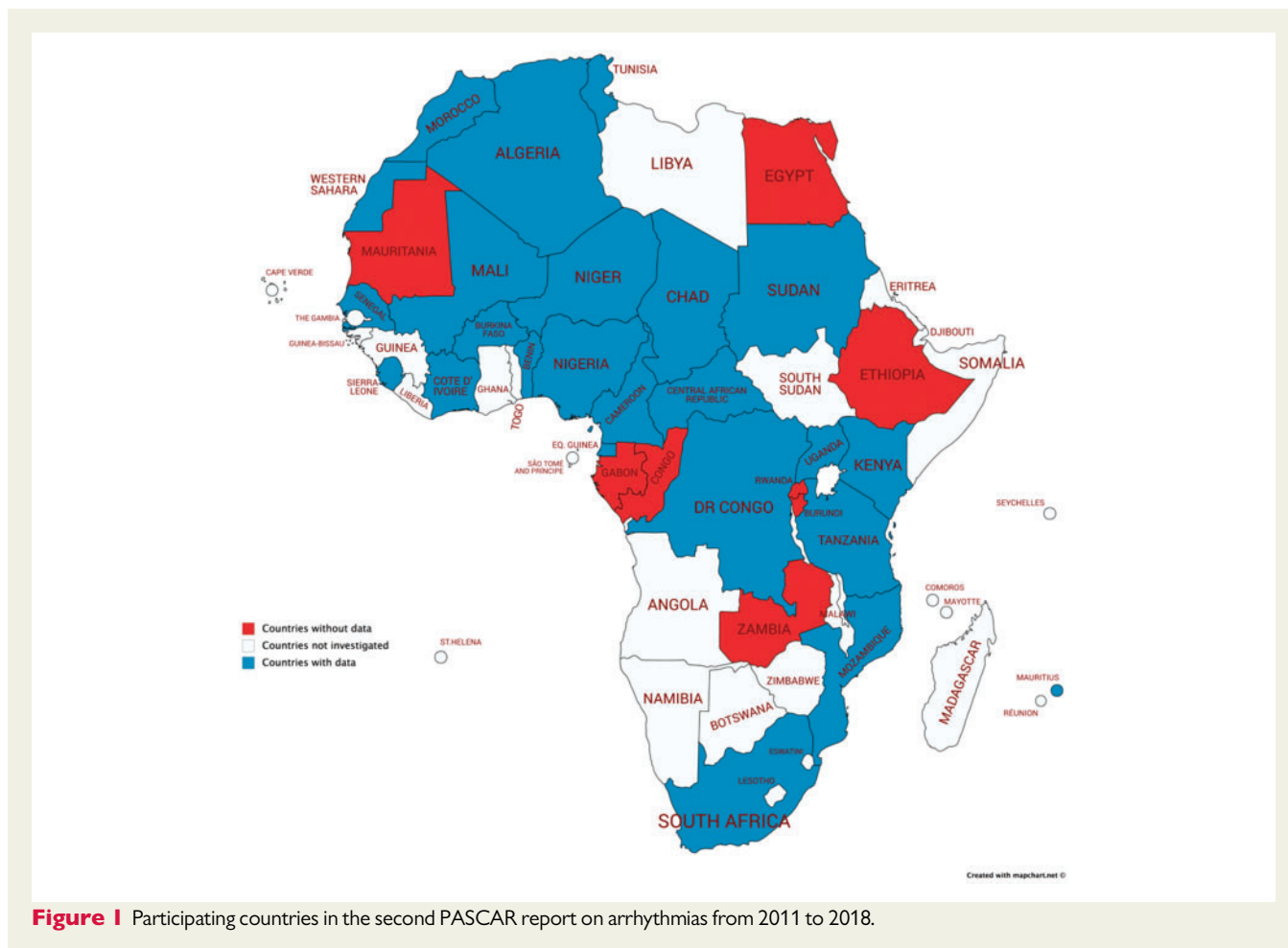
widely with a population of more than 818 million, which represents about 65.5% of the total African population.[5] Of these, the most populous country was Nigeria (193 392 517), while Mauritius had the smallest (1 265 303) population. Regarding the financial profile of the different African countries, it is worth stressing that in 2018, GDP per capita ranged between $411.7 in Niger and $11 238.7 in Mauritius (*Table 1*). The human development index (HDI), which is a statistic that takes into account life expectancy, education, and per capita income indicators, follows the same trend in all 23 countries. Of all the countries under review, Mauritius was the best country in terms of human well-being. This clearly demonstrates the marked heterogeneity in the financial profiles of the countries and the competing impact of population and public policies on the meagre resources.

Healthcare systems and expenditures

The healthcare infrastructure across the PASCAR countries is heterogeneous with few providing universal healthcare services to the entire population. In most of these countries, healthcare services are primarily supported by household incomes (out-of-pocket payment expenditures) rather than by public or commercial health insurance companies.[3] In 2014, between 40% and 60% of total health expenditures (THE) were funded by households in half of sub-Saharan African (SSA) countries.[3] Healthcare expenditure has been escalating rapidly in some countries but in general, this progression is pending in many countries.[3] Most countries committed to increase public health spending to at least 15% of the government's budget in line with the 2001 Abuja Declaration.[3] However, between 2002 and 2014, government healthcare expenditures diminished in 50% of African countries.[3] The health expenditure per capita was lowest in Central African Republic ($16) and highest in Mauritius ($553). Hence, there was more than 30-fold difference between the lowest and highest healthcare expenditures per capita in the survey. Importantly, these statistics have direct implication on the HDI, which was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone.

Drug therapy (anticoagulants and antiarrhythmics)

Tables 2 and *3* show the availability of anticoagulants and antiarrhythmic drugs by country. Vitamin K antagonists (VKAs), digoxin, and amiodarone were available in all surveyed countries. The remaining

Table 1 Socio-demographics, financial and economic, and vital statistics of 23 surveyed African countries

Country	Population	Life expectancy at birth	Death rate/1000 population	GDP (USD)	GDP per capita (USD)	Health expenditure as % of GDP	Health expenditure per capita (USD)	Human development index (HDI)
Mauritius	1 265 303	75	8	14 220 348	11239	5.75	553.1	0.79
Algeria	42 228 429	76	5	1.81E+08	4279	6.65	260.41	0.754
Tunisia	11 565 204	76	6	39 860 716	3447	6.95	256.5	0.735
South Africa	57 779 622	63	10	366 298 210	6340	8.11	428.18	0.699
Morocco	36 029 138	76	5	118 495 328	3238	5.84	171.45	0.667
Equatorial Guinea	1 308 974	58	10	13 317 453	10 174	3.38	281.37	0.591
Kenya	51 393 010	67	6	87 908 263	1711	4.55	66.21	0.59
Cameroon	25 216 237	59	10	38 502 060	1527	4.69	64.47	0.556
Tanzania	56 318 348	66	6	57 437 074	1051	4.14	35.5	0.538
Nigeria	1.96E+08	54	10	9 239 514	2028	3.65	79.34	0.532
Uganda	42 723 139	60	9	27 476 946	643	6.17	37.61	0.516
Benin	11 485 048	61	9	10 358 986	902	3.86	30.4	0.515
Senegal	15 854 360	67	6	24 129 600	1522	5.51	52.61	0.505
Sudan	41 801 533	65	7	40 851 536	977	5.66	152.02	0.502
Cote d'Ivoire	25 069 229	54	12	43 007 046	1716	4.4	67.57	0.492
Democratic Congo Rep.	84 068 091	60	10	47 227 535	562	3.87	20.52	0.457
Mozambique	29 495 962	59	10	14 457 964	490	5.07	19.21	0.437
Mali	19 077 690	58	10	17 196 689	901	3.82	29.79	0.427
Burkina Faso	19 751 535	61	8	14 441 964	731	6.75	40.94	0.423
Sierra Leone	7 650 154	52	13	3 999 945	523	16.53	86.31	0.419
Chad	15 477 751	53	13	11 302 544	730	4.54	31.69	0.404
Central Africa Rep.	4 666 377	53	13	2 379 717	510	4.28	16.36	0.367
Niger	22 442 948	60	9	9 239 514	412	6.23	22.68	0.354

GDP, gross domestic products; USD, United States Dollars.

medications were present in the African market in widely different rates. Among non-vitamin K oral anticoagulants (NOACs), of the 23 surveyed countries, rivaroxaban, dabigatran, and apixaban were available in 90%, 45%, and 22% countries, respectively, whereas edoxaban was not available at all in the African market. Interestingly, none of NOACs was present in Tunisia which provides the best invasive arrhythmia services in the continent, whereas 4 (17%) countries (Democratic Republic of Congo, Morocco, Sierra Leone, and South Africa) introduced all three main NOACs in their markets. Procainamide is not used in Africa, and flecainide (80%), sotalol (75%), propafenone (22%), quinidine (17%), and mexiletine (4%) were available. None of the countries offered all available antiarrhythmic, 3 (13%) of them (Burkina Faso, Ivory Coast, and South Africa) having the better stocks with six out of seven antiarrhythmic drugs (Table 3).

Cardiac implantable electronic devices

Pacemaker facilities and operators

Figure 2 shows the density of pacemaker implanting operators in each country in 2018. As we showed in the first PASCAR report,[3] the density of pacemaker centres was <1 per million inhabitants.[3] In 2018,

the median of 0.158 operators per million population per country was reported. Mauritius had the highest density of operators (9.48 per million population) in contrast to the Democratic Republic of Congo, Mozambique, and Uganda which all had <0.10 per million population. Chad, Niger, Central African Republic, and Equatorial Guinea (about 18% of countries surveyed) did not have local pacing facilities (Table 2). Pacemakers were implanted via humanitarian visiting missions in 5 (22%) countries, of which three (Kenya, Nigeria, and Sierra Leone) had co-existing local pacing centres and operators (Table 2).

Pacemaker implantation rates and costs

Table 4 shows the pacemaker implantation rates per million inhabitants from 2011 to 2018. In 2016, the median pacemaker implantation rate was 1.957 per million population per country (range 0.000–163.421) which is 200-fold less than in western countries.[3] In 2018, the implantation rate was 2.78 per million inhabitants with Nigeria having the lowest rate of 0.2 per million inhabitants which is more than 7500-fold less than in Germany,[2] followed by Mali, Democratic Republic of Congo, and Uganda, which all had implant rates of <1 per million inhabitants (Figure 3). Even though Mauritius (150.2), and South Africa (92.1) were the second and the third countries, highest implant rates were seen in the Northern African countries with highest being Tunisia with 164.3 per million inhabitants. SSA countries

Table 2 Pacemaker and anticoagulation regimen for 23 surveyed African countries

Country	Pacemaker activity						Anticoagulation regimen				
	Pacemaker	Humanitarian mission	Re-used PMK	Operators (n)	Single-chamber cost (USD)	Dual-chamber Cost (USD)	VKA	Apixaban	Rivaroxaban	Endoxaban	Dabigatran
Algeria	green	green	red	55	1340	1675	green	red	red	red	green
Benin	green	red	green	2	2736	3573	green	green	green	red	green
Burkina Faso	green	red	red	3	1786	2457	green	green	green	red	green
Cameroon	green	red	red	4	1898	2345	green	red	red	red	red
Central Africa Rep.	red	red	red	0	NA	NA	green	red	NA	red	NA
Chad	red	green	red	0	NA	NA	green	green	NA	red	NA
Cote d'Ivoire	green	red	red	4	3000	4000	green	red	green	red	green
Democratic Congo Rep.	red	red	red	1	2000	3000	green	red	green	red	red
Equatorial Guinea	red	red	red	0	NA	NA	green	red	NA	red	NA
Kenya	green	green	red	21	2625	3938	green	green	green	red	green
Mali	green	red	red	3	1780	2543	green	green	green	red	red
Mauritius	green	red	red	12	Free	Free	green	red	green	red	green
Morocco	green	red	red	30	2792	3908	green	red	red	red	green
Mozambique	red	red	red	2	1675	2792	green	red	green	red	red
Niger	red	green	green	0	NA	NA	green	green	green	red	green
Nigeria	green	green	red	20	3500	5000	green	green	green	red	red
Senegal	green	green	green	13	2233	2568	green	green	green	red	green
Sierra Leone	red	red	red	1	0	0	green	red	green	red	green
South Africa	green	red	red	NA	1380	3350	green	green	green	red	green
Sudan	green	red	red	25	740	1480	green	green	green	red	green
Tanzania	green	red	red	10	2608	5217	green	red	green	red	red
Tunisia	green	red	red	25	1500	2000	green	green	green	red	green
Uganda	green	red	red	4	3000	4000	green	red	green	red	green

Green colour, availability of the procedure/drug in the country; red colour, unavailability of the procedure/drug in the country; VKA, vitamin K antagonist; NA: not added.

Table 3 **Antiarrhythmic drugs, device implantations, and electrophysiologic procedures data for 23 African countries**

Country	Antiarrhythmic drugs							CRT		ICD	EP	Ablation	
	Digoxin	Amiodarone	Quinidine	Mexiletine	Propafenone	Sotalol	Flecainide	CRT-P implantation	CRT-D implantation	ICD implantation	EP available	At least one type of simple ablation	Complex ablation-atrial tachycardia
Algeria													
Benin													
Burkina Faso													
Cameroon													
Central Africa Rep.								NA	NA				
Chad								NA	NA				
Cote d'Ivoire													
Democratic Congo Rep.								NA	NA				
Equatorial Guinea													
Kenya													
Mali													
Mauritius													
Morocco													
Mozambique													
Niger													
Nigeria													
Senegal													
Sierra Leone													
South Africa													
Sudan													
Tanzania													
Tunisia													
Uganda													

CRT, cardiac resynchronization therapy; ICD, implantable cardioverter-defibrillator; EP, eletrophysiology; green colour, availability of the procedure/drug in the country; red colour, unavailability of the procedure/drug in the country; NA: not added.
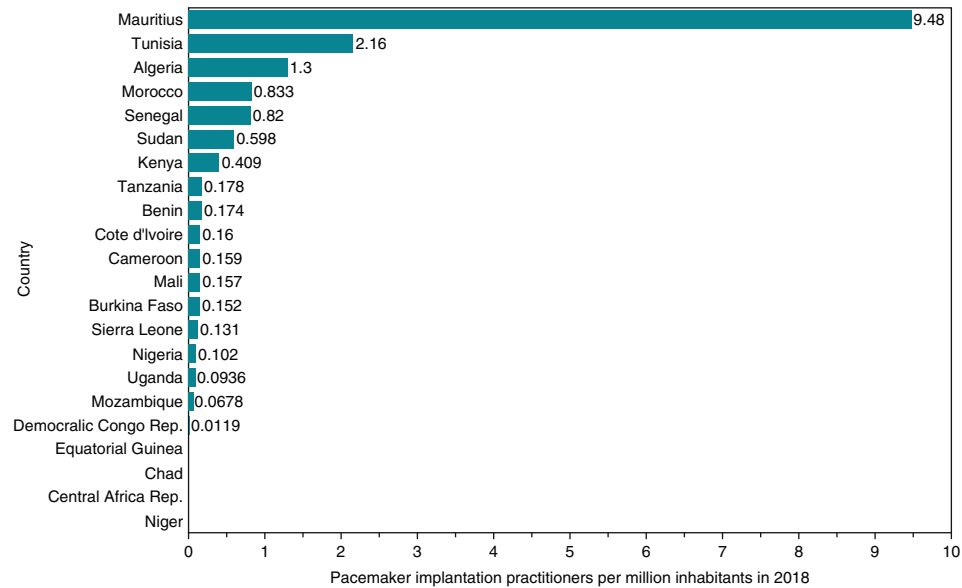
Figure 2 Pacemaker implantation practitioners per million of inhabitants in 2018. Mean: 0.772; median: 0.158; standard deviation: 2.015; IQR: 0.600. IQR, interquartile range.

Table 4   **Pacemaker implantation rates per million populations from 2011 to 2018**

| Country	Pacemaker implanting rate per million population							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Algeria	9.71	43.57	47.95	61.57	66.54	84.07	83.59	82.88
Benin	1.48	0.61	0.61	1.39	2.18	2.44	1.13	1.13
Burkina Faso	2.03	2.03	2.03	2.28	2.28	2.78	2.78	2.78
Cameroon	2.14	2.93	3.65	2.74	2.93	2.82	3.37	4.36
Central Africa Rep.	0	0	0	0	0	0	0	0
Chad	0	0	0	0	0	0	0	0
Cote d'Ivoire	NA	NA	NA	NA	NA	1.48	1.8	3.99
Democratic Congo Rep	NA	NA	NA	NA	NA	0.05	0.15	0.43
Equatorial Guinea	0	0	0	0	0	0	0	0
Kenya	0	1.21	1.46	2.41	4.3	5.29	7.1	9.05
Mali	NA	NA	0.31	0.52	0.31	0.26	0.21	0.26
Mauritius	NA	NA	NA	98.79	118.55	121.71	111.44	150.16
Morocco	NA	NA	NA	NA	NA	27.67	28.09	29.2
Mozambique	NA	NA	NA	1.19	1.19	1.19	1.19	1.19
Niger	0	0	0	0	0	0	0	0
Nigeria	0.03	0.06	0.09	0.1	0.13	0.18	0.2	0.2
Senegal	4.6	5.61	6.43	8.14	8.39	7.44	12.74	12.68
Sierra Leone	NA	NA	NA	NA	NA	NA	NA	3.14
South Africa	NA	NA	99.84	102.11	NA	127.28	NA	92.09
Sudan	5.43	5.38	5.55	5.74	5.98	5.86	8.61	11.91
Tanzania	NA	NA	0.05	0.2	0.18	0.46	0.78	1.3
Tunisia	132.29	136.62	141.8	149.59	152.18	163.42	158.23	164.29
Uganda	0.12	0.16	0.42	0.77	0.87	0.82	1.17	0.84

NA: not added.
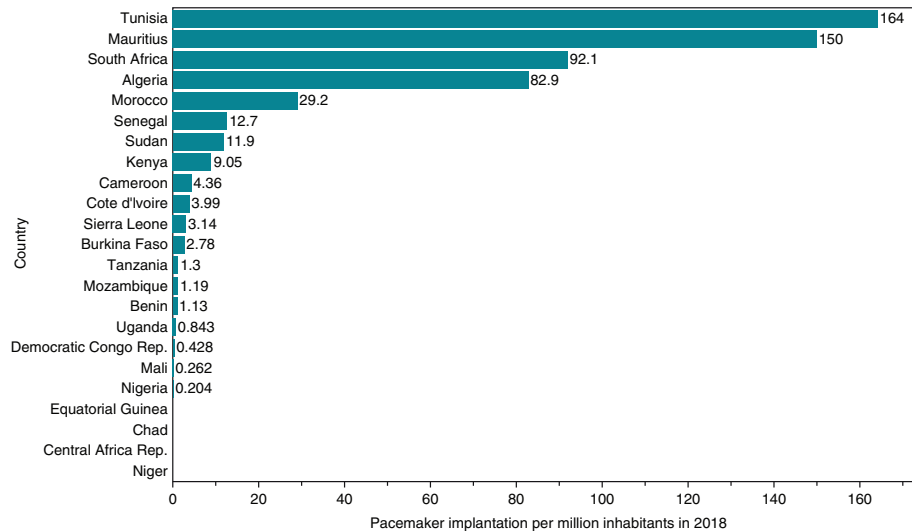
Figure 3 Pacemaker implantation per million of population in 2018. Mean: 24.865; median: 2.785; standard deviation: 48.600; IQR: 12.416. IQR, interquartile range.

displayed much lower rates which varied from 0 to 13 per million inhabitants. In general, although marginal, we observed positive trends of pacemaker implantation activity from 2011 to 2018 in most African countries (Table 4). Compared to statistics in the western world where more dual-chamber pacemakers are implanted and encouraged as they have been shown to be associated with reduced incidence of stroke and atrial fibrillation,[2,6,7] in Africa, the trends show almost equal implantation rates between single and dual-chamber devices in many countries. Countries with the lowest pacing activity like Nigeria, Benin, Niger, Mali, Mozambique, Chad, Sierra Leone, and Democratic Republic Congo predominantly implanted single-chamber devices, while in the rest of countries they were evenly distributed (Figure 4A and B).

Marked variation in cost was observed across countries. The cost of a single-chamber pacemaker procedure varied from $690 to $3500 and dual pacemakers from $1380 to $5000 (Table 2). Algeria, Mauritius, and Sierra Leone offered free of charges CIED implantations in public hospitals. Figure 5 shows pacemaker implantation rate per ratio of implantation cost and GDP per capita. The lower the ratio, the better is the accessibility to devices. The regression analysis (Table 5) revealed that for a unit increases in this ratio, there was a decrease of 20 implantations per million inhabitants [−20.32, 95% confidence interval (CI) −27.89 to −12.76; $P \leq 0.0001$]. In other words, the more affordable the cost of pacemakers compared to the GDP per capita, the higher the pacemaker implantation rate. Reconditioned devices were used in 22% of countries, while humanitarian medical groups for CIED services visited only 23% of the countries (Table 2).

Cardiac resynchronization therapy and implantable cardioverter-defibrillator

Use of cardiac resynchronization therapy (CRT) and implantable cardioverter-defibrillator (ICD) devices remain low and highly variable across the continent, despite the proven life-saving benefits afforded by such devices.[8] Of the 23 African countries for whom data is available, ICD implantation was reported in 15 countries (65%) (Table 3). Re-used ICDs were utilized in fewer countries, with only two countries reporting use of such devices. Similarly, CRT-pacemaker (CRT-P) and CRT-defibrillator (CRT-D) implantation were reported in 52% and 45%, respectively (Table 3). Fewer countries reported incorporating re-used CRT-P (13%) and CRT-D (5.6%). The results suggest that cost is a major barrier to the use of ICDs, CRT-P, and CRT-Ds, given that the cost ranged from $4467 in Algeria to $12 000 in Nigeria, $3350 in Algeria, $16 751 in Morocco, $6 142 in Algeria to $22 334 Morocco, which did not match the GDP per capita of the respective countries (Table 6). To emphasize the severe mismatch between affordability and cost of these devices, the GDP per capita and cost of ICD, CRT-P, and CRT-D in 13 implanting countries is shown in Table 6: cost of ICD, CRT-P, and CRT-D were on average five-fold, seven-fold, and eight-fold greater than the GDP per capita of the countries reported. In fact, in only one country (Algeria) was the cost of any of these devices (ICD) lower than the GDP per capita. As the consequence of the low operator density and the high cost of procedures, the implantation rates of CRT and ICD remain dismally low. Using CRT-P as an illustration, Figure 6 shows that in 2017 and 2018, none of the countries had a CRT-P rate >10 procedures per million inhabitants. As previously reported, first African countries in terms of CRT and ICD implantation rates (Tunisia and South Africa) displayed a lower volume of procedures than countries from Eastern Europe with comparable GDP per capita (Georgia, Bosnia-Herzegovina, and Serbia).[3] This difference in CRT implantation rate has reached the threshold of eight-fold between Tunisia and Germany.[3]

Catheter ablation

Table 3 shows the availability of electrophysiology (EP) procedures in Africa. To our knowledge, no national EP or ablation registry exists in
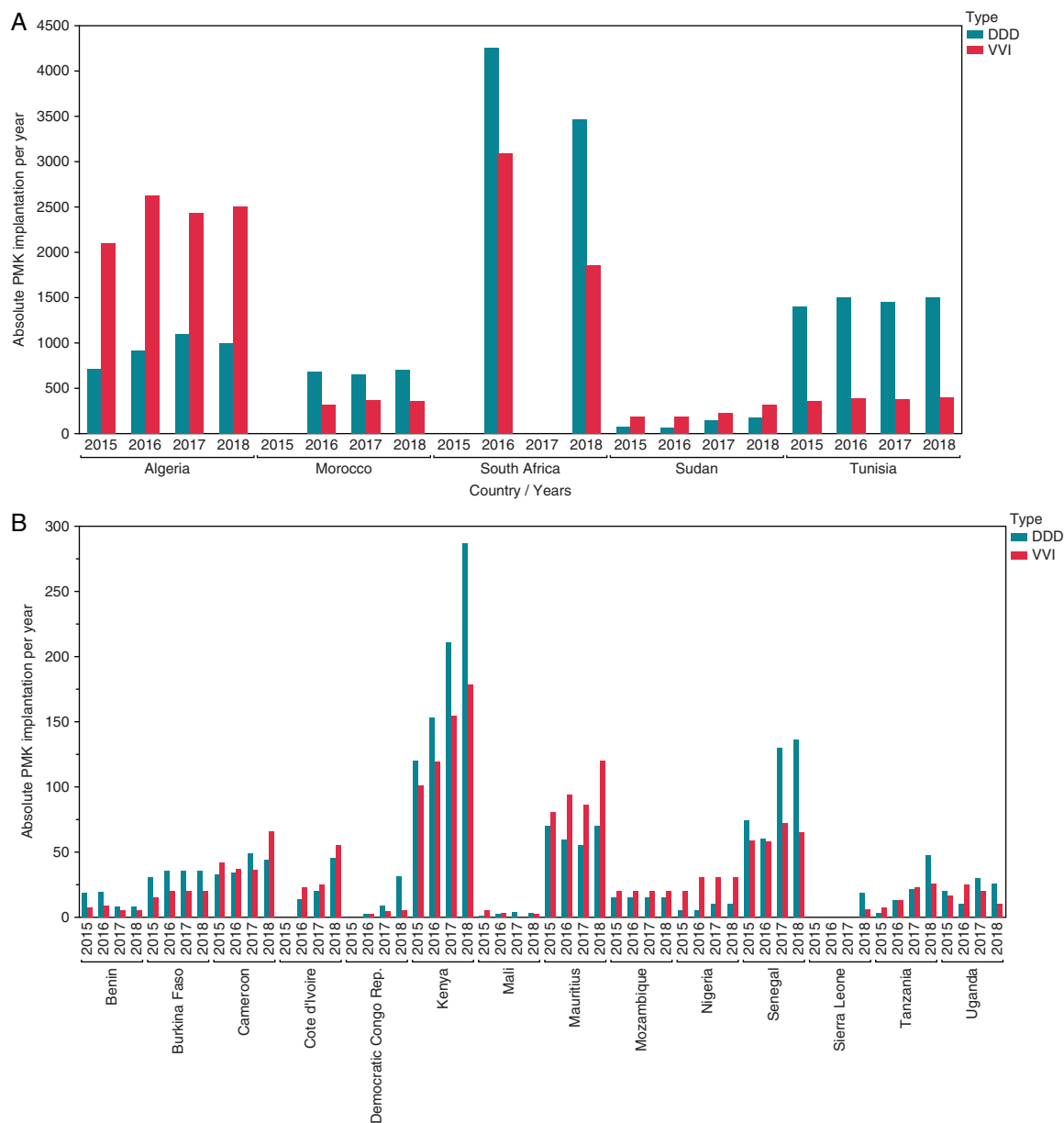
Figure 4 (*A*) Trend in number of single- and dual-chamber pacemaker implantations in the five countries with higher implantations absolute amount from 2015 to 2018. (*B*) Trend in number of single- and dual-chamber pacemaker implantations in the remaining countries from 2015 to 2018.

any country and national data was estimated by doctors working at centres where EP studies and ablation procedures are performed. A total of 14 (60.9%) countries (Burkina Faso, Benin, Democratic Republic of the Congo, Niger, Mali, Cameroon, Cote d' Ivoire, Sierra Leone, Nigeria, Mauritius, Central African Republic, Equatorial Guinea, Chad, Tanzania, and Sudan) did not perform EP studies or catheter ablations (*Figure 7*). Algeria, Egypt, Kenya, Morocco, South Africa, and Tunisia were the only countries in Africa where both simple [atrioventricular (AV) node ablation, accessory pathway ablation, AV nodal re-entrant tachycardia (AVNRT) ablation, atrial flutter

ablation], and complex ablations (atrial fibrillation ablation, atrial tachycardia ablation, ventricular tachycardia ablation) using 3D ana-tomical mapping, were performed. Simple, but not complex ablations were performed in Senegal and Uganda. Simple ablations are per-formed in Mozambique only during humanitarian missions. North African countries (Egypt, Tunisia, Morocco, Algeria, and Libya) have greater access to EP studies and catheter ablations compared to SSA countries.[3] Atrioventricular node ablations were performed in 6 (26%), atrial flutter ablations in 8 (35%), AVNRT ablations in 7 (30%), accessory pathway ablations in 7 (30%), atrial fibrillation ablations in 4
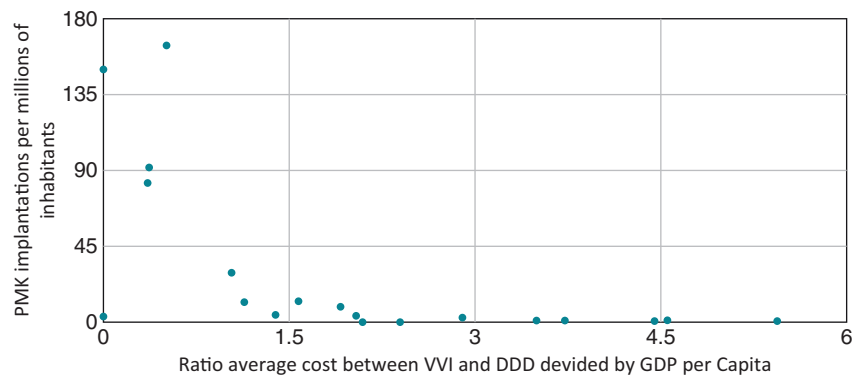
Figure 5 Pacemaker implantation rate per ratio of implantation cost on GDP per capita. *Note*: Result weighted by population available in country. GDP, gross domestic product.

Table 5 Simple linear regression between pacemaker implantation rate per ratio of implantation cost on GDP per capita

Parameters	Estimate	Std. error	t ratio	Prob > |t|	Lower 95%	Upper 95%
Intercept	46.246585	9.105281	5.08	0.0001[a]	26.944252	65.548919
Ratio average cost per GDP	−20.32594	3.568874	−5.70	<0.0001[a]	−27.89162	−12.76027
(Ratio average cost per GDP)^2	8.9004825	2.150454	4.14	0.0008[a]	4.3417243	13.459241

A regression analysis has been performed between the pacemaker rate implanted in 2018 per million of inhabitants and the average cost between DDD and VVI, standardized by the GDP per capita. The result shows that for a unit increase in the ratio, there is a decrease of 20 implantations per million habitants. In other words, the more affordable the cost of a CIED is compared to the GDP per capita, the higher is the rate of device implantation. However, given that a positive quadratic term is statistically significant, both trends cancelled out around the unit ratio of 2.28 for the average cost between VVI and DDD divided by the GDP per capita. This indicates the necessity to reduce the cost of CIED as a main driver to increase the use of pacemakers when needed.
$R^2 = 0.69$.
[a]less than 0.05.
GDP, gross domestic product.

Table 6 Cost of cardiac resynchronization therapy and implantable cardioverter-defibrillator

Country	GDP Per capita in 2018 ($ US)	CRT-P charge ($ US)	CRT-D charge ($ US)	ICD charge ($ US)
Nigeria	2028	12 000	15 000	12 000
Tanzania	1051	11 304	11 300	6080
Cameroon	1527	8934	13 400	13 400
Kenya	1711	8000	14 500	9000
Morocco	3238	7817	22 334	16 751
Cote d'Ivoire	1716	7258	10 609	8000
Tunisia	3447	7000	15 000	13 000
Uganda	643	7000	11 000	11 000
Sudan	977	6000	12 000	10 000
Senegal	1522	5919	13 735	12 876
Burkina Faso	731	5025	NA	NA
Algeria	4279	4467	6142	3350
Democratic Congo Rep.	562	NA	NA	6000

CRT-D, cardiac resynchronization therapy with defibrillation; CRT-P, cardiac resynchronization therapy with pacing only delivering; GDP, gross domestic product; ICD, implantable cardioverter-defibrillator.
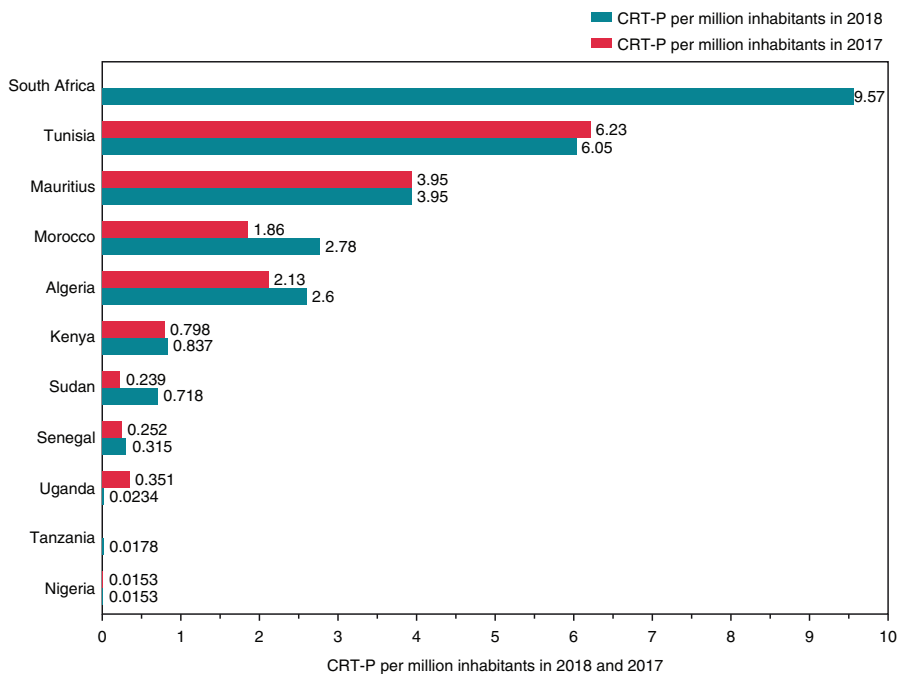
Figure 6 CRT-P implanted in 2018 and 2017 per million of inhabitants across the 23 countries participating. CRT-P, cardiac resynchronization therapy-pacemaker.
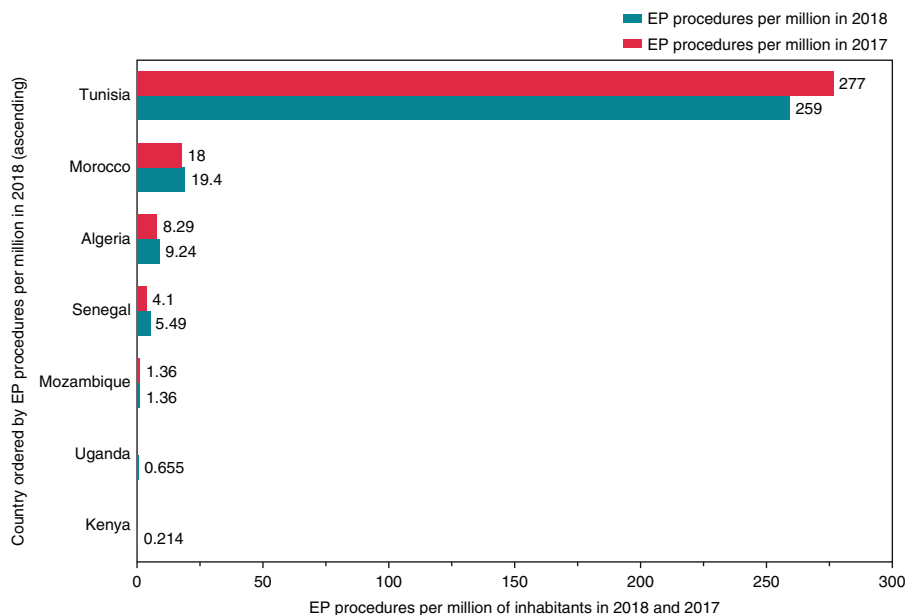

Figure 7 EP procedures per million of inhabitants in 2018 and 2017. EP, electrophysiology.

(17%), and atrial tachycardia ablations in 4 (17%) countries in Africa. In Tunisia, the number of EP procedures per million population have been increasing over the 8 years increasing from 56 per million in 2011, 78 per million in 2014 to 277 per million in 2018 (*Figure 7*). The

number of EP procedures surveyed from other countries was very low, ranging from 0.2 per million in Kenya to 18 per million in Morocco. Since the first PASCAR survey, three new countries (Uganda, Kenya, and Mozambique) have reported EP activity.
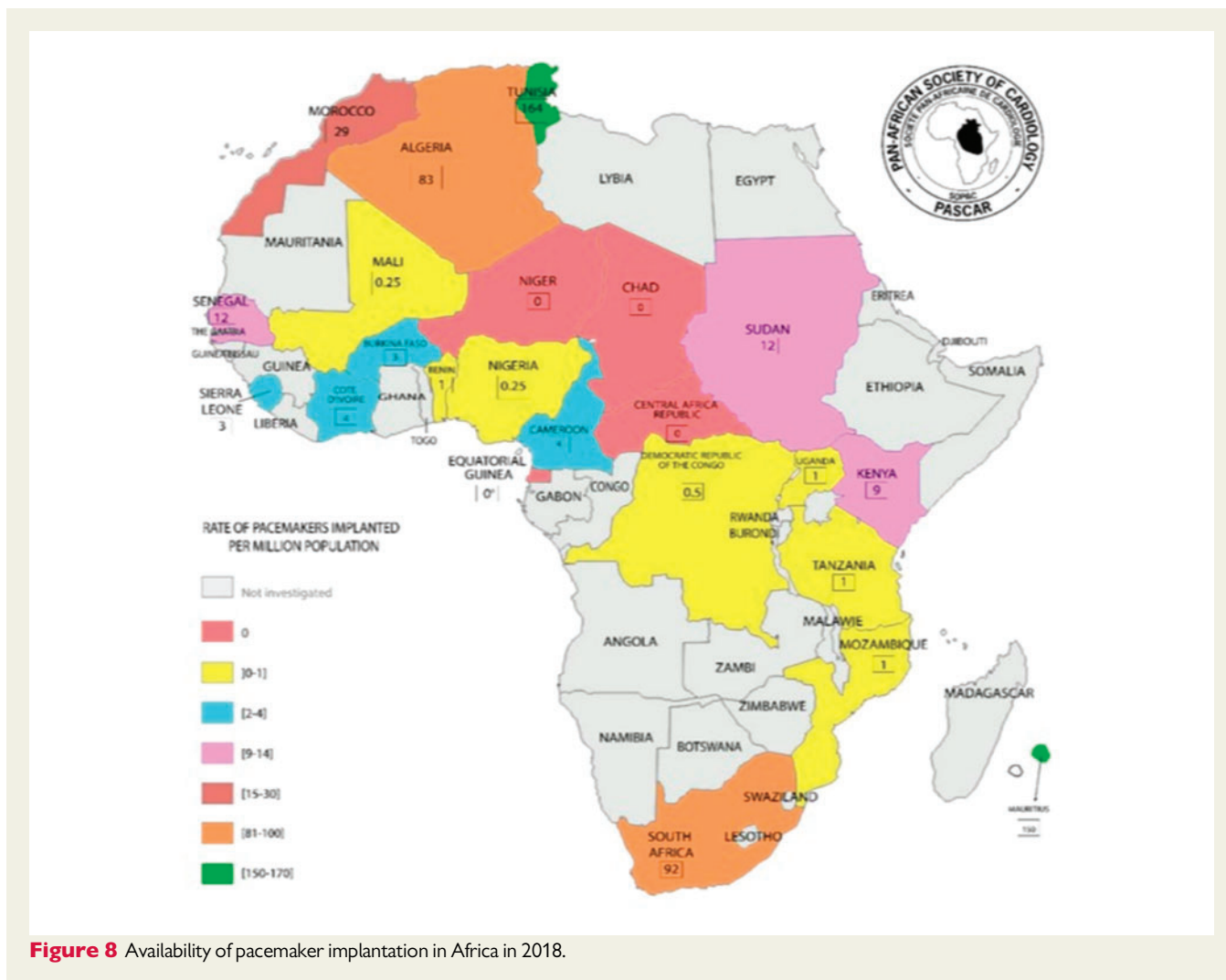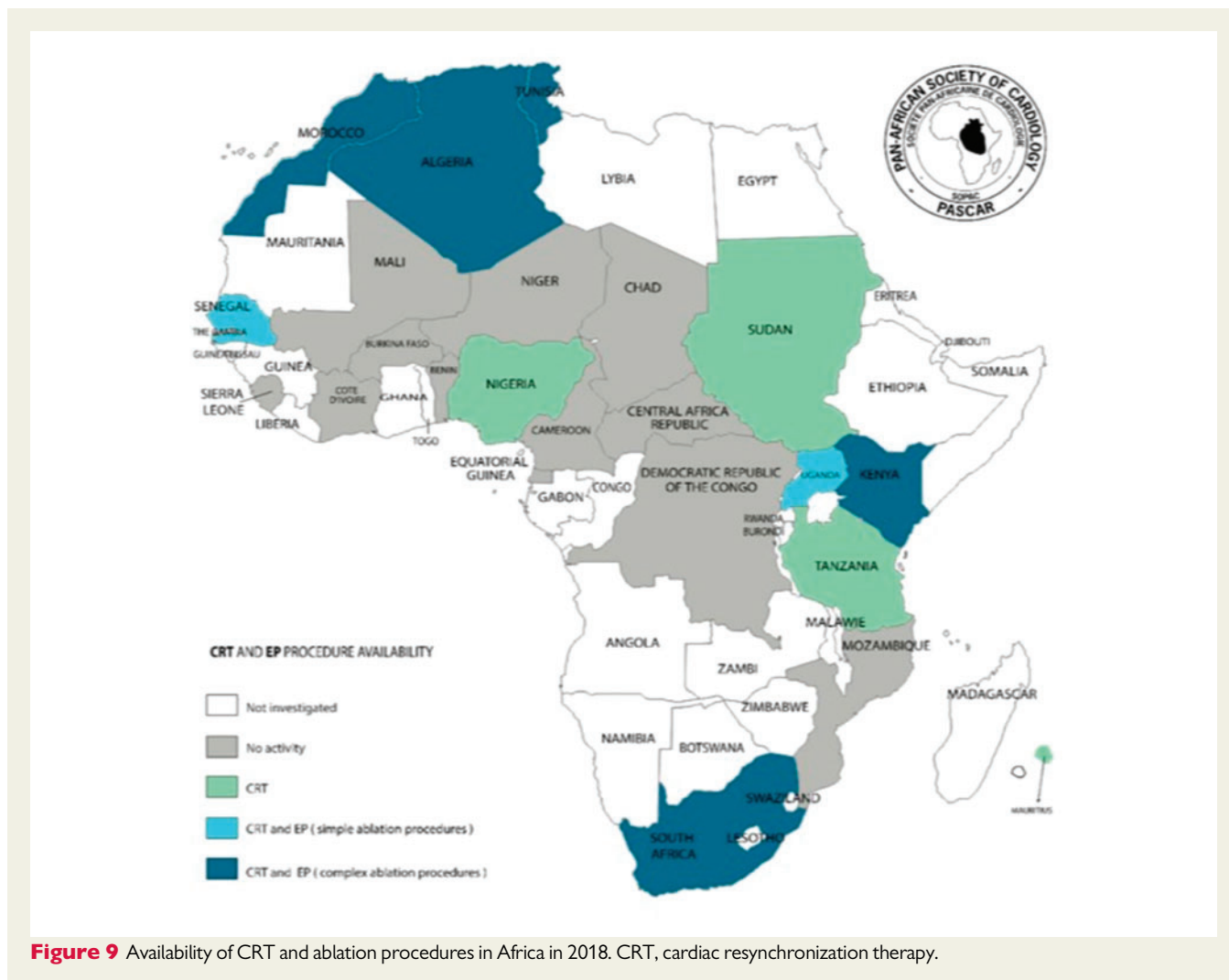
Figure 8 Availability of pacemaker implantation in Africa in 2018.

Discussion

As already shown in the first PASCAR survey,[3] this second survey confirms that the treatment of arrhythmias in Africa is still far from optimal,[3,4] unequally affordable in the continent, being more challenging in sub-Saharan countries apart from South Africa (*Figures 8* and *9*). The barriers to promote good practices in managing arrhythmias are numerous: (i) economic reasons, (ii) lack of facilities (cardiac catheterization laboratories and EP equipment), (iii) lack of political wills in many countries to treat non-communicable disease like arrhythmias, (iv) shortage of trained cardiologists and EP physicians, and (v) high cost of the CIEDs implantation procedures in the context of out-of-pocket healthcare. The mean cost of single- and dual-chamber pacemaker implantation is $1778 and $2379, which exceeds the yearly earnings of the average citizen in lower-income and middle-income countries. The astronomical costs of pacemakers, ICDs, CRT-Ps, and CRT-Ds relative to the per capita GDP provides the appropriate context within which to view cost as a barrier to the implantation of these life-saving therapies. Only three countries (Algeria, Mauritius, and Sierra Leone) offered free healthcare for CIED in the public sector. Unfortunately, most SSA countries have not got established

programmes for use of reconditioned devices usually offered by humanitarian medical missions for CIED to reduce the costs of these services. Consequently, invasive arrhythmia treatment remains unavailable in most SSA countries, apart from South Africa. To improve access to modern arrhythmia therapy, we recommend that governmental institutions and stakeholders will need to join forces to provide adequate implantation facilities, adequately trained personnel (through South-South and South-North fellowship programmes) and implement sustainable measures to reduce out-of-pocket expenditure via complete reimbursement through universal insurance schemes.

The average life expectancy in Africa is significantly lower than in Europe. According to the World Health Organization statistics, the average life expectancy in Africa was 60.0 years compared with 76.8 years in Europe.[9] In Western societies, arrhythmias such as atrial fibrillation (AF), severe bradycardia due to sinus node or atrioventricular node dysfunction, and ventricular tachyarrhythmias tend to occur much more commonly in the elderly population. The lower reported prevalence of these arrhythmias may be due to younger African population, but it may also be due to an under-reporting bias because of a lack of diagnostic equipment and skilled personnel to

Figure 9 Availability of CRT and ablation procedures in Africa in 2018. CRT, cardiac resynchronization therapy.

make correct diagnoses and implement treatment. These factors explain the lower device implant rates in Africa.[10] Africa has a different disease spectrum compared to the higher-income regions. Conditions as rheumatic heart disease, peripartum cardiomyopathy, and endomyocardial fibrosis are in many African countries more commonly contributing to heart failure, arrhythmia, and sudden death than ischaemic heart disease. In the Heart of Soweto study, 246 (4.6%) of 5238 newly diagnoses cases at a tertiary hospital presented in AF with 21% of those due to RHD.[11] AF is becoming increasingly common in sub-Saharan Africa,[13] but anticoagulation remains a big challenge.[12–14] The adequate control of INR in patients taking VKAs in the continent as assessed by time in therapeutic range seems to be grossly inadequate.[13,14] The availability of NOACs is variable across the continent. Interestingly, more advanced countries in terms of managing invasive treatments from North Africa were not better supplied by NOACs as well as antiarrhythmic drugs compared with SSA countries.

Since the first PASCAR survey, there has been small but promising increase in the number of countries able to implant pacemakers and perform cardiac ablations. This is partly due to the success of physician training programmes in Africa (like the PASCAR fellowship in

cardiac pacing which has trained three physicians to implant pacemakers). Kenya and Uganda have started performing complex (for the first) and simple (for the second) ablations which were not reported in the first survey (*Figure 9*). Mozambique organized some visiting missions to cure atrial flutter and AVNRT. This is a positive sign that arrhythmia care is slowly becoming more accessible.

Study strengths and limitations

The lack of prospective registries in all the countries led to retrospective declarative survey with known limits for CIED implantation rates and ablation procedures. The method of sampling in this study (voluntary survey) may have limitations for the data obtained and the results should be interpreted in the context of these limitations. Specifically, there may be a selection bias in terms of data sources. However, given the very limited number of physicians performing invasive cardiac procedures in Africa, and the limited number of countries in which such procedures are even available, we believe that most if not all such data provided by the respondents were identified and captured accurately. Nonetheless, this approach may introduce some bias in the data obtained as well as in the analysis performed.

The relationship between the affordability, the cost of pacemakers compared to the GDP per capita, and the higher pacemaker implantation rate (-20.32, 95% CI -27.89 to -12.76; $P \leq 0.0001$) might be limited to a ratio under 2.28. In fact, there is a positive quadratic term related to the ratio average cost per GDP per capita (8.90, 95% CI 4.34–13.46; $P \leq 0.0008$) associated with pacemaker implantation. Both trends cancelled around $20.32/8.90 = 2.28$ units of the ratio, which indicates that above this ratio the association is limited. *Figure 5* provides an overview of the analysis as above 2.28, countries appears to be on a flat line. For the reliability of our statistics which are comparable with the first report, we matched our information from Maghreb with the data published in EHRA white books,[2] given that Algeria, Egypt, Libya, Morocco, and Tunisia have annual report of their activities in this European database.

Conclusion

This survey clearly demonstrates that access to cardiac arrhythmia treatments was more challenging in sub-Saharan Africa where hundreds of millions of people remain at risk of dying from heart block. Increased economic and human resources as well as investment in infrastructure are the critical targets for improving cardiac arrhythmia services throughout Africa.

Acknowledgements

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