Title
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Journal
Anesthesia and analgesia, 129(3)

ISSN
0003-2999

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Publication Date
2019-09-01

DOI
10.1213/ane.0000000000004302

Peer reviewed

Anesthesia Provider Training and Practice Models: A Survey of Africa

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BACKGROUND: In Africa, most countries have fewer than 1 physician anesthesiologist (PA) per 100,000 population. Nonphysician anesthesia providers (NPAPs) play a large role in the workforce of many low- and middle-income countries (LMICs), but little information has been systematically collected to describe existing human resources for anesthesia care models. An understanding of existing PA and NPAP training pathways and roles is needed to inform anesthesia workforce planning, especially for critically underresourced countries.

METHODS: Between 2016 and 2018, we conducted electronic, phone, and in-person surveys of anesthesia providers in Africa. The surveys focused on the presence of anesthesia training programs, training program characteristics, and clinical scope of practice after graduation.

RESULTS: One hundred thirty-one respondents completed surveys representing data for 51 of 55 countries in Africa. Most countries had both PA and NPAP training programs (57%; mean, 1.6 pathways per country). Thirty distinct training pathways to become an anesthesia provider could be discriminated on the basis of entry qualification, duration, and qualification gained. Of these 30 distinct pathways, 22 (73%) were for NPAPs. Physician and NPAP program durations were a median of 48 and 24 months (ranges: 36–72, 9–48), respectively. Sixty percent of NPAP pathways required a nursing background for entry, and 60% conferred a technical (eg, diploma/license) qualification after training. Physicians and NPAPs were trained to perform most anesthesia tasks independently, though few had subspecialty training (such as regional or cardiac anesthesia).

CONCLUSIONS: Despite profound anesthesia provider shortages throughout Africa, most countries have both NPAP and PA training programs. NPAP training pathways, in particular, show significant heterogeneity despite relatively similar scopes of clinical practice for NPAPs after graduation. Such heterogeneity may reflect the varied needs and resources for different settings, though may also suggest lack of consensus on how to train the anesthesia workforce. Lack of consistent terminology to describe the anesthesia workforce is a significant challenge that must be addressed to accelerate workforce research and planning efforts. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

- **Question:** What training pathways are available to become an anesthesia provider in Africa, and what are the scopes of practice of these providers?
- **Findings:** There are many heterogeneous pathways to become an anesthesia provider in Africa, though the scopes of practice of these providers are largely similar.
- **Meaning:** The multiplicity of training pathways has implications for policy makers assessing different options to increase the number and quality of anesthesia providers and suggests possibilities for greater harmonization of training.

GLOSSARY

ASA = American Society of Anesthesiologists; **HIC** = high-income country; **IFNA** = International Federation of Nurse Anesthetists; **LMIC** = low- and middle-income country; **NPAP** = nonphysician anesthesia provider; **NSOAP** = National Surgical, Obstetric, and Anesthesia Plan; **PA** = physician anesthesiologist; **SAO** = surgeon, anesthesiologist, and obstetrician; **SSA** = sub-Saharan Africa; **WFSA** = World Federation of Societies of Anaesthesiologists

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DOI: 10.1213/ANE.0000000000004302

Accepted for publication May 16, 2019.

The majority of people living in African countries do not have access to safe and affordable anesthesia, analgesia, and surgical care.[1,2] In some African countries, anesthesia-related mortality has been reported to be as high as 1:100s (Malawi, 1:504; Zimbabwe, 1:482; Nigeria, 1:387 for cesarean deliveries; Togo, 1:133 to 1:250).[3–7] In a recent study of adults undergoing inpatient surgery in 247 hospitals from 25 African countries, the reported 30-day in-hospital mortality rate (2.1%) was twice the global average, despite a younger and lower American Society of Anesthesiologists (ASA) class population.[8]

Many factors impact access to safe anesthesia and surgical care worldwide, yet the shortage of anesthesia providers is one of the most striking and relatively neglected. This workforce shortage is most severe in sub-Saharan Africa (SSA), where most countries have fewer than 1 anesthesiologist per 100,000 population as compared to >20–30 per 100,000 in many high-income countries (HICs) or the 4 per 100,000 that has been recommended.[2,9–11] When nonphysician anesthesia providers (NPAPs) are included in calculations of total anesthesia provider density, 16 countries in SSA still report <1 anesthesia provider per 100,000.[9] The shortage in absolute numbers of providers is compounded by maldistribution of providers in urban centers and in the private sector.[12,13]

NPAPs play a large role in the global anesthesia workforce. Task-sharing models for anesthesia (ie, those with specialist physicians working in collaboration with nonphysicians) are currently utilized in most countries around the world and are components of most national plans to achieve global surgeon, anesthesiologist, and obstetrician (SAO) workforce goals in a timely or cost-effective manner.[2,14,15] Despite the significant role of NPAPs and polarized views on who should provide anesthesia care, few data have been systematically collected and reported about NPAP training and practice models in low- and middle-income countries (LMICs).[16–25] Recommendations for achieving specific workforce numbers assume that providers are adequately supervised during education, and competent for clinical practice. Prior attempts to characterize global anesthesia workforce data focused mainly on physician anesthesiologist (PA) provider numbers, did not delineate NPAP training pathways, or utilized data that had not been updated in multiple decades.[9,16,19,23,26,27]

The limited understanding of current anesthesia provider training models not only hinders efforts to establish sustainable, high-quality training programs, but may also perpetuate confusion in the discussion of NPAP cadres. Data that accurately describe who is currently providing anesthesia around the world and how they are trained can be important for efforts that aim to determine what models are working and should be replicated.

The primary goal of the survey was the identification of training pathways to become an anesthesia provider (either PA or NPAP) in each country in Africa, with an emphasis on NPAP training characteristics. A secondary objective was the characterization of training details. Africa was selected as a region with a dearth of data on existing training programs and the greatest need to expand the anesthesia workforce.

METHODS

We conducted a 2-round (emailed Internet-based questionnaire, and in-person or phone-based structured interview) survey (Supplemental Digital Content, Tables 1–2, http://links.lww.com/AA/C860) to gather data on anesthesia provider training models in all African countries.

We also collected training program characteristics (entry criteria, duration of training, qualification awarded, teaching methods, and curriculum content), data about provider scope of practice after graduation, and the practice of anesthesia at a national level.

Participants were eligible to complete the survey if they were anesthesia providers with self-identified experience living and working in an African country. We identified potential respondents through contacts made at a workshop on NPAP training models at the 2016 World Congress of Anesthesia, the World Federation of Societies of Anaesthesiologists (WFSA) member contact list, the International Federation of Nurse Anesthetists (IFNA) member contact list, and the authors' personal contacts. This purposive sample aimed to ensure that all African countries were represented. Several potential respondents from each country were contacted where possible, and participants were invited to forward the invitation to additional potential respondents.

The first round of the survey (2016–2017) was conducted by distributing an electronic survey link (RedCap 8.5.7, 2018 Vanderbilt University, Nashville, TN) via email. Invitations were sent in English, French, Portuguese, and Arabic. Reminder emails were sent at 1, 3, and 6 months.

The second round of the survey was conducted due to poor response rate in the first round (no data retrieved for 25 of 54 countries at 9 months), conflicting data from some countries with multiple respondents, and respondent feedback about excessive survey length. In response, we created a focused survey using a subset of questions from the first round questionnaire (Supplemental Digital Content, Table 1, http://links.lww.com/AA/C860) and administered the survey as a structured in-person or phone interview so that interviewers (authors M.S.L., F.B., T.J.L., H.E., R.S.W., P.M.B., D.B., E.Z., F.L., P.R.) could provide clarification when needed. We identified respondents for the second round of the survey from the All Africa Anesthesia Conference 2017, Internet searches for anesthesia society contacts, additional WFSA and IFNA contacts, and the contact list created for round 1. Data collection continued until a survey was completed in round 2 for all countries for which anesthesia contacts were available.

Funding: This work received funding Hellman Family Foundation and received additional funds from the International Relations Committee of the Association of Anaesthetists/Royal College of Anesthetists for travel support.

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (www.anesthesia-analgesia.org).

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Reprints will not be available from the authors.

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All electronic and in-person surveys were conducted in English, Portuguese, or French by a native speaker, depending on the preference of the respondent. In-person surveys were recorded on paper and transcribed into a spreadsheet, while those conducted by phone were entered directly into a secure electronic data capture tool.[28] Data were merged into a single spreadsheet and analyzed using Python 2.7.15 and Pandas library 0.23.0 to derive summary statistics.[29,30] Maps were created with QGIS 3.2.1.[31]

A list of distinct training pathways was identified by the combination of entry requirement, duration, and qualification. For country-level integer questions, responses were averaged or the median was taken. When conflicting responses were obtained from a single country, significant outliers were either confirmed by contacting additional respondents or discarded (noted in all instances in the spreadsheet), and the mean or median was taken where appropriate.

Consent was obtained using the online survey tool or orally when administered in person or via phone. Ethical approval for this study and method of consent were obtained from the Institutional Review Boards of the University of California San Francisco, King's College London (United Kingdom), Mbale Regional Referral Hospital, and the Uganda National Council for Science and Technology (Uganda).

RESULTS

Respondent Characteristics

One hundred thirty-one respondents completed surveys, providing data for 51 countries (mean of 2.7 per country). There were 70 respondents to the electronic survey in round 1 and 61 respondents for the in-person or phone-based focused survey in round 2 (15 in person and 46 via phone). Seventeen percent reported their profession to be nonphysician anesthetists, and 83% as PAs, and both professions provided data where they were knowledgeable.

Training Pathways

There are 30 distinct pathways to train as an anesthesia provider in Africa, defined as the unique combination of entry qualification, duration, and qualification awarded. Most of the 51 countries surveyed have >1 of these pathways (mean, 1.6) (Figure 1; Supplemental Digital Content, Tables 3–4, http://links.lww.com/AA/C860). Of the 30 distinct pathways, 22 (73%) were for NPAPs. Most countries had both PA and NPAP training programs (29/51, PA only = 4, NPAP only = 10, no programs = 8, Cabo Verde, Chad, Comoros, Djibouti, Guinea, Guinea-Bissau, Lesotho, and Somalia).

Of all the NPAP training pathways, 60% required a nursing background for entry, 14% required either nursing or other clinical experience, 12% specifically required clinical experience other than nursing, and 14% required no prior clinical experience. Clinical experience other than nursing included a range of professions, most often clinical officers, but also midwives, pharmacists, and other medical certificate. Among NPAPs, a technical qualification was most commonly awarded (such as a diploma, license, or certificate, 60%). Bachelor's and Master's degrees were awarded 24% and 10% of the time, respectively.

Of the 37 physician training programs identified, 4 (12%) produced nonspecialist physician anesthesia providers, with the remainder training specialist PAs. The median

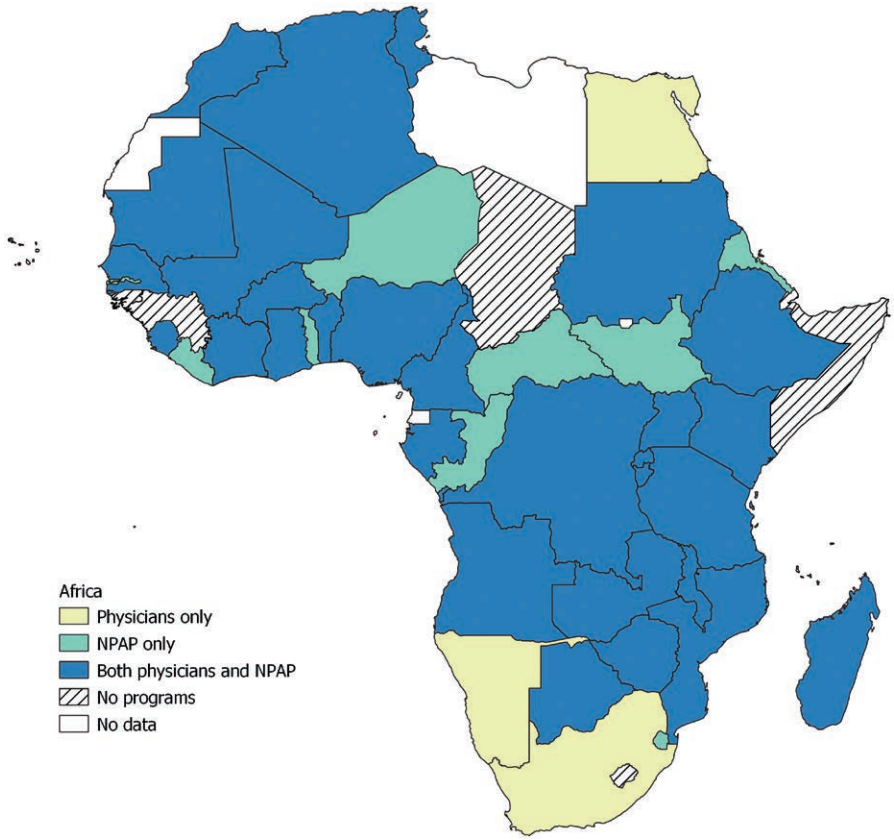

Figure 1. Map of training programs in Africa. NPAP indicates nonphysician anesthesia provider.

duration of physician specialist training programs was 48 months (range: 36–72), compared with 9 months for physician nonspecialist programs (6–36 months) that conferred a diploma in anesthesia. NPAP training programs had a median duration of 24 months overall (9–48 months), and NPAP programs conferring technical, Bachelor's, and Master's degrees had a median duration of 24 (6–36), 36 (18–48), and 24 (24–36) months, respectively (Figure 2).

Training Program Characteristics

Physicians provided clinical supervision and curriculum teaching for NPAP programs less than half the time (48% and 23%, respectively; Table). Responses for NPAP programs reported a median of 2 (range: 0.4–15) trainees per supervisor in the operating room, compared with 2 (range: 0.2–10) trainees per supervisor in physician training programs (Figure 2). These ranges reflect that some respondents reported multiple supervisors per trainee. Twenty-eight percent of responses reported NPAP programs to be dependent on the presence of foreign faculty to run.

Lectures and in-theatre supervision were ubiquitous teaching modalities in NPAP programs, and 100% of respondents reported their use (Table). Simulation scenarios and online materials were used in fewer than half the training programs (43% and 15% of respondents). Subspecialty content, except cardiac anesthesia, was taught >50% of the time (Table). Conversely, nonclinical topics such as ethics and law were taught less than half the time (44% and 19%).

Respondents reported that NPAP programs trained students to perform most clinical skills independently. A notable exception is regional anesthesia—60% of respondents reported that programs did not include regional techniques other than spinal anesthesia (where 90% report being trained to perform spinal anesthesia independently; Figure 3).

Country-Wide Characteristics

Thirty-three percent of country respondents reported the presence of a body that sets practice guidelines, and 81% reported the presence of a professional society. Thirty-three percent reported the presence of a standardized examination that must be taken before entry into practice. Ninety-two percent of respondents reported that >50% of anesthetics in their country were provided by nonphysicians.

Countries reported a median of 1 NPAP and 1 physician training program (ranges: 1–13 and 0–11). From these programs, a median of 25 NPAP and 7 physician graduates were reported per country per year (ranges: 4–700 and 0.5–220). A median of 106 NPAPs and 43 physicians were working in these countries (ranges: 0–1133 and 0–2000).

DISCUSSION

Summary of Findings

Few studies have systematically characterized anesthesia training pathways and practice models in Africa, and none has attempted to do so recently for PA and NPAP pathways continent wide.[19,26,27,32–35] This study provides information on anesthesia training programs in 51 African countries and demonstrates that most countries (65%) have both PA and NPAP training pathways, while 8 countries have no programs at all. Most NPAP programs train providers with a nursing background, result in a technical qualification, and have a median duration of 24 months. There are numerous anesthesia training pathways on the continent, which are heterogeneous in duration and qualification awarded. Despite these differences, NPAP provider scopes of practice are largely similar in Africa (ie, full scope of independent practice; Figure 3).

Our data are consistent with those previously reported, while also providing new levels of detail, as well as data for several countries not previously reporting training programs. We found that countries with the most limited anesthesia training capacity (ie, NPAP-only or no training programs) were the same as those facing the most severe workforce shortages as reported by the WFSA Workforce Survey.[9] It will likely be helpful to compare the amount of heterogeneity in training pathways in other regions; further work is currently underway, and based on preliminary evaluation, the level of heterogeneity in Africa is higher than other regions, although marked heterogeneity exists worldwide.

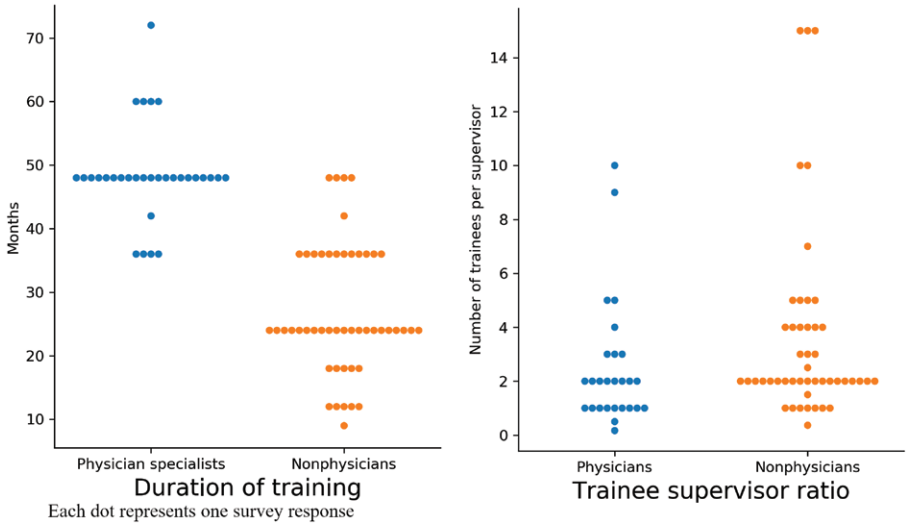

Figure 2. Duration of anesthesia training, and trainee–supervisor ratio, by provider type.

Table. NPAP Training Program Details

	Yes	No	I Do Not Know
Is there a standardized examination? (n = 54)	33%	66%	…
National professional society? (n = 62)	81%	17%	2%
Is there a practice guideline setting body? (n = 54)	33%	66%	…
Dependent on foreign faculty? (n = 40)	28%	68%	5%
Program characteristics			
The majority of the curriculum is taught by physicians (n = 101)	48%		
The majority of clinical supervision done by physicians (n = 40)	23%		
Teaching modalities (% that use this modality, n = 47)			
Lectures in classroom	100%		
In-theatre supervision/instruction	100%		
Workplace assessments	68%		
Skills workshops in a classroom	55%		
Simulation scenarios on mannequins	41%		
Online materials	16%		
Subspecialty teaching (n = 43)			
Obstetric anesthesia	100%		
Pediatric anesthesia	95%		
Regional anesthesia	83%		
Trauma management	78%		
Critical care	71%		
Neuroanesthesia	66%		
Ethics	41%		
Information technology skills	37%		
Management skills	32%		
Teaching skills	29%		
Cardiac anesthesia	27%		
Law	17%		

Abbreviation: NPAP, nonphysician anesthesia provider.

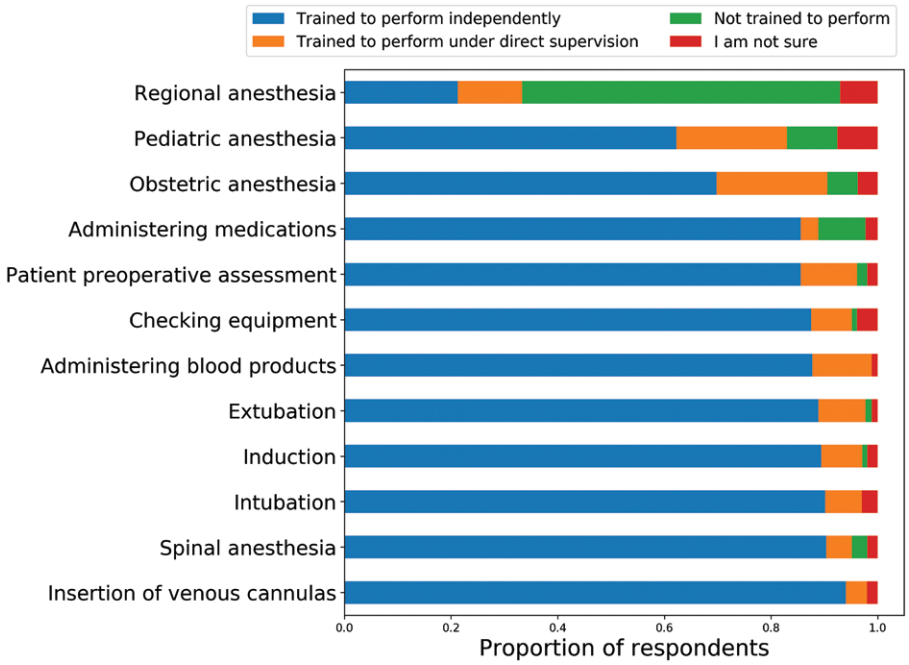

Figure 3. NPAP scope of practice. NPAP indicates nonphysician anesthesia provider.

Some of the training program characteristics we report in Africa are similar to those found in other regions. For example, the duration of anesthesia-specific training for NPAPs in Africa is comparable to what is found in Europe and North America, where NPAPs receive approximately 2–3 years of training and have a varied scope of practice. While our data provide some insights into NPAP training in Africa, it is important to note that the quality of training and provider competencies can be highly variable and were not assessed in this study.

Challenges: Few Providers

Studies that attempt to collect accurate anesthesia workforce data in resource-constrained settings will encounter some challenges worth enumerating. The number of anesthesia providers is small in many LMICs, and well-maintained databases are

rare and difficult to access, making data difficult to collect and to verify. As a result, there were relatively few NPAP respondents to the survey, because it was difficult to identify NPAP providers with country-wide knowledge. We were unable to overcome this challenge, which we shared with prior studies, though the IFNA was engaged in active collaboration. Under- or incomplete reporting of program details, particularly NPAP programs, may have resulted from this.

Challenges: Terminology

Because there is no accepted terminology to describe anesthesia provider types or training, it was necessary to create simplified categories to allow for comparison across countries, while still retaining sufficient detail for interpretation. For instance, physician specialists and both nurse and non-nurse NPAPs were explicitly separated to limit misinterpretation of the more general term "anesthesia provider," but this is hardly the only discriminating characteristic. As another example, our categorization of qualifications awarded by training programs combined "diploma" and "license," as they sometimes imply different things in different countries and different languages. This facilitates intercountry comparison, but does not replace a nuanced understanding of the differences in regional and national qualifications. Universal anesthesia provider definitions that are comprehensive and developed in a participatory fashion would significantly improve the validity of future anesthesia workforce research and provide the language needed for health workforce planning.

Challenges: Conflicting Data

One approach used by previous global workforce surveys has been to prioritize a single response on behalf of a national anesthesia society. This will yield a precise and accurate answer when the society has complete and accurate nationwide data. We chose an alternative approach, to accept responses from multiple respondents, anticipating that in many countries a single source may not have accurate nationwide data. The decision to include multiple responses for a given country unsurprisingly led to some conflicting data points and may have decreased the accuracy of the resulting point estimate. We feel this is a relative strength because it adds a measure of variance to the estimate, providing information on uncertainty in the data. In addition, restricting survey respondents would have likely resulted in more countries with no responses, especially because many countries did not have national societies (particularly for NPAPs). In our experience with similar ongoing studies, interviewing multiple respondents may uncover details about additional anesthesia provider cadres that are either not reported or not recognized by societies that may politically represent only a single cadre.[36] Because the purpose of this survey was descriptive not prescriptive, we prioritized gathering input from multiple stakeholders and sources as a way to avoid this potential reporting bias.

We addressed large discrepancies in reported data with direct phone or email follow-up communication with at least 1 provider. These conflicts likely contributed to some discrepancies between the number of NPAP and PA numbers reported between the previous WFSA workforce study and our own. Other factors include locally different interpretations of the survey question (eg, total PAs, or PAs registered with the national society, versus specialist and nonspecialist PAs).

Future Directions

Though the workforce shortage remains profound, there is a large amount of training activity across the continent. The level of heterogeneity we observed raises several important questions relevant to anesthesia workforce expansion efforts: What are the levels of competency for different provider cadres? How can we evaluate competency? What are the optimum training durations or supervision ratios? What role might harmonization of training pathways at a regional or national level play in improving the scale-up of a safe anesthesia workforce? How can the number of trainers be increased and sustained? Each of these questions warrants additional investigation.

Anesthesia workforce expansion efforts, including research, require coordination with surgeons and obstetricians among other health care workers. In many settings with anesthesia provider shortages, there are also few surgeons and obstetricians. Workforce scale-up efforts must account proportionately for all SAO providers. This can be a significant role for ongoing National Surgical, Obstetric, and Anesthesia Plans (NSOAPs).

Further characterization, including evaluation of anesthesia training programs, is needed in other regions to more fully inform health systems planning. A global, collaborative network and universal terminology to describe the existing anesthesia workforce could accelerate anesthesia workforce research. These provided the impetus for our newly formed Global Anesthesia Workforce Study Group. We hope to expand this group to create a diverse, global network that includes all anesthesia workforce stakeholders and facilitates timely, accurate, and harmonized anesthesia workforce research.

CONCLUSIONS

Despite profound anesthesia provider shortages throughout Africa, most countries have both NPAP and PA training programs. NPAP training pathways, in particular, show significant heterogeneity despite relatively similar scopes of clinical practice for NPAPs after graduation. Individual health care settings have varied needs and resources and thus potentially require different workforce solutions. It is possible that efficiencies may be gained from reducing the amount of training heterogeneity, especially across similar contexts. Accurate descriptions of current anesthesia training and practice models are needed to facilitate efforts to categorize and potentially harmonize training systems at national and regional levels, as well as to aid in understanding of how different models may be integrated into global anesthesia workforce planning. Data on provider performance are needed to contextualize the impact of various training and provider models on patient outcomes. Harmonization of anesthesia workforce terminology is a significant challenge that must be addressed to accelerate workforce research and planning efforts. ■

ACKNOWLEDGMENTS

We would like to acknowledge Mark Newton, MD, Professor of Clinical Anesthesiology, Department of Anesthesiology, Vanderbilt University, Nashville, TN, and Jesse M. Mumba, MD, Head of Anesthesia and Critical Care, Ondangwa Private Hospital, Namibia, for providing and clarifying data throughout this project.

DISCLOSURES

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REFERENCES

1. Alike BC, Raykar NP, Shrime MG, et al. Global access to surgical care: a modelling study. *Lancet Glob Health.* 2015;3:e316–e323.
2. Meara JG, Leather AJ, Hagander L, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet.* 2015;386:569–624.
3. Hodges SC, Mijumbi C, Okello M, McCormick BA, Walker IA, Wilson IH. Anaesthesia services in developing countries: defining the problems. *Anaesthesia.* 2007;62:4–11.
4. Ouro-Bang'na Maman AF, Tomta K, Ahouangbévi S, Chobli M. Deaths associated with anaesthesia in Togo, West Africa. *Trop Doct.* 2005;35:220–222.
5. Hansen D, Gausi SC, Merikebu M. Anesthesia in Malawi: complications and deaths. *Trop Doct.* 2000;30:146–149.
6. Glenshaw M, Madzimbamuto FD. Anaesthesia associated mortality in a district hospital in Zimbabwe: 1994 to 2001. *Cent Afr J Med.* 2005;51:39–44.
7. Sobhy S, Zamora J, Dharmarajah K, et al. Anaesthesia-related maternal mortality in low-income and middle-income countries: a systematic review and meta-analysis. *Lancet Glob Health.* 2016;4:e320–e327.
8. Biccard BM, Madiba TE, Kluyts H-L, et al. Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study. *Lancet*. 2018;391:1589–1598. doi:10.1016/S0140-6736(18)30001-1
9. Kempthorne P, Morriss WW, Mellin-Olsen J, Gore-Booth J. The WFSA Global Anesthesia Workforce Survey. *Anesth Analg.* 2017;125:981–990.
10. Davies JI, Vreede E, Onajin-Obembe B, Morriss WW. What is the minimum number of specialist anaesthetists needed in low-income and middle-income countries? *BMJ Glob Health.* 2018;3:e001005.
11. Holmer H, Lantz A, Kunjumen T, et al. Global distribution of surgeons, anaesthesiologists, and obstetricians. *Lancet Glob Health.* 2015;3(suppl 2):S9–11.
12. Dussault G, Franceschini MC. Not enough there, too many here: understanding geographical imbalances in the distribution of the health workforce. *Hum Resour Health.* 2006;4:12.
13. Brouillette MA, Aidoo AJ, Hondras MA, et al. Anesthesia capacity in Ghana: a teaching hospital's resources, and the national workforce and education. *Anesth Analg.* 2017;125:2063–2071.
14. Daniels KM, Riesel JN, Meara JG. The scale-up of the surgical workforce. *Lancet.* 2015;385(suppl 2):S41.
15. Shrime MG, Verguet S, Johansson KA, Desalegn D, Jamison DT, Kruk ME. Task-sharing or public finance for expanding surgical access in rural Ethiopia: an extended cost-effectiveness analysis. In: Debas HT, Donkor P, Gawande A, Jamison DT, Kruk ME, Mock CN, eds. *Essential Surgery: Disease Control Priorities*. Vol. 1. 3rd ed. Washington (DC): The International Bank for Reconstruction and Development/ The World Bank; 2016.
16. Federspiel F, Mukhopadhyay S, Milsom PJ, Scott JW, Riesel JN, Meara JG. Global surgical, obstetric, and anesthetic task shifting: a systematic literature review. *Surgery.* 2018;164:553–558.
17. Meeusen V, van Zundert A, Hoekman J, Kumar C, Rawal N, Knape H. Composition of the anaesthesia team: a European survey. *Eur J Anaesthesiol.* 2010;27:773–779.
18. Mullan F, Frehywot S. Non-physician clinicians in 47 sub-Saharan African countries. *Lancet.* 2007;370:2158–2163.
19. McAuliffe MS, Henry B. Countries where anesthesia is administered by nurses. *AANA J.* 1996;64:469–479.
20. Vaughan E, Sesay F, Chima A, et al. An assessment of surgical and anesthesia staff at 10 government hospitals in Sierra Leone. *JAMA Surg.* 2015;150:237–244.
21. Bashford T. Anesthesia in Ethiopia: providers' perspectives on the current state of the service. *Trop Doct.* 2014;44:6–13.
22. Newton M, Bird P. Impact of parallel anesthesia and surgical provider training in sub-Saharan Africa: a model for a resource-poor setting. *World J Surg.* 2010;34:445–452.
23. Lokossou T, Zoumenou E, Secka G, et al. Anesthesia in French-speaking Sub-Saharan Africa: an overview. *Acta Anaesthesiol Belg.* 2007;58:197–209.
24. Galukande M, Kaggwa S, Sekimpi P, et al. Use of surgical task shifting to scale up essential surgical services: a feasibility analysis at facility level in Uganda. *BMC Health Serv Res.* 2013;13:292.
25. Lipnick MS, Bulamba F, Ttendo S, Gelb AW. The need for a global perspective on task-sharing in Anesthesia. *Anesth Analg*. 2017;125:1049–1052.
26. Ashengo T, Skeels A, Hurwitz EJH, Thuo E, Sanghvi H. Bridging the human resource gap in surgical and anesthesia care in low-resource countries: a review of the task sharing literature. *Hum Resour Health.* 2017;15:77.
27. Zoumenou E, Chobli M, le Polain de Waroux B, Baele PL. Twenty years of collaboration between belgium and benin in training anesthesiologists for Africa. *Anesth Analg.* 2018;126:1321–1328.

28. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42:377–381.
29. van Rossum G, Python Development Team. *The Python Language Reference: Release 3.6.4*. New York, NY: 12th Media Services; 2018.
30. McKinney W. Data structures for statistical computing in python. In: van der Walt S, Millman J, eds. Proceedings of the 9th Python in Science Conference, June 28 to July 3, Austin, TX. 2010:51–56.
31. QGIS Development Team. QGIS Geographic Information System. 2018.
32. Kruk ME, Wladis A, Mbembati N, et al. Human resource and funding constraints for essential surgery in district hospitals in Africa: a retrospective cross-sectional survey. *PLoS Med.* 2010;7:e1000242.
33. Petroze RT, Nzayisenga A, Rusanganwa V, Ntakiyiruta G, Calland JF. Comprehensive national analysis of emergency and essential surgical capacity in Rwanda. *Br J Surg.* 2012;99:436–443.
34. Enright A. Anesthesia training in Rwanda. *Can J Anesth.* 2007;54:935–939.
35. Nyamtema AS, Pemba SK, Mbaruku G, Rutasha FD, van Roosmalen J. Tanzanian lessons in using non-physician clinicians to scale up comprehensive emergency obstetric care in remote and rural areas. *Hum Resour Health.* 2011;9:28.
36. Abounasr A, Lipnick M, Gelb A, Delagnes E, Lilaonitkul M, Law T. Heterogeneity in anesthesia practice models worldwide: a descriptive review of 11 high-income countries. Presented at the: American Society of Anesthesiologists Meeting, 2018; San Francisco, California.