A Model for Training Biomedical Equipment Technicians in Low-Resource Settings
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Table of Contents

MESSAGE FROM MARY LOGAN, PRESIDENT OF AAMI AND THE AAMI FOUNDATION .............................................. 2
MESSAGE FROM THE AUTHOR ON PERSPECTIVE AND INTENTION ........................................................................ 3
DISCLAIMER .................................................................................................................................................................. 4
SUGGESTED CITATION .................................................................................................................................................. 4
EXECUTIVE SUMMARY ................................................................................................................................................ 5
OVERVIEW ..................................................................................................................................................................... 7
INTRODUCTION .......................................................................................................................................................... 7
BACKGROUND: STATUS OF GLOBAL BIOMEDICAL EQUIPMENT TECHNICIAN TRAINING ......................................... 9
THE BIOMEDICAL EQUIPMENT TECHNICIAN ECOSYSTEM ..................................................................................... 9
STAKEHOLDER FEEDBACK ON STUDENTS, TRAINERS, AND GRADUATES .............................................................. 12
CURRENT AND DESIRED STATE OF BIOMEDICAL EQUIPMENT TRAINING .................................................................. 14
ZAMBIA AND RWANDA SITE VISIT OVERVIEWS .................................................................................................... 17
RECOMMENDATIONS: BIOMEDICAL EQUIPMENT TECHNICIAN TRAINING MODEL .................................................. 19
TRAINING PROGRAMS ................................................................................................................................................ 20
BIOメディカル EQUIPMENT TECHNICIAN COMPETENCIES .................................................................................. 21
CORE CURRICULUM .................................................................................................................................................. 22
TRAINER COMPETENCIES .......................................................................................................................................... 26
STUDENT IDENTIFICATION AND RECRUITMENT ...................................................................................................... 29
CONTINUING EDUCATION AND SUPPORT .............................................................................................................. 30
CONCLUSION ............................................................................................................................................................. 31
RECOMMENDATIONS: GLOBAL CENTER OF EXCELLENCE .......................................................................................... 32
DEVELOPING THE GLOBAL CENTER OF EXCELLENCE ............................................................................................ 35
GLOBAL CENTER OF EXCELLENCE PARTICIPATION .................................................................................................. 36
RECOMMENDATIONS: FUNDING STRATEGIES .............................................................................................................. 40
FUNDING BASICS ....................................................................................................................................................... 41
FUNDING THIS INITIATIVE ............................................................................................................................................ 41
ISSUES TO BE WORKED OUT ..................................................................................................................................... 42
RECOMMENDATIONS: GCOE SCALABILITY, REPLICABILITY, & SUSTAINABILITY ....................................................... 43
LOOKING THROUGH THE LENS OF SCALABILITY ......................................................................................................... 43
LOOKING THROUGH THE LENS OF REPRODUCIBILITY, NOT REPLICABILITY ............................................................... 44
LOOKING THROUGH THE LENS OF SUSTAINABILITY .................................................................................................... 45
CLOSING: LOOKING AHEAD ........................................................................................................................................ 46
ACKNOWLEDGEMENTS ................................................................................................................................................. 49
ACRONYMS AND KEY RELATED ORGANIZATIONS .................................................................................................... 50
REFERENCE LIST ........................................................................................................................................................ 51
APPENDIX A – ABOUT GE FOUNDATION AND AAMI FOUNDATION ........................................................................... 53
APPENDIX B – ABOUT THE TEAM .................................................................................................................................. 55
APPENDIX C – SUMMARY OF KEY RECOMMENDATIONS .......................................................................................... 57
APPENDIX D – TRAINING ADULT LEARNERS ........................................................................................................... 58
APPENDIX E – FINANCING AND FUNDING ................................................................................................................ 59
APPENDIX F – 2015 STAKEHOLDER MEETING SUMMARY .......................................................................................... 63

FIGURES AND TABLES
Figure 1. Technician Training Ecosystem
Figure 2. Situation Analysis: Biomedical Equipment Technician Training System
Figure 3. Training Process for Biomedical Equipment Technicians
Figure 4. AAMI Core Competencies for the Biomedical Equipment Technicians (2013)
Figure 5. Global Center of Excellence Role Contributions
Figure 6. Center of Excellence Structure
Figure 7. Training Program Levels

Table 1. Current State of Training vs. Desired Future State
Table 2. Hypothetical Three Phase Training Model
Table 3. Medical Equipment Inventory: Comparing Prevalence of Use and Complexity of Repair
Table 4. ATD Competency Model: Specialized and General Competencies Defined
Table 5. Future Funding Options by Type
MESSAGE FROM MARY LOGAN, PRESIDENT OF AAMI AND THE AAMI FOUNDATION

This initiative, supported by a grant from the GE Foundation, for the first time shines a comprehensive spotlight on the need for trained biomedical equipment technicians (BMETs) in low-resource countries as a critical element to improving patient outcomes. While this comprehensive report and recommendations include many important points, the one that spoke to me the most was the need for a strong, compelling global call to action.

The need is not new. Appropriate training of BMETs is one of the keys to having technology that works, and that is available when and where needed, to diagnose, treat, and care for patients. Many dedicated individuals and organizations have devoted their careers and resources to “doing their part” to help bring this training, primarily from Europe and the United States, to low-resource countries. This is the first time, though, that the need has been addressed in such a comprehensive way: helping the reader to understand the current state, addressing all of the disparate challenges, and offering a clear path forward.

In highly resourced, well-developed economies, we take for granted that healthcare technology will function when we need it. We seldom stop to think about the fact that an entire profession of technology-savvy individuals – healthcare technology management (HTM) professionals – quietly works behind the scenes to ensure the proper functioning of this equipment. Their critical role in healthcare brings to mind a quote from Dr. Atul Gawande, “We’re obsessed in medicine with having great components – the best drugs, the best devices, the best specialists – but pay little attention to how to make them fit together well” (Gawande, 2010, p. 184).

A single read through this report will make it clear to a much broader audience that HTM professionals are critical partners in healthcare delivery. It is my hope that this report will also inspire that compelling, global call to action for trained BMETs and that this report becomes an action agenda.

On behalf of the AAMI Foundation, I dedicate this report to all of the individuals and organizations who have given of themselves to build these skill sets around healthcare technology in low-resource settings, one person at a time. Their passion, expertise, and humble commitment are inspiring, and they have persevered without much attention or resources. It is their voices we hear in this report, and it is their vision that should inspire us to make a commitment to do much more.

Sincerely,
Mary Logan, JD
President/CEO of AAMI and the AAMI Foundation
MESSAGE FROM THE AUTHOR ON PERSPECTIVE AND INTENTION

I am honored to author this report. In writing a report for a global audience, I believe it is important to specify the viewpoint from which one writes. I acknowledge that I am comparatively privileged – socially, economically, and politically – by virtue of where I was born, raised, educated, and live and by virtue of who I am now. Certainly, I am affected by being middle-aged, white, well-educated, and female, as well as by being professional, middle class, and born into a large working-class family in the U.S.

Social demographics (age, economic class, education, gender, race/ethnicity, religion, sexual orientation, etc.) affect how we experience and come to understand the world around us. It comprises our social location. Due, in part, to social location, we each have implicit and explicit biases and blind spots. Some of my biases or blind spots will no doubt be evident to the reader, although my goal has been to address these biases. I also recognize that some of my examples might be most typical of the U.S. and while I have tried to use generic, non-country specific language, I am sure I have failed in some instances.

Another goal has been to be as objective as possible and to hold the stakeholders’ hopes, dreams, frustrations, and challenges front of mind. At the same time, I fully recognize that objectivity exists only in the eye of the beholder. We humans are assessing and judgment-making beings and these activities occupy our minds every day. All we can hope for is enough self-awareness to lessen the impact of the biases and judgments that inevitably and regularly creep into our thoughts and language.

The data collection process has been rigorous. I spent hundreds of hours interviewing stakeholders and researching the fields of biomedical equipment engineering, training, education theory, scalability, replicability, reproducibility, sustainability, social entrepreneurism, fundraising, financing, international development, and more. I attended meetings. I conducted sites visits with the U.S. military biomedical equipment training program; the biomedical equipment department at Scripps Mercy Health, a large integrated health system in the U.S.; and with key government officials, training programs, hospitals, a clinic, NGOs, and more in Rwanda and Zambia.

This report describes what I heard from stakeholders, including their recommendations, my interpretation of those recommendations, my analysis, and my recommendations. It is not an academic research study, although I rely on some studies to make my points. I intentionally selected information and examples that I believe best represent a general picture of the current state of biomedical technician training in low-resource settings. There are many people and programs doing good and tireless work, but because this report is not a case study or an evaluation, it does not highlight individual efforts outside of the site visits.

The report is deeply rooted in my knowledge and experiences, including leading healthcare technology associations; working for state and national governments; owning and managing a business; fundraising; managing change at organizational and industry levels; organizing, planning, and leading coalitions; conducting training; and educating and advocating for healthcare technology. I am not, however, an engineer, technician, or academic. What I offer is a practical approach to a complex situation.

As you read this report, I hope you will consider your own biases and social location and how these might influence your understanding of what is presented or missing and the assumptions you or I, the author might be making. I welcome the opportunity to hear your perspective. Thank you for reading mine.

Yours respectfully,
Jackie Eder-Van Hook, PhD
DISCLAIMER

The presentation of the material, interpretations, and conclusions contained in this report are those of the authors and do not represent the views of the GE Foundation, GE, the AAMI Foundation, the Association for the Advancement of Medical Instrumentation (AAMI), their boards of directors, members, or staff.

The authors have taken all reasonable precautions to verify the information contained in this publication. However, the published material is being distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall the sponsors of this initiative or its authors be liable for damages arising from its use.

The mention of specific companies or of certain manufacturers’ products does not imply an endorsement or recommendation by the sponsors or authors, or a preference over those not mentioned.

This report in no way implies or promises resources of any kind (funding or training) will be available due to this initiative. No resources were offered or promised to any organization or setting.

The report illustrates by way of a few examples the many county-specific social and cultural factors that may hinder achieving some of the recommendations presented here. While describing these factors comprehensively in all their varied complexity is beyond the scope of this report, the authors recognize that such factors are both multiple and significant and recommends that they should be explored and taken into consideration with sensitivity on a case-by-case basis in implementing this work around the world.

While the authors believe that distance learning is a cost-effective way to provide training, it is not yet a viable training solution because the infrastructure (Internet, computer access) in low-resource settings generally does not support it, especially outside of major metropolitan areas. Training programs should utilize distance learning, where, if, and when the culture and infrastructure supports it. Additionally, the author does not mention advanced educational theories, gamification, simulation training, or virtual reality training for similar reasons, although these techniques hold great promise for education and training purposes.

Finally, there are some obvious things not discussed in this report. The report does not, for example, list or describe existing biomedical equipment technician training programs. While a number of programs were examined, most programs were not contacted or visited, nor were in-depth studies or assessments of existing programs conducted. Rather than risk omitting programs or mischaracterizing them, the author chose to omit mention of specific programs, except related to the site visits to Rwanda and Zambia.

SUGGESTED CITATION

EXECUTIVE SUMMARY

Without technology that supports the appropriate diagnosis and treatment of health conditions, patients are vulnerable to needless pain and suffering, poor health outcomes, and even death. Timely access to emergency care and the use of diagnostic and therapeutic tools reduces patient mortality. Yet much of the available equipment – between 40 percent and 70 percent – of the available equipment in low-resource settings is idle or not functional (Perry & Malkin, 2011; WHO, 2000).

The GE Foundation’s Chief Medical Officer David Barash, MD, points out that even one piece of equipment out of service is too many for any patient (Barash, 2015). A primary cause of this significant problem is a lack of skilled biomedical equipment technicians able to analyze, maintain, repair, and upgrade the equipment used to diagnose and treat patients. This problem is global, but particularly acute in low-resource settings (Eder-Van Hook, 2015).

In response to this issue, the GE Foundation and the AAMI Foundation collaborated to develop recommendations for a model to train biomedical equipment technicians in low-resource settings that is scalable, replicable, and sustainable within the next 3 to 5 years. The key goals of the initiative are to create a model that will accomplish the following:

- Train more biomedical equipment technicians overall.
- Train biomedical equipment technicians more quickly.
- Systematize ongoing professional support and development for biomedical equipment technicians.

In gathering data for this initiative, the AAMI Foundation convened a meeting of stakeholders interested in training for biomedical equipment technicians in low-resource settings. The authors conducted hundreds of hours of interviews and site visits and reviewed relevant reports and research.

The findings that emerged from this data create a call to action for governments, medicine, engineering, academia, philanthropy, NGO, and international aid and development communities to collaborate and address the critical need for trained biomedical equipment technicians in low-resource settings. This report describes the current global environment for biomedical equipment technician trainings; and makes a number of recommendations specific to training programs that address curriculum, scalability, sustainability, and funding.

Most importantly, the report calls for the creation of a virtual Global Center of Excellence (GCOE) as an overarching structure to address the needs identified by stakeholders and describes ways it would address these needs and support an acceleration of training in low-resource settings. The outcome of this study is that no one model will increase the number of biomedical equipment technicians in low-resource settings. There is too much variability in needs, readiness, and culture. However, instead of focusing at the individual training level program, this report places the focus at the community level. The proposed GCOE recommendation, or intervention, if you will, is to create an overarching structure that brings the Community together to determine the critical and flexible elements in curricula, program specifications,
trainer competencies, student expectations, and more.

Operating under the principles of collaboration, stakeholder involvement, and shared resources, a virtual GCOE would focus on four primary roles: convener, aggregator, supporter, and communicator. The Center’s responsibilities would include, among other things:

- Convening stakeholders to work through problems and approaches collaboratively.
- Aggregating and developing knowledge, including evaluations and research.
- Sharing resources and best practices.
- Offering training and providing technical assistance to training programs and trainers.
- Communicating the value and importance of the biomedical equipment technician role.
- Advocating for and raising awareness of the biomedical equipment technician profession globally.

If enacted, the future proposed in this report will offer these desired outcomes to participants.

- **Training Programs** receive technical assistance and professional support, such as networking opportunities.
- **Trainers** access training aids, continuing education, certification, and networking opportunities.
- **Students** graduate from sustained member training programs with opportunities to champion, refer, and possibly train students.
- **Graduates** access continuing education, professional support, and networking opportunities.
- **Governments, industry, and donors** have an efficient single point of contact.
- **Patients** and **clinicians** benefit from equipment that supports the diagnoses and treatments.

To achieve this envisioned future requires high levels of collaboration, a commitment to continuous improvement, as well as adequate funding, most likely from industry.

There is a clear and present opportunity to articulate the value and demonstrate the worth of biomedical equipment technicians locally and globally. The Community must roll up its sleeves and work toward these critically important goals together – collaboratively – and present the profession as an integral and important player in creating healthcare solutions, not just some “techie” in the basement.
A Model for Training Biomedical Equipment Technicians in Low-Resource Settings

OVERVIEW

Introduction

Without technology to support the appropriate diagnosis and treatment of health conditions, patients are vulnerable to needless pain and suffering, poor health outcomes, and even death. Timely access to emergency care and the use of diagnostic and therapeutic tools can reduce patient mortality. Yet, according to the World Health Organization (WHO) and others, much of the available medical equipment in low-resource countries is inoperable.

The WHO (2000) estimates that in Sub-Saharan Africa alone, as much as 70 percent of all laboratory and medical equipment is idle or out of service at any given time. Perry and Malkin (2011) estimate the number is closer to 40 percent. The wide variation is undoubtedly dependent on the setting (country, location). David Barash, MD, Chief Medical Officer at the GE Foundation points out that even one piece of equipment not in the service of patients is one piece too many (Barash, 2015). The authors conducted site visits in two countries, Rwanda and Zambia, where they met with biomedical equipment technicians, physicians, administrators, students, and faculty who estimated that the portion of inoperable equipment was as high as 50 percent. They all agreed with the challenges of inadequate numbers of biomedical technicians. A number of them strongly stated that the problems are systemic and not solved by doing more of the same. They need financial resources for sure, but they also need technical assistance, leadership training, and opportunities to share their experiences with others who are facing similar challenges, thus, enabling them to take ownership of the situation and find the solutions that will work for them. In brief discussions with six expatriate (“expat”) physicians and nurses in Rwanda and Zambia who were in country to provide medical training, all confirmed the high prevalence of inoperable medical equipment. They also affirmed the importance of this initiative.

A primary cause of the significant problem of inoperable equipment is the shortage of skilled biomedical equipment technicians who are capable of maintaining, repairing, configuring, and ensuring the safety of medical devices and equipment used to appropriately diagnose and treat patients. The shortage of technicians also means that fewer technicians are unavailable to serve in a bridge role between the technology and clinical users, helping users learn the proper use of the technology – a critical role for biomedical equipment technicians. (This report uses the normative term “biomedical equipment technician.” Similar titles include biomedical engineering technician or technologist (BMET) and biomedical equipment or engineering specialist (BES or BMES). These technicians, along with degreed engineers, are part of the “healthcare technology management” (HTM) profession.)

In response to this issue, the GE Foundation and the AAMI Foundation collaborated to identify the characteristics of and develop recommendations for a model to train biomedical equipment technicians in low-resource settings that may be scalable, replicable, and sustainable ideally within the next 3 to 5 years. The key goals of the initiative are to create a model that will accomplish the following:
• Train more biomedical equipment technicians in low-resource settings overall.
• Train biomedical equipment technicians in low-resource settings more quickly.
• Create a system of ongoing professional support and development for biomedical equipment technicians in low-resource settings.

As a part of the extensive data gathering for this initiative, the GE Foundation, the AAMI Foundation, and their team convened a meeting of stakeholders that attracted approximately 55 people from around the world, conducted multiple stakeholder interviews, made site visits in the U.S., Rwanda, and Zambia, and reviewed numerous relevant reports, articles, and research.

As the initiative progressed, it became clear that the stakeholder community needed to describe and document the current global environment for biomedical equipment technicians and share perspectives and experiences. Each stakeholder seemed to have a unique understanding of a particular aspect of the system. For example, one person might understand the student cycle (identification, recruitment, training, support, development, and graduation), while another person may understand the intricacies of public policy and regulations. Rarely did participants exhibit a systemic understanding of the entire biomedical equipment technician training ecosystem, although given its complexity, the lack of a comprehensive view is unsurprising. Therefore, identifying the range of stakeholders and articulating their varied needs and requirements became a critical aspect of the initiative.

From conversations with stakeholders (meeting participants and interviewees), the need to develop a vision became clear. The vision needed to highlight a realistic, adaptable, and sustainable training model that builds biomedical equipment technician capacity; creates shared responsibilities on the clinical care team; and, ultimately, improves patient outcomes in low-resource settings. Meeting stakeholders reviewed and accepted the initial vision and identified critical elements necessary to strengthen the existing system. A new vision based on the site visits and additional input was developed. The recommendations made in this report build on key elements of this feedback.

**VISION (Revised)**

By engaging a community of concerned stakeholders, we create a model for training quality biomedical equipment technicians for employment in low-resource settings around the world that is scalable, reproducible, sustainable, and respectful of the diversity of local goals, needs, culture, and history.

Biomedical equipment technicians in low-resource settings have access to a system of ongoing professional training and development that fosters an environment where they are respected members of the clinical care team and hospital staff. Through ongoing support, technicians learn how to access training, equipment, parts, tools, test equipment, consumables, accessories, information, and other resources necessary to affect patient outcomes positively.

Stakeholders recognize the need to bring order to a fragmented and decentralized training environment that is currently operating with severely limited resources. This report describes the current state of biomedical equipment technician training and contributing factors. It also proposes a model true to the vision and recommendations suggested by stakeholders to address challenges described herein. Finally, it serves as a call for global collaboration among stakeholders to address the critical need for trained biomedical equipment technicians in low-resource settings.

Information about the GE Foundation, the AAMI Foundation, and their team is included in Appendixes A and B. A list of key recommendations is found in Appendix C. Information about training adult learners appears in Appendix D and financing and funding in Appendix E. The summary of the 2015 stakeholder meeting is provided in Appendix F. A list of acronyms and key organizations is included.
Background: Status of Global Biomedical Equipment Technician Training

Achievements in biomedical equipment technician training in low-resource settings have occurred through the dedication, creativity, and resilience of small groups of people, organizations, and donors scattered around the globe. If the present initiative accomplishes more, it will be, as Sir Isaac Newton said, because we are “standing on the shoulders of giants.” This initiative builds on the noteworthy accomplishments of many people and programs working tirelessly to meet of low-resource settings.

This section summarizes the general findings from the 2015 stakeholder meeting, extensive interviews conducted to learn about current biomedical equipment technician training in low-resource settings, and site visits. Interviews were held with biomedical equipment technicians, trainers, and individuals from the academic, government, NGO, military, association, and private sectors. The stakeholders described the students; trainers; employment; working conditions; the biomedical equipment technical roles; continuing education; professional associations; procurement processes; laws and regulations; budgeting processes; political, economic, and social environments; historical realities; and cultural considerations.

The Biomedical Equipment Technician Ecosystem

It is difficult to talk about biomedical equipment technician training in low-resource settings without considering the context in which individuals are trained. The ecosystem system in which the technicians are trained and operate is complex and includes the key elements of national will and commitment; social, political, and economic stability; individual character and leadership qualities; education infrastructure; procurement policies and procedures; voluntary professional associations, and national and local history and culture (Figure 1).

National Will and Commitment:
Training programs operate within countries and, therefore, affected significantly by the national will and the commitment of governments. Around the world governments are awakening to the shortage of biomedical equipment technicians necessary to keep critical equipment functioning and the importance of addressing these shortages. The WHO also recognized this need and added it to its plan for low-resource countries. National commitment often comes first in the form of health plans at the national and provincial levels. Many countries are trying to follow through on their plans with funding for training programs and jobs. National will and commitment is necessary in order for training programs to succeed.

Social, Political, and Economic Stability: Without a relative degree of social, political, and economic stability, training programs are unlikely to thrive or, in some instances, survive. In extreme cases like the 1994 Rwandan genocide, social upheaval can completely disrupt a functioning society for decades. More
commonly unstable economic periods, like the one currently confronting Zambia, results in a weakened economy that hinders the ability of governments to fund training and employment programs.

**Individual Character and Leadership Qualities:** The probability that the technicians will succeed is affected by their countries’ national and local histories, values, and customs – and how they were trained, who trained them, and under what circumstances the training occurred. The expectations placed on students by faculty, programs, governments, partners, and employers, whether demanding excellence or adopting more a passive approach also has an impact. However, much of their success will hinge on the attitudes and behaviors students bring to school and work (openness, conscientiousness, extraversion, agreeableness, initiative). The styles of leadership they exhibit (charisma, innovative, servant, control, or laissez faire) also make a difference. Further the technicians’ own goals and underlying expectations of their professional lives post-graduation play a role, for example, do their goals relate to achievement, learning, conformity, power/status, security, or a genuine desire to help others. Finally, they will be affected by the level of support they receive from administrators (resources, tools, space, parts, test equipment, leadership access, networking, and training) and colleagues (respect, knowledge, mentoring).

**Education Infrastructure:** Trained biomedical equipment technicians are relatively new in low-resource settings. Historically, technicians received on-the-job training from manufacturers and in NGO-sponsored courses. Today, more academically oriented programs are available, but the volume of students graduating is inadequate to address the number of technicians needed. Rwanda and Zambia, for instance, are trying to close this gap by creating training programs housed in existing technical, vocational education and training institutions that are already preparing graduates to work in clinical environments, academic institutions, government agencies, NGOs, and private sector companies. Training programs work with government ministries (health, education, labor, finance) as necessary to determine the number of graduates needed and in what timeframe. The training programs provide a variety of educational opportunities (diploma, certificate, and BSc).

A critical challenge facing these training programs is the availability of an adequate number of qualified instructors to teach both theoretical courses (mechanical and electrical engineering, anatomy, physiology), as well as to provide hands-on experience in maintenance, repair, troubleshooting, and calibration. These instructors must meet nationally or locally specified requirements, such as being educated at one level higher than the students they teach and possess teaching and hands-on experience. This requirement is a challenge generally, given the newness of the field and training programs and historic availability of jobs (or lack thereof) as a biomedical equipment technician. Further investigation demonstrates that a lack of qualified trainers is central to the inability of training programs to train more students. Without well-trained and experienced biomedical equipment technicians with the capacity to teach, the programs are stymied in their ability to grow and produce more technicians.

**Procurement Policies and Procedures:** National procurement policies and budgeting can either enable or stifle productivity. Unfortunately, in many low-resource countries, the latter seems true. Perhaps the most frustrating aspect of the biomedical equipment technician ecology is the difficulty in acquiring parts, test equipment, and tools. Repeatedly, stakeholders described the delays in acquisition, as well as high costs (shipping, fees) on topic of acquisition costs. In establishing stringent procurement policies, low-resource countries are trying to do the right things – reduce waste, eliminate corruption, enhance accountability, and support local businesses. However, as they try to address these larger societal problems, they frequently establish procurement processes that make acquisition a lengthy and costly process. In some places, it may take more than a year to get a battery for a patient monitor or a tube for an x-ray machine. In one country, the national legislative body approves each equipment and supply purchase. In another, a pharmacist must approve all medical purchases, including medical devices.
Inoperable medical equipment is frustrating for clinicians, administrators, and technicians alike. The technicians may know where to find parts but be unable to acquire the necessary items because of lengthy budget cycles, convoluted approval processes, lack of credit cards or payment systems for foreign transactions, funding availability and authority, tendering requirements, or mandatory use of in-country parts distributors, many of whom do not specialize in medical parts.

A related factor in this ecosystem is the plethora of donated equipment, some of which is new and comes with a service contract; sometimes the equipment arrives broken; and at other times, the equipment breaks soon after arrival. When the equipment does function upon arrival, much of it does not arrive with user and service manuals, preventive maintenance kits, consumables, and rarely with spare parts, specialized tools, or test equipment. So even if the country has a cadre of fully trained biomedical equipment technicians, the equipment is doomed to fail, because the system as a whole is not functioning efficiently. At a minimum, a set of fully vetted and enforced medical equipment donation standards would help.

Voluntary Associations: A bright spot in the ecosystem is that as more biomedical equipment technicians are trained in low-resource countries, more biomedical associations are springing up. Voluntary professional associations, while common in the developed world, especially in the U.S., are a relatively new phenomenon in low-resource countries. These nascent organizations have the potential to support training for biomedical equipment technicians and their career paths. Associations can convene individuals and provide professional support through networking, relationship development, leadership development, and recognition. Associations also communicate information to their members, government, industry, public, and other interested stakeholders through meetings and publications. They educate others through a variety of strategies that may result in advocacy and/or collective action.

History and Culture: Compounding the shortage of qualified instructors is the history of a place itself. Many of these low-resource settings are “new countries,” even though they may have existed as people for centuries. Zambia, for example, achieved its independence just 51 years ago. Rwanda has had to rebuild itself following the tragic 1994 genocide that saw the decimation and displacement of more than 2 million people out of a population of 7 million (Kigali Genocide Memorial) and the destruction of the socio-political infrastructure. The 2012 Rwandan census confirmed the youthfulness of the population with a mean age of 22.7 years. Of the total resident population, only 4.9 percent is over the age of 60.

At the macro level, the role of the biomedical equipment technician in low-resource settings is complex and abuts existing systems (finance, education, labor) and processes (procurement, budgeting) at the national and local levels that are at best cumbersome, but are more likely inefficient or do not work. To increase the number of trained biomedical equipment technicians requires tackling these related issues.

Inherent in the current weaknesses and desired strengths cited here are opportunities for collaboration and new and continued leadership. Together stakeholders may determine best practices, identify opportunities for innovation, build public-private-academic partnerships, and create messages that communicate the need for biomedical equipment technicians in low-resource settings. Collaboration offers incredible promise for capacity building and creating a global community of biomedical equipment technicians, healthcare technology management, and other professionals. The Global Center for Excellence recommended later in this report is designed to do just that. In the end, this report serves as both a call for action as well as a plan for action. It requires trust, commitment, collaboration, a setting aside of individual and organizational egos to achieve a higher purpose, and behavior changes at every level, clearly a tall request.
Stakeholder Feedback on Students, Trainers, and Graduates

Stakeholders described the students, trainers, and graduates as talented, bright, and motivated people from diverse backgrounds. They spoke of them with affection and admiration for their accomplishments under often-difficult conditions. Students may come from the field, where they have been working in hospital workshops or directly from school. Some students may have attended school, but their formal education may be limited, especially older students. In Rwanda and Zambia, students today are expected to graduate from secondary school, whereas students in Cambodia may only have 5-9 years of education. English may be taught in schools so students often speak some English, although they may not be fluent. At times, the authors observed extensive language challenges – some of which were clearly proficiency-related, some probably cultural, or others likely a lack of experience or discomfort answering direct questions. Stakeholders affirmed that some students are unable to comprehend oral or written technical instructions presented in English. Additionally, students may not be literate in their native languages or fluent in the local language.

Few students have technical skills, although some older students possess mechanical or similar skills from serving as motorcycle mechanics, hospital repair people, or electronics technicians outside of healthcare. Students often have very limited skills in math and computers and almost never have skills in budgeting, managing, or soft skills. They face challenges and significant pressures in attending the trainings, and yet overcome a variety of obstacles or outright challenges (lack of resources, language, literacy, family and community support, transportation, and lodging) in order to participate. One student shared the difficulty she faces leaving her three children at home in order to attend school.

Stakeholders often mentioned that the shortage of skilled local trainers is a challenge in most countries. To meet this demand, two simultaneous systems have operated. First, training programs have used “expat trainers” who fly into a country to deliver trainings and then leave. While this approach offers skilled trainers immediately, it comes at what is perceived to be a high cost (transportation and not developing local teaching talent). Simultaneously, some programs offer a train-the-trainer (TOT) course to build local capacity and overcome some shortcomings of current instructors. For example, some current trainers may lack the requisite theoretical knowledge and may not have the hands-on skills necessary to demonstrate how to repair a piece of equipment. One stakeholder described a trainer who took two class sessions to demonstrate a repair unsuccessfully, undoubtedly frustrating both the trainer and students.

The Zambian Permanent Secretary and MTI, the Rwandan agency responsible for coordinating the work of the biomedical equipment technicians, were clear in their desire that local trainers provide training to their students. At least one expat lecturer agreed. Stakeholders observed that some local trainers work in biomedical equipment training programs to gain experience and bolster their applications to become university professors, thus, reducing the number of in-country trainers. The Rwandan genocide, for example, created a situation where experienced technicians simply do not exist. An insufficient number of experienced biomedical equipment technicians translate into an inadequate number of future trainers. Instability in the trainer pool results in the need for training programs to focus continually on trainer identification and preparation, creating a direct and dramatic impact on the program’s capacity to train more students and achieve long-term sustainability.

Stakeholders also said that currently the availability of appropriate wage-paying jobs post-graduation is, at times, limited. In some cases, wages may not exceed the sums paid to a hospital repairperson, a situation that proved to be demoralizing for one Honduran graduate. There may also be no difference in pay for a trained, experienced graduate compared to someone learning on the job. In Zambia, for instance, the government has committed to hiring biomedical equipment technicians over the next five years, but
hiring is dependent on the government’s ability to fund those positions. This ability is in question, given the recent concerns about Zambia’s struggling economy.

Graduates face limited career mobility, social mobility as they desire to stay near their families, a lack of available jobs, and constrained access to training programs (general or advanced). In Rwanda there are five tertiary and 42 hospitals, often with one to two funded biomedical equipment technicians in each location. Health centers have a limited amount of equipment, and what they have is often serviced by technicians from hospitals who travel, sometimes long distances, to address centers’ needs. After gaining experience, some biomedical equipment technicians leave their institutions for better paying jobs in private facilities or NGOs, such as Red Cross, or in countries with higher wages.

In some locations, clinical facilities operate under a centralized health system that limits control by local administrators and staff. Stakeholders reported that in some instances hospital administrators may not understand the biomedical equipment technician’s role or how it contributes to clinical care and management functions. A lack of trained staff and budgetary constraints also may limit hiring. Public hospital and clinic administrators confront difficult decisions every day. Do they, for example, hire another nurse, a biomedical equipment technician, order pharmaceuticals, or purchase equipment parts or tools? Stakeholders recognize the constraints and acknowledge the trade-offs to every decision made.

Low-resource settings also require biomedical equipment technicians to improvise and be creative, often discovering their roles as they go along. It is common for a facility to have only one biomedical equipment technician on staff, two if it is lucky, even if they have approval for more. The limited number of technicians compromises facilities, their staffs (clinicians, technicians, and administrators), and patients when equipment is left idle because a technician is ill, injured, on vacation, in training, leaves for another job, retires, or is unavailable for any other reason.

In addition to bearing the stress of often being the only one in his or her role, the biomedical equipment technician may be the primary or only person onsite with any technical or mechanical skills, causing coworkers to expect the technician to perform tasks beyond managing healthcare technology (such as plumbing, HVAC repairs, and changing light bulbs). These demands place an additional burden on the technician’s time, reducing his or her availability to maintain and repair medical equipment. Of course, in under-resourced facilities, someone must perform these tasks, and it often falls to the person with the most technical skill. This development can lead to feelings of frustration and disrespect for the technician. When the biomedical equipment technician’s role is not well understood or appreciated by others, the situation is exacerbated. All of these factors undermine the technician’s ability to earn the respect of colleagues. When asked whether he and his colleagues respect biomedical equipment technicians, a physician executive at a teaching hospital replied, that, yes, the technicians can build a good rapport when the technicians possess confidence and demonstrate competence and knowledge. Thus, the end user’s confidence increases when the technician repairs the equipment properly, however, the challenge arises when a lack of parts, test equipment, or training thwarts the repair. Biomedical equipment technicians must find ways to communicate the challenges they face to end users, while simultaneously seeking and offering alternative solutions.

One of the key roles that a technician can play is training clinicians how to use a device properly. In fact, those who created the field deemed this a critical and valuable service. Many biomedical equipment technicians confessed that they were too busy to train users on equipment. Instead, they relied on visits from the manufacturer’s service representatives. Often, too, personality and culture may complicate the situation. In some societies, it is outside cultural norms for a person of one social status to direct or provide feedback to someone of another higher status. Gender differences can play a role, as well. These
difficulties may play out, for example, when the technician is uncomfortable or unwilling to provide instructions or constructive feedback on issues such as equipment usage. In such cases, the facility loses an opportunity to improve clinician behavior and the way equipment is used. In addition, clinicians’ respect for the technician may be undermined and the technician’s self-respect eroded.

Stakeholders said that biomedical equipment technicians also routinely face numerous other challenges related to their roles and maintaining the equipment. These include lack of access to service and owner manuals; shortages of equipment, parts, tools, and consumables; lack of planning and budgeting tools; and a lack of continuing professional development opportunities. They also face a myriad of basic infrastructure issues, such as irregular power and/or fresh water supplies, limited Internet and computer access, lack of a consistent supply chain, and inconsistent transportation systems.

**Current and Desired State of Biomedical Equipment Training**

Table 1 summarizes characteristics of the current and desired future states of training and post-training.

<table>
<thead>
<tr>
<th>Table 1. Current State of Training vs. Desired Future State</th>
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<tbody>
<tr>
<td><strong>Training: Current State</strong></td>
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<tr>
<td>Programs operate with <strong>limited resources</strong> (equipment and tools, funding, trainers, space, shared knowledge).</td>
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<tr>
<td><strong>Student recruitment</strong> is not systematized; focuses on the current class of students.</td>
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<tr>
<td>Committed, dedicated volunteers and/or consultants serve as <strong>instructors</strong> and in other supportive ways.</td>
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<tr>
<td><strong>Subject matter experts</strong> (SME) serve as volunteers and paid trainers (lecturers) providing practical, hands-on information, and mentor local faculty.</td>
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<tr>
<td><strong>Training of Trainers</strong> (TOT) is not systematized and there is no coordinated or long-term plan to provide a rigorous training program.</td>
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<tr>
<td><strong>Curricula</strong> is developed by trained biomedical equipment technicians and NGOs, and delivered independently.</td>
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<tr>
<td>Internships (Attachments) provide time limited opportunities for students to work and experience clinical environments. Faculty <strong>mentorship</strong> occurs primarily as part of training programs and as part of internships/attachments in clinical settings.</td>
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<tr>
<td>Some graduates have limited job opportunities. MOHs may fund positions depending on budget availability, but may not pay at an acceptable wage, may not differentiate between different skill levels and experience, or pay regularly.</td>
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<tr>
<td>Academic or training workshops (aka laboratories) are named <strong>centers of excellence</strong>, but the term is applied without qualification or consistency, thus, making the term mostly aspirational.</td>
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<tr>
<td>A small number of <strong>training programs</strong> operate in low-resource countries; some use structured clinical internships in hospitals and some are predominately theory-based. Some programs collaborate with well-known universities. In Rwanda, the IPRC partners with Duke University and its NGO counterpart, Engineering World Health. <strong>Programmatic sustainability</strong> is considered accomplished when the training program is turned over to local institutions and individuals to manage.</td>
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<tr>
<td><strong>Leadership training</strong> occurs in formal and informal settings through short-courses, workshops, distance learning courses and mentoring, although not in a systematic way. <strong>Professional associations</strong> are in a nascent stage of development and may eventually be a source of local leadership.</td>
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<tr>
<td><strong>Post-Training: Current State</strong></td>
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<tr>
<td><strong>Procurement systems and policies</strong> are complex. In part to provide checks and balances to address corruption, but are inefficient and cause prolonged delays and expense.</td>
</tr>
<tr>
<td><strong>Procuring equipment and parts</strong> is costly (shipping, transport, taxes assessed on the commercial value, doctor or pharmacist approval, fees, loss, damage) and time consuming (tendering, shipping, transport, licensing requirements, documentation, custom house processing, pre-approval procedures, port handling time, mandatory pre-shipment inspections, inspections, multi-jurisdictional approvals, border checks, security controls, certificates of conformity, customs authority acompaniment, monopolies, clearing and forwarding agents, manufacturer distribution models).</td>
</tr>
<tr>
<td>The availability of <strong>parts and specialized tools</strong> in hospitals is very limited and severely hinders the work of the biomedical equipment technician, ultimately diminishing the technician’s reputation with hospital administrators and clinical care team.</td>
</tr>
<tr>
<td><strong>Availability of test equipment</strong> is very limited and requested by biomedical equipment technicians; their ability to use the test equipment is questionable.</td>
</tr>
<tr>
<td><strong>Donated equipment</strong> is available throughout low-resource settings, but it is not standardized by make and model, age, or local needs (use, capacity to repair). Equipment may or may not be operable upon receipt. It may be damaged, lack manuals, spare parts, accessories, consumables, test equipment. Training, guarantee periods, or service contracts may not be available. MOHs and health facilities may be incapable of declining gifts for cultural or political reasons.</td>
</tr>
<tr>
<td>The availability of dedicated <strong>workshops</strong> in hospitals is very limited (space, tools, computers, test equipment).</td>
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<tr>
<td>A limited number of <strong>training program evaluation studies</strong> exists, making it difficult to know which programs should or might be reproduced or scaled. Some studies have been conducted by individuals affiliated with the training program being evaluated.</td>
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<tr>
<td><strong>Minimal research</strong> has been conducted (quantifying equipment operability in low-resource settings).</td>
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Stakeholders had much to say about the current state of biomedical equipment technician training in low-resource settings. They characterized the current training as uneven and disjointed, delivered as diploma or certificate programs, continuing education (general or specialized), or professional development offered by universities, polytechnics, technical and vocational education programs, NGOs, manufacturers, private companies, and more. Comparing the current and desired future states reflects this perspective. There is a lack of shared knowledge and experiences (curriculum, teaching methods, best practices, student materials). There is a lack of standardization or shared agreement (core curricula, teaching methods, best practices, program accreditation, and standards). There is a lack of general information and data (procurement processes, terminology, government policies and regulations, needs assessments, research). There is a lack of tools and metrics (outcomes, budgeting techniques, repair schedule, return on investment (ROI), and success measures). Siloed programs and fragmented successes prevent training programs from taking advantage of what has been learned to date, best practices, and economies of scale. This is not a sustainable approach.

Training more biomedical equipment technicians could be enhanced with a coordinated, consistent, and systemic global approach and a long-term stable funding stream for hiring faculty; recruiting and developing students; procuring equipment, materials, and facilities; securing in-country coordination; and developing and maintaining a network of training programs and trainers. Continuing to conduct and fund programs individually is unlikely to result in widespread success. A coordinated multi-stakeholder approach that includes representation from the following sectors is essential:

- Aid and Development Organizations
- Associations
- Certifying Organizations and Bodies
- Clinical Staff
- Communities
- Concerned Global Citizens
- Employers
- Funders, Donors, Investors
- Governments, Policymakers, Regulators (Ministries, Public Health)
- Healthcare Providers
- Intergovernmental Organizations (IGO)
- Local Champions and Advocates
- Manufacturers of Medical Technology
- Nongovernmental Organizations (NGO)
- Patients, Families, Consumers
- Private Sector, Corporate Foundations
- Researchers
- Students, Current and Future
- Trainers, Faculty, and Instructors
- Training Institutions and Programs
- Universities and Polytechnics

Stakeholder collaboration and coordination efforts to support, implement, and further develop a global biomedical equipment technician training model for use in low-resource settings would go a long way to alleviate many of the pressures and issues that trainers, students, and technicians face. The next section describes a recommended model.
ZAMBIA SITE VISIT OVERVIEW

In Zambia, the Ministry of Health (MOH) and the Tropical Health & Education Trust (THET), a U.K. charity, support the biomedical program at Northern Technical College (NORTEC), an engineering institution in technical and vocational training located in Ndola, Copperbelt Province. NORTEC is a self-funded institution with over 1,400 adolescent and adult students and is regulated by the Technical Education, Votional and Entrepreneurial Training Authority (TEVETA). THET's locally based staff supports the program.

Graduates of the 39-month program earn a diploma in biomedical engineering. Students are selected based on minimum entry requirements, including a Grade 12 Certificate or equivalent with a minimum of five credits in mathematics, science, or physics/chemistry, biology, English language and other subjects. Students receiving the highest marks on a national examination are admitted to the program based on availability of openings.

The first cohort in the biomedical engineering program began in September 2013 with 30 students. Two adult students who already worked in the hospital were funded by the MOH. Enrollment declined to 21 students after some self-sponsored students were unable to pay tuition, and several students were discharged for ethical issues. The school expects the first cohort to graduate in 2016. The second cohort enrolled 40 students, 10 of which are Ministry funded. There has been no attrition to the third cohort enrolled 33 students.

The biomedical engineering training program reserves 30 percent of its enrollees for the MOH; however, the Ministry’s ability to use those slots is dependent on the national budget. A recent global drop in commodity prices is expected to affect the national budget, since copper represents 80 percent of all export receipts. Drought has also affected the output of hydropower plants, causing electricity cuts of 10-14 hours a day across the country, at least one mine has closed.

Speaking to Parliament, Finance Minister Chikwanda said the only way to stabilize Zambia's currency after the Kwacha had lost fifty percent of its value by July 2015, is to grow the economy by exporting more and reducing imports (Lusaka Times). President Lungu expressed the seriousness of the situation in October and called for a national day of prayer and fasting to seek "divine intervention to save the African country's currency from a record drop” (Kissi & David, 2015).

Besides national economic stability, the biggest issue NORTEC's biomedical engineering training program faces is the availability of skilled trainers. Program administrators are working to cross-train faculty from other programs, technical engineering, and electronics, for example, and are using a small number of expat lecturers to close this gap, NORTEC recently opened a new workshop able to accommodate some 30 students.

Photos (Top to Bottom): 1) Ministry of Health: Chief Medical Equipment Officer Gilbert Mursunda; Director, Clinical Care and Diagnostic Services Dr. Kenneth Lishimpi; THET Program Staff Edward Tonkin; Permanent Secretary Dr. Peter Mwamba; GET-AAMIF Project Lead Dr. Jackie Eder-Van Hook, Assail International Ray Schmidt; and Transition Management Consulting Robert Van Hook; 2) Technical Education Vocational and Entrepreneurial Training Authority (TEVETA): Ray Schmidt, Director, Curriculum Development Orphan Hachimene; Dr. Jackie Eder-Van Hook, Director General David Chakonta, Edward Tonkin. 3) University Teaching Hospital, Student Attachment: Kapuka Kalongo, Chanda Mubanga, Chipo Siantika, Kaluba Katali, Mazuba Ngwama, Peter Magawa with Cornelius Mwape, Dr. Jackie Eder-Van Hook, Ray Schmidt, Edward Tonkin. 4) NORTEC: Dr. Jackie Eder-Van Hook and Edward Tonkin presenting a token of appreciation and support to Training Manager Mar in Kasonso and Volunteer BMET Lecturer and Coordinator Dr. Chris Mol. Not shown: Head of Department, Electrical Engineering Ezra Ng'andwe.
In Rwanda, the Integrated Polytechnic Regional Centre-Kigali (IPRC) has collaborated with Engineering World Health (EWH), Duke University, and the GE Foundation to deliver a three-year hands-on biomedical equipment technician training certificate program. The first cohort of students graduated in June 2016. EWH supports the program through a part-time, local in-country coordinator. Programmatic staff is located in the U.S.

The EWH BMET training program features a needs-based curriculum where students learn about healthcare technology management, computer skills, principles of medical device operation, and professional development. They build their equipment repair abilities through a broad base of specific skills that apply to the maintenance and repair of numerous types of biomedical equipment. Technicians attend a two-month intensive course twice per year. Classroom learning allows working students to alternate class time with hands-on practice at the hospital where they are employed. After three years and six training sessions, the students receive a certification in BMET. Courses are offered during both the day and evening.

Program demand is high because of the perceptions that jobs are available in Rwanda as four new provincial hospitals come online and that outside of Rwanda jobs exist in NGOs and mobile hospitals. MOH staff stated that they only want to hire trained biomedical equipment technicians. The government estimates that 120-150 biomedical equipment technicians are needed. Students participate in the IPRC-Kigali program through support from the Ministry of Health or self-sponsorship. Students meet minimum entry requirements, including the completion of at least nine years of basic education, a letter of completion from the former secondary school, and high marks on a national examination certificate.

The biggest issues for IPRC-Kigali program are the availability of skilled trainers, and helping students keep current on new, modern equipment. Program administrators are working to cross-train faculty from other programs such as electrical engineering, and electronics. IPRC-Kigali is about to open a state-of-the-art workshop.

The MOH Division for Medical Technology and Infrastructure (MTI) is responsible for healthcare technology management, and supervising or assisting in engineering infrastructure for health facilities in whole of Rwanda. They exist to provide support to five tertiary hospitals, 42 district hospitals, and 524 health centers.

The Rwandan Military Hospital, Kanombe currently treats both civilian (80%) and military (20%) patients. It is considered one of the fastest-growing referral hospitals in the country.

Photos (Top to Bottom, Left to Right): 1) MTI, Ministry of Health: Biomedical Engineer, International Technical Assistant RBC/MTI (BCT); Mr. Sankaran V. Narayanan, MSc; Division Manager Mr. BIRASA Jean Marie Vianney; Eng. Thiegene NAMAHUNGU; Mr. Benjin Joshua, Assis International; and other MTI staff 2) Dr. Jackie Eder-Van Hook and Dr. NDEKEZI Deogratias, Ruhengezi Hospital Director 3) Mr. Cosica Uwiringize, On-the-Ground Coordinator, BMET Rwanda, Engineering World Health; Dr. Jackie Eder-Van Hook, a former IPRC student now stationed at Kanombe; and Mr. Benjin Joshua. 4) Dr. Jackie Eder-Van Hook; Dr. Jus in Wane, Head of Treatment and Diagnostic Support Services Division, King Faisal Hospital; and Mr. Benjin Joshua.
RECOMMENDATIONS: BIOMEDICAL EQUIPMENT TECHNICIAN TRAINING MODEL

Since the goal of this initiative is to create a model for training biomedical equipment technicians in low-resource settings, it is useful to define training and education for our purpose. Training is teaching a person a particular skill or behavior to enable that person to perform better. Education is broader. It focuses on helping a person be a better thinker, problem solver, and consumer and user of information. A well-educated person can more efficiently learn to do specific tasks, among many other benefits.

This section describes training model recommendations at the training program level and addresses desired competencies of biomedical equipment technicians, curriculum, trainer competencies, student identification and recruitment, continuing education, and professional support. Ultimately, a training model needs to be adaptable, responsive to the realities of local environments, and attentive to issues of reproducibility, scalability, and sustainability. The section that follows recommends an overarching support structure for the training programs.

In order to develop a systemic approach to biomedical equipment technician training, a logic and framework are essential to informing the discussion. The Situation Analysis in Figure 2 specifies the types of investments necessary to conduct training programs, describes the activities and participants involved, and specifies the desired outcomes across three time horizons.

Figure 2. Situation Analysis: Biomedical Equipment Technician Training System
Additional conversations about future training systems should begin by convening a small advisory group of knowledgeable stakeholders (10-15 people) who come to shared agreements about required inputs, who to engage and when, what activities need to occur, and what outcomes are desired at a macro level. Based on these findings, training programs should consider how their programs compare locally, consider whether the recommended changes make sense in their settings, and answer key questions. 1) What needs or might need to change? 2) What would be the implications of those changes? 3) What resources would be required to make the changes? 4) What obstacles or barriers might or would prevent those changes from happening? 5) Who will champion and shepherd those changes? Answers to these programmatic questions will enable the development of more effective future strategies.

**Training Programs**

The process of developing a system of training has eight key steps: identify needs; assess resources; assess competencies; develop learning objectives; design training programs; assure quality; evaluate students, trainers, and programs; and, conduct programmatic improvement.

Figure 3 illustrates the elements of a training process that each program should include to ensure quality instruction and well-trained biomedical equipment technicians.
Most biomedical equipment technician training programs in low-resource countries are 3-year or longer programs because:

- Graduates will be required to maintain and repair complex and varied medical technology.
- Local educational systems often have deficiencies in preparing students for technical training.
- Curricula include a range of topics: engineering, math, anatomy, healthcare system, and sciences.
- Some students see the program as a first step towards becoming biomedical engineers.
- High national and local expectations for these programs and their graduates.

Several accomplishments are necessary in order to shorten the amount of time needed for training and to improve the quality of training. These include achieving the following outcomes:

- High-quality trainers capable of conveying both theoretical and practical materials and demonstrating techniques to adult learners
- A streamlined curriculum designed to meet the needs of students in local settings
- Training programs routinely identifying and recruiting high quality students as early as possible
- Availability of standard tools (business model, planning, finance, budgeting, marketing, funding)
- Systems for collecting and analyzing data about students, trainers, and outcomes to ensure, among other things, the appropriate allocation of resources and continuous improvement
- Programs actively engage, as a part of a biomedical equipment technician ecosystem, graduates who demonstrate programmatic success, serve as referral sources for students and jobs, and become potential future trainers, champions, and program advocates
- Commitment to the fundamental aspect of medical device use - ensuring patient health and safety.

These accomplishments are critical aspects of improving biomedical equipment technician training.

**Biomedical Equipment Technician Competencies**

Agreed-upon competencies appropriate for global technicians should guide the core curriculum. Malkin and Garst (2010) suggest an initial biomedical technician assistant (BTA) curriculum focus on five domains of knowledge: electrical, mechanical, motors, plumbing, power supply, and 115 basic skills. The first trial of the BTA curriculum is being implemented in Rwanda in partnership between the Engineering World Health, Duke University, the Rwandan Ministry of Health and the Ministry of Education, and the GE Foundation. Malkin and Garst’s data suggests, “a graduate of the BTA curriculum could return 66% of the broken medical equipment in their hospital to service independently.”

AAMI (2013) suggests ten core competencies arrayed in two areas (Figure 4): functional competencies (biomedical equipment technology, electronics, information technology, anatomy and physiology, mathematics, physics, and chemistry) and personal competencies (practical experience, professional skills, and English.)
Additional conversations about core competencies should begin by convening a small advisory group of knowledgeable stakeholders (10-15 people), including subject matter experts on competency development, who are able to agree upon a core set of competencies across a range of job classifications and environments, including low-resource settings. A training curriculum that responds to the desired core competencies should then be developed that will help ensure that students receive training in those competencies. With appropriate external funding, an organization like AAMI could convene stakeholder groups to determine, for example, the core competencies of a global biomedical equipment technician or similar professional serving at different levels in low-resource settings.

Core Curriculum

A standardized curriculum is critical to the reproducibility, scalability, and sustainability of biomedical equipment technician training. However, that does not imply a lack of flexibility or rigid adherence at the local level; rather it identifies a core curriculum that is ideal and supported by evidence.

While a few of the people and programs contacted generously shared their curricula for the purpose of this project, most did not, and some were audibly uncomfortable discussing it at all. Several stated that their curricula is proprietary and/or used as a basis for fundraising.

A lack of coordination creates substantial, unwanted variability in the quality of training worldwide. The need for standardization is urgent, as the potential for patient harm increases daily with each piece of equipment that remains idle, inadequately used, or in disrepair. The goal of training more biomedical equipment technicians is in jeopardy if programs continue to function in silos and if funders continue to provide funds, often at inadequate levels, to a variety of individual programs without the benefit of an overarching plan, a clear set of goals, and a model of service.

While recommending a specific curriculum is outside the scope of this initiative, it is clear that further conversations about creating a core curriculum for low-resource settings are critical. The process should begin by convening a small advisory group of knowledgeable stakeholders (10-15 people), which includes, at a minimum, educators, trainers, training program administrators, funders, and other key
stakeholders. The purpose of which is to collaboratively identify a core curriculum and optimal course order based on the agreed upon core competencies (as discussed above).

One potential approach might be to categorize a curriculum in three training phases: core, intensive, and ancillary, along with the articulation of key supplemental activities (internships/attachments, mentoring, site visits, and conferences). Table 2 illustrates a hypothetical three-phase curriculum model, which contains key programmatic elements considered as a training benchmark or gold standard, which would be delivered over three- to four-years, depending on access to workshops, equipment, and faculty; school schedule; and remedial work, for example.

<table>
<thead>
<tr>
<th>Table 2. Hypothetical Three-Phase Training Model</th>
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<tbody>
<tr>
<td><strong>Phase 1 – Core Courses</strong></td>
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<tr>
<td>Introduction: Algebra I</td>
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<td>Introduction: Critical Thinking</td>
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<tr>
<td>Introduction: Problem Solving</td>
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<tr>
<td>Introduction: Troubleshooting</td>
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<tr>
<td>Introduction: Medical Equipment</td>
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<tr>
<td>Introduction: Engineering</td>
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<tr>
<td>Introduction: Computer, Applications</td>
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<tr>
<td>Physics Engineering: DC/AC Circuits</td>
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<tr>
<td>Shop Practices, Tools</td>
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<tr>
<td>Preventative Maintenance, Repair</td>
</tr>
<tr>
<td>Anatomy, Physiology, Terminology</td>
</tr>
<tr>
<td>Health and Safety: Regulations, First Aid</td>
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<tr>
<td>AED, Adverse Events</td>
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<tr>
<td>Infection Prevention and Control, Decontamination</td>
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<tr>
<td>Waste Management and Equipment Decommissioning and Disposal</td>
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<tr>
<td>Maintenance Management</td>
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<tr>
<td>Ethics</td>
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<tr>
<td><strong>Phase 1 – Supplemental Activities</strong></td>
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<tr>
<td>Site Visits (Hospitals, Clinics, Service Organizations, Factories, Government)</td>
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<tr>
<td>Hospital Internships/Attachments</td>
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<tr>
<td>Hospital Inventory Assignments</td>
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<td>Be Mentored</td>
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</table>

In this hypothetical three-phase model, students progress to the next phase of more complex topics after mastering the earlier phase of training. The model contains elements similar to current curricula in use in some well developed economies and combines theory with demonstrations and practical hands-on learning. Teaching students how to maintain and repair the most common pieces of equipment might be a good first step with only the most capable students offered advanced training as they demonstrate success.

An early-stage, introductory training (Phase 1) could help programs to identify students with the greatest aptitude, interest, commitment, integrity, and likelihood of success. Exposing students to a rigorous educational environment and healthcare settings early in their training allows attrition to occur early in the program. Programmatically, there is no value in enrolling or training students who are unlikely to be successful either completing the training or serving in the technician role once trained.

Whether the application of the entire three phases of this illustrated curriculum is warranted in low-resource settings or even possible at this stage of development is questionable given the infrastructure, level of education, availability of faculty, tuition costs, and language skills. However, local training
programs (non-degree) should be supported to provide, at a minimum, the first-phase of training. Malkin and Garst (2010) recommend the creation of a biomedical technician assistant (BTA) training program that teaches 115 basic skills necessary for equipment repair. The BTA training spans two years with up to six months preparatory work in a hospital, five weeks of training, and 18 months of mentoring in a hospital. Other aspects of the illustrated curriculum might be included in bachelor degree programs.

In a dialogue about possible approaches to training more biomedical equipment technicians, a technical school training manager thought that, with adequate resources, it might be possible to create a similar program for biomedical technician assistants. While such a program might be conceivable, NGO staff familiar with similar training programs questioned the potential impact on existing training programs and biomedical equipment technicians. Would the work of the newly trained biomedical technician assistants reflect poorly on the more highly trained technicians? Would the assistants become overconfident and attempt to make repairs that they were not qualified to do (as happened in one large hospital)? Would there be a pay difference to reflect the higher level of experience?

In Zambia, NORTEC has created one-year program for 20-35 year old “out of schoolers” that provides training in several key areas (electrical engineering, mechanical engineering, welding, automotive, heavy equipment, refrigeration/air conditioning). Students alternate between one month in the classroom and three months spent in industry internships/attachments. Funded through a grant from the African Development Bank (AfDB), the program uses existing curriculum. The first cohort graduated in 2015.

Regardless of the precise approach, a preparatory curriculum would focus on training technicians how to maintain and repair the most common pieces of equipment in use, with the expectation that it would reduce the initial time devoted to theory and spend more time on repair along the lines of a technical and vocational education and training (TVET) model. Of course, the complexity of the equipment requires that biomedical equipment technicians or biomedical technician assistants understand basic engineering theory (e.g., fluid mechanics), physics, and anatomy, among some things. Such an approach would deliver education and training aimed at equipping people with the required knowledge, skills, and/or competencies to perform specific basic repairs as quickly as possible.

Along these lines, AAMI (2015) has developed a set of standardized online job descriptions1 for entry-level through senior technical positions for use or modification by healthcare institutions. Each description addresses education, public safety and regulatory requirements, equipment experience, and customer service expectations. For example, the job classification for an entry-level position, “Healthcare Engineering Technician I” (HET I, commonly referred to as BMET I) is for an individual with minimal experience in a clinical environment. In this role, the technician maintains clinical equipment through the effective use of the Medical Equipment Management Plan2 and performs a variety of routine tasks associated with the installation, maintenance, calibration, and repair of a limited scope of biomedical equipment under the guidance and direct supervision of an experienced healthcare technology management (HTM) professional. The model position description specifies that an incumbent possesses or demonstrates the following basic competencies:

- Basic knowledge of the position or function with supervision or mentoring
- An ability to learn from others on the job and to teach some basic skills to new hires or interns
- Basic understanding and skills related to general electromechanical systems and devices

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2 A Medical Equipment Management Plan defines the mechanisms for interaction and oversight of the medical equipment used in the diagnosis, treatment, and monitoring of patients. Governing documents (policies and procedures) specify the process and procedures for the selection, acquisition, incoming inspection, and maintenance of medical equipment.
• Basic understanding and ability to communicate the use of supported devices
• Basic support of acuity equipment for direct patient care
• Familiarity with the operations and environment that is supported (hospital, clinic, etc.)
• Basic understanding of clinical equipment, radiological, laboratory and network medical systems
• Basic understanding of both local and national public safety and regulatory issues
• Basic knowledge of front-line customer service issues
• Basic understanding of project management terms and methods.

A preparatory curriculum might focus on the most common and least complex equipment to repair, applying logic similar to that behind the HET I (BMET I) position. For example, an in-house technician is the ideal choice to repair equipment that is in widespread use and easy to repair. For equipment that is limited in use or difficult to repair, a more senior technician, if available, would be a better choice. If one were not available, a manufacturer’s service organization, authorized service agent, or third-party service provider would be appropriate, depending upon available resources.

Table 3 categorizes equipment based on the frequency of use (prevalence) and the complexity of the repair. It is intended to be illustrative given the more than 10,000 types and 1.5 million pieces of medical equipment available today (WHO, 2011a). Other frameworks could serve to specify the types of devices that a new technician could reasonably be expected to repair. One example is the U.S. Food and Drug Administration’s (FDA) classification system for medical devices. The FDA classifies devices based on the intended use, the risk the device poses to the patient, and the level of regulatory control required by the FDA. It assigns them to one of three categories, Class I, Class II, and Class III, based on design, history of safe use, complexity, and potential for harm (and degree of harm) to the patient.

The available equipment will vary by type of health facility (hospital, primary, secondary, and tertiary; health centers, provincial, district), public health needs, burden of disease, and burden of injury. The age of the equipment will affect the determination, as newer equipment is typically more complex to repair. Technicians with basic training should be able to check the proper operation on some of the “difficult to repair” devices. Some pieces of equipment will require a technician to possess a high attention to detail.

<table>
<thead>
<tr>
<th>Complexity of Repair</th>
<th>Prevalence of Use</th>
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<tbody>
<tr>
<td></td>
<td>Widespread Use</td>
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<tr>
<td>Not Difficult to</td>
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<tr>
<td>Repair</td>
<td>Balance</td>
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<td></td>
<td>Bil-lights</td>
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<td>Blood pressure</td>
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<td>cuffs</td>
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<td>Centrifuges</td>
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<td>CPAP</td>
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<td></td>
<td>Dental unit</td>
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<td>Electrocardiogram</td>
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<td>Electrosurgical</td>
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<td></td>
<td>unit</td>
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<tr>
<td></td>
<td>Exam tables &amp;</td>
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<tr>
<td></td>
<td>chairs</td>
</tr>
<tr>
<td></td>
<td>Fetoscope (manual)</td>
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<tr>
<td></td>
<td>Hospital beds</td>
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<tr>
<td></td>
<td>Humidifiers</td>
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<tr>
<td></td>
<td>Infant incubators</td>
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<td>Infant warmers</td>
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3 This table is focused on equipment used in low-resource settings and was created with the help and support of both biomedical equipment technicians and clinical engineers. It should serve as a starting point for discussions of a technical advisory team who discuss the merit of the approach and classify the equipment after ample consideration.
Overall, a standardized curriculum should include sufficient flexibility to accommodate country-specific variations, including equipment and resource availability and public and population health issues, and it should allow the programs to focus on the most practical and needed information. An evidenced-based curriculum, as noted above, should be based on the core competencies, such as the ones identified by AAMI (2013). Further, instructional design and evaluation principles should guide curriculum development. Instructional design provides the philosophical framework that underpins the theory base and instructional specifications (policies and procedures) ensuring the quality of the instruction (Smith & Ragan, 1999). Evaluation principles allow students and trainers to demonstrate their proficiency in each instructional area through routine assessments.

It is critical to identify and process promising students upfront when the training resource and collective commitment is small. This preparatory approach addresses the goal of exposing students to the realities of the job as quickly as possible, including performing preventive maintenance, repairs, or troubleshooting on tight schedules, for instance. It would significantly reduce the amount of training time necessary to provide a set of skills that will put students in a medical environment to begin experiencing the psychological stress of repairing equipment on which a patient’s life may depend. Students will experience the sights, sounds, and smells of a clinical setting (Wear, 2004). They also will experience working with clinicians under stress and a need to interact with people and not just the equipment. If they are lucky, they will observe or gain experience serving as a bridge between clinicians and the technology. Those who have good communication skills serve in this more advanced role add considerable value to the profession overall. Some students will find the environment uncomfortable. The sooner students understand those realities, the sooner they will embrace the job fully or opt out. Only motivated students with the aptitude, dexterity for the work, and ability to manage the stress would receive advanced training, such as the curriculum described in the second and third phases of Table 2.

Trainer Competencies

No curriculum for training biomedical equipment technicians can be successful without competent trainers. To date, there is no shared agreement about what defines a competent trainer.

The Association for Talent Development (ATD, formerly ASTD) published a competency model (2014) that describes the skills and knowledge required for training and development professionals to be successful (Table 4). The complete model: 1) defines the competencies needed for success across all training and development efforts; 2) provides a professional development roadmap for training and development (T&D) leaders and practitioners; and 3) identifies gaps in skills and suggests ways to close the gaps.
The model emphasizes both foundational competencies (important to everyone in the field), namely, business skills, global mindset, industry knowledge, interpersonal skills, personal skills, and technology literacy. It also emphasizes specific areas of expertise (specialized knowledge and actions required by specific roles), including instructional design, training delivery, learning technologies, evaluating learning impact, managing learning programs, integrated talent management, coaching, knowledge management, change management, and performance improvement. ATD evaluates proficiency in each competency as 1) no to little proficiency, 2) limited proficiency, 3) consistent proficiency, 4) advanced proficiency, and 5) exceptional proficiency; and it identifies ways to fill any competency gaps. A trainer with exceptional proficiency will master both expertise and foundational competencies.

<table>
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<tr>
<th>Table 4. ATD Competency Model: Specialized and General Competencies Defined</th>
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<tbody>
<tr>
<td>Training &amp; Development Areas of Expertise (Specialized)</td>
</tr>
<tr>
<td>Instructional Design                                         Design and develop informal and formal learning content using various methods</td>
</tr>
<tr>
<td>Training Delivery                                            Deliver formal and informal learning solutions that are engaging and effective</td>
</tr>
<tr>
<td>Learning Technologies                                        Apply various learning technologies to address learning and performance needs</td>
</tr>
<tr>
<td>Evaluating Learning                                          Measure learning and performance solution impact</td>
</tr>
<tr>
<td>Managing Programs                                            Lead and execute learning strategy and implement projects and activities</td>
</tr>
<tr>
<td>Integrated Talent Management                                 Build an organization’s culture, capability, capacity, and engagement through talent acquisition and employee development</td>
</tr>
<tr>
<td>Coaching                                                     Apply a systematic process to maximize goal setting, actions, and strengths</td>
</tr>
<tr>
<td>Knowledge Management                                         Capture, distribute, and archive intellectual capital for sharing and collaboration</td>
</tr>
<tr>
<td>Change Management                                            Apply a systematic process to shift people/organizations from current to desired state</td>
</tr>
<tr>
<td>Performance Improvement                                      Apply a systematic process for analyzing and closing human performance gaps</td>
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<th>Foundational Competencies (General)</th>
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<tbody>
<tr>
<td>Business Skills                                              Demonstrate business understanding and drive business results and outcomes</td>
</tr>
<tr>
<td>Global Mindset                                               Work effectively with people across boundaries, cultures, and generations</td>
</tr>
<tr>
<td>Industry Knowledge                                           Maintain knowledge of relevant industries and industry segments</td>
</tr>
<tr>
<td>Interpersonal Skills                                         Interact with others in a way that builds influence and trust</td>
</tr>
<tr>
<td>Personal Skills                                              Demonstrate adaptability and continuous learning</td>
</tr>
<tr>
<td>T&amp;D Technology Literacy                                      Demonstrate awareness and proficiency using existing and emerging technologies</td>
</tr>
</tbody>
</table>

It is typical for an entry-level instructor in adult education to have earned a bachelor’s degree or equivalent with at least one year of experience in a professional training position. A master’s degree in education, adult education, communication, or related field is often preferred. Additional requirements for education and/or certification may be required based on subject matter, programmatic goals, student population, contracts, or grants. In Rwanda and Zambia, for instance, instructors are required to hold one degree higher than the students they are teaching. Achieving this requirement can be problematic, given that the field has historically relied on-the-job training as its preferred training method.

Specifically, a proficient adult education instructor possesses effective written and oral communication skills enabling him or her to create and facilitate workshops, training sessions, and training materials, including the ability to translate theoretical/conceptual information into clear and easily understood terminology and practical application. The instructor has knowledge of adult learning theory (Appendix D), training and facilitation techniques, instructional design methods, and specific subject matter expertise. Instructors also may be required to perform administrative tasks (scheduling, recordkeeping).

It appears that many, and perhaps most, of the biomedical equipment technician trainers delivering services for NGOs and corporations are trained technicians, but not necessarily trained to serve as trainers. Some have college degrees, while others do not. These individuals appear to be skilled technicians able to communicate technical information. There is no data to confirm or even suggest that
they are knowledgeable about training modalities or instructional design, however. This situation is a significant deficiency in the current training models.

At a minimum, trainers should demonstrate mastery of the competencies included in the ATD Model:

- Possess instructional design skills and the ability to design and develop formal and informal learning content using various methods, including conducting needs assessments; applying learning theory; designing a curriculum, program, or learning solution, and instructional materials; and evaluating learning design.
- Deliver engaging and effective formal and informal learning solutions, including aligning learning solutions with course objectives and learner needs; creating a positive learning climate; delivering content using various learning methodologies; facilitating learning; encouraging participation; building learner motivation; and delivering constructive feedback.
- Apply various learning technologies to address learning and performance needs, including applying technology effectively across the different areas of expertise and identifying when and how to use technology as a training and development solution.
- Use learning metrics and analytics to measure the impact of learning solutions, including selecting appropriate strategies, research design, and measures; communicating and garnering support for evaluation plans; managing data collections; analyzing and interpreting data; applying learning analytics; and recommending solutions to aid decisionmaking.
- Apply continuous process improvement to course design and content.

Additionally, trainers delivering content in low-resource settings should possess general expertise, and especially an open-minded and global mindset, the ability to accommodate cultural differences, convey respect for different perspectives and demographics (age, class, gender, race/ethnicity), expand their own awareness, risk taking, adapt their behaviors to accommodate others, collaborate across cultures, and serve as a champion for diversity and inclusion. These competencies require a deep level of self-awareness and courage.

Ideally, Trainer-the-Trainer programs will develop and support trainers regionally or nationally. The objectives of which will, at a minimum, include the creating effective training programs; elements of training success; training methods to reach a variety of learners; techniques to maximize understanding and retention; encourage practice and feedback; engage in supportive training techniques; assessment; training technologies; and use of training exercises.

With a modest amount of resources, any number of possible programs or products could be collected, developed, and piloted to support trainers. These trainer aids could include job descriptions, training, certification, and career paths. Training aids could include demonstration and facilitation techniques, training technologies, descriptions of errors inserted into equipment trainers for students to analyze and correct (when equipment trainers are available), mnemonics/memory aids, assessments, trainer notes, PowerPoint presentations, collections of relevant articles, other print or electronic materials, and videos. Flashcards with images and text both in English and the local languages could help students learn English words, pronunciations, equipment names and purpose, processes (testing, troubleshooting, and critical thinking prompts), anatomy, and other topics. Additional aids might include providing access to new or existing smartphone/tablet apps, such as Duolingo, a foreign language-training app; Google Translate, a foreign language translation app; or games similar to Transmission that teaches players how to connect transmitters and receivers and send information through increasingly complex networks.
Capacity building in low-resource settings includes critical training of trainers to serve the local population. Where there is a lack of local trainers, and this is a challenge in many settings, a regional Train-the-Trainer approach should be considered and used in conjunction with expat trainers. A database of names, contact information, training evaluations, and a summary of work experience (training and practical) should be maintain in a central repository. In time, however, the goal is that local trainers deliver courses to students locally. It was clear from the Rwandan and Zambian site visits that there is a high desire for more well-trained trainers with high levels of competence and relevant college degrees. Given the need for trainers in many places to have earned a degree one level higher than the students they are teaching, support, ultimately, will be needed for degree programs at the bachelor’s level and higher. Realistically, the ability to increase the number of skilled trainers substantially will take time.

**Student Identification and Recruitment**

Training programs, ministries of health, or other appropriate entities should work together to determine the appropriate number of students to be trained. In part, training and staff budgets, patient census statistics, student attrition rates, and patient demographics (age, gender, health conditions, life expectancy, poverty, etc.) will factor in to the calculations. In the U.S. military, for example, the Defense Health Agency sets the quotas for the tri-service biomedical equipment technician training program based on anticipated missions. It supplements mission numbers with an analysis of the equipment maintenance and replacement schedule per facility, training program attrition, and anticipated personnel separations.

Wear (2004) suggested that facilities calculate the total dollar value of the equipment and the total number of pieces of equipment to determine training needs. This formula might work for facilities located in high-resource economies; however, facilities in low-resource settings that receive large amounts of donated equipment with high rates of inoperability may need to modify it. The WHO (2011c) offers an inventory-based procedure for calculating workload. Given the medical equipment donation model used throughout low-resource settings, a lack of data about technician workload, and a lack of inventory lists, it may be difficult initially to establish accurate training quotas. As more data is gathered and analyzed, the formula or numbers should continue to be refined. To do otherwise, to simply train as many people as possible, is likely be counter-productive to the healthcare system. At a minimum, a facility needs at least two technicians on staff at all times to accommodate illness, injuries, vacations, training, and attrition.

Identifying high quality student candidates requires a rigorous assessment. Programs should assess potential students for mechanical aptitude, manual dexterity, ethics, personality, attitude, and interest along with basic skills, such as English, literacy, and mathematics. By examining age, education level, experience, and life circumstances of successful students, training program directors can create a profile of the prototypical successful student. While this effort would provide a sense of the types of students who have succeeded, it, of course, would not be predictive. The difficulty of finding the right mix of students will vary by country based on literacy rates, program funding, training accessibility, job prospects, compensation, retention, and government placement strategies, to name a few.

The lack of shared content is a considerable challenge that needs to be resolved, regardless of the intended use or platform (paper/pen, telephones, pads, laptops, desktop computers, or whatever technology comes next). Stakeholders should continue to think creatively about how to collect and deliver content in appropriate formats for low-resource settings with the goal of creating a long-term strategy that enables the deployment of solutions as quickly as possible. While schools in low-resource settings today experience challenges in acquiring textbooks, the proliferation of technology and access to the Internet may make that challenge less critical. Access to the Internet is increasingly available at centralized points (libraries, schools) or at low-cost hotspots (Royston, Hagar, Long, McMahon, Pakenham-Walsh,
Wadhwani, and others, 2015). Google is experimenting with the use of solar-powered drones sent aloft for up to five years and designed to deliver Internet access to customers (Depra, 2015). Mobile phones that can access the Internet are becoming more prevalent and affordable. The cost of computing is on the decline. Raspberry Pi, a low cost, credit-card sized computer that plugs into a computer monitor or TV and uses a standard keyboard and mouse enables users to explore computing and programming. It is capable of browsing the Internet, playing high-definition video, word processing, creating spreadsheets, and playing games. A base level model costs $35 (https://www.raspberrypi.org/).

Along these lines, device and equipment manufacturers should be convened to strategize on how best to get service and operator manuals to the technicians and clinicians who need them, particularly for equipment they no longer service.

At the same time, a set of strategies for developing a student pipeline is essential for future programmatic stability and sustainability. A systematic and consistent student and trainer recruitment and enrollment process will allow training programs to manage budgets and workloads to keep trainers employed and engaged. A pipeline should focus beyond the immediate need of the next entering class to include medium- and long-term needs. It is not too early to begin developing interest and identifying qualified students who might enter the program in 3 to 5 years from now or even later.

In the U.S., associations and educational institutions are beginning to invest resources in future students beginning as early as primary schools. Training programs in low-resource settings might consider holding open houses to highlight their programs and familiarize potential future students and government officials with tools, terms, needs, and outcomes. For students with a potential aptitude and interest in biomedical equipment technician training, early English language training, and communication skills, mathematical skills, critical thinking, problem-solving, and computer skills is valuable. Stakeholders should work with their Ministry of Education to assure that students receive an adequate basic education, since providing basic education is not the responsibility of training programs.

With a modest amount of resources, any number of possible programs or products (games, flashcards, workbooks, books, playing cards, smartphone apps, computer programs, videos, or training kits like the commercially available Snap Circuit Jr.®) could be used to teach English names and purpose of tools and equipment. Pilot programs could teach basic electronic circuitry to children and youth. It is not too early to begin exposing younger students to a potential career as a biomedical equipment technician.

**Continuing Education and Support**

Professional development, whether through continuing education or associations can provide training and foster learning, but associations are uniquely poised to develop leadership, share and develop knowledge, build and expand community, and provide education and advocacy. Many low-resourced countries do not have a history of association or civil society development, although South Africa has a fairly well-organized association. Recently, biomedical equipment technician-related associations have been initiated in several locations in Africa and other low-resource settings. There are discussions of developing an East Africa BMET Association. These associations have the potential to coalesce the power of the growing biomedical equipment technician numbers into a force for continuing education, support, and advocacy within their countries and regions and to overcome obstacles to technician training, distribution, and practice. Locally, associations are more likely to affect positively constraining conditions.

- **Learning** – provides opportunities to engage in professional development activities online or in person, synchronously or asynchronously, and demonstrate proficiency through certifications.
• **Leadership Development** – allows members to develop leadership capabilities by serving in governance roles, presenting, providing subject matter expertise, and mentoring.

• **Knowledge** – disseminates information and knowledge developed or procured by the association, including publications, research, or websites on topics of interest to the members.

• **Community** – provides opportunities to interact and share ideas through online forums, social media, and conferences/conventions to enhance the profession and professional networks.

• **Education and Advocacy** – provides opportunities to educate or influence policymakers, legislation, and regulations that support the work of their members.

Following a meeting of African biomedical equipment technicians, AAMI’s Mary Logan stated there is a hunger for leadership development in low-resource settings (personal communication, Nov. 3, 2015).

We take for granted the bottomless well of resources at our disposal in North America and Europe for learning how to be leaders, from the time we are children throughout our careers. We have role models, books, videos, training, and practical opportunities to try our hand at leadership. But leadership development is a scarce commodity in Africa, and there is a deep need for it. These folks have great ideas and a passion for improving healthcare. They lack the knowledge and skills to know how to turn the ideas into action, and they lack the infrastructure support to implement action plans. They long for leadership development opportunities.

With adequate funding, an organization like AAMI could offer a continuing education package that might include subscriptions, newsletters, training materials, a calendar of events, leadership development materials, certification information and preparatory materials, and association management materials targeted toward low-resource settings.

**Conclusion**

This report has identified the need for a coherent training model, the need to develop a consistent training curriculum, the necessity of defining trainer competencies, the importance of student identification and recruitment, the importance of building a student pipeline, and the ongoing need for continuing education and support. Many, if not all, of these needs would best be addressed collaboratively within the global training community.

**KEY RECOMMENDATIONS:**

1. Develop a system for training program: identify needs; assess resources; assess competencies; develop learning objectives; design training programs; assure quality; evaluate students, trainers, and programs; and, conduct programmatic improvement.

2. Develop a consistent training curriculum.

3. Define trainer competencies.

4. Define a student pipeline that includes the identification and recruitment of students.

5. Identify gaps in continuing education and support and ways to fill those gaps.
RECOMMENDATIONS: GLOBAL CENTER OF EXCELLENCE

This section puts forward recommendations for the creation of a virtual global organization that provides an overarching leadership structure and addresses the needs related to key elements of training programs, including curriculum, trainers, students, facilities, and funders. The global structure needs to be collaborative, adaptable, responsive to the realities of both local environments and global standards, as well as attentive to issues of scalability, reproducibility, and sustainability.

To that end, this report recommends the creation of a Global Center of Excellence for Healthcare Technology Management (HTM), which would operate primarily virtually to promote cross-functional collaboration, coordination, integration, and efficiency. The Global Center of Excellence (GCOE) would implement many of the recommendations in this report. As the GCOE does its work, it would raise the profile of the biomedical equipment technician profession and related issues and be used strategically to engage stakeholders, funders, and policymakers in discussions about investment, innovation, and long-term sustainability. It also would serve as a focal point for change by identifying, developing, and connecting strong champions and networks of champions and experts.

The creation of a virtual Global Center of Excellence focused on healthcare technology management would serve four primary roles: convener, aggregator, supporter, and communicator.

1. **Convener of Stakeholders.** Given the complexity of medicine, the dynamic nature of medical devices, and the variety of widely dispersed stakeholders, a coordinated approach is essential. The GCOE would convene stakeholders to create a global community for action. Working with stakeholders, the GCOE would develop a core curriculum to increase both the quality and rigor of the training worldwide. The GCOE would share this curriculum with participating (member) training programs and institutions. Stakeholders convened by the GCOE would develop trainer competencies and guidelines. The GCOE would also collect data, pilot, and test programs and approaches; and it would evaluate outcomes to discern what is truly scalable, reproducible, and sustainable. Further, GCOE participants would develop a rigorous process to help identify and qualify students with the greatest potential for success now and 3-5 years in the future.

   The act of convening, however, is not sufficient alone. The role of convener requires an understanding of the hopes, dreams, challenges, and realities of each stakeholder group, allowing honest and comprehensive conversations to occur. Stakeholders have articulated their problems clearly and proposed some narrowly focused solutions. Some stakeholders suggested that more funding for individual programs would result in more trained technicians. While, undoubtedly, there are many who might believe this approach would work, such an argument is unconvincing. As has been described, the ecosystem is too complex. Some stakeholders were the torchbearer for research, critics of corruption, and guardians against equipment dumping. The GCOE would consider and build on these passions and others to light and fan many fires of change.

   Certainly, the availability and allocation of financial resource is important, but equally important is a coherent vision and strategic plan for the profession, a broad training model, an agreed-upon set of core technical and instructional competencies, and a consistent agreed-upon curriculum. Convening and sharing stakeholders’ varying perspectives can help everyone expand their knowledge and build on the combined knowledge of their colleagues. A more comprehensive picture of the challenges and realities will help the Community create better solutions.
2. **Aggregator of Information and Resources.** The GCOE would collect information on activities relevant to stakeholders. In planning the June 2015 stakeholder meeting, the planning team became aware that there is no single repository for information or resources about biomedical equipment technician training. There is no collection of current best practices or lists of trainers, curriculum, evaluation studies, research, equipment manuals, etc. Without a knowledge management strategy, community members cannot systematically learn from one another. When programs do not learn from one another, they naturally tend to reinvent strategies and approaches already in use, creating redundancy, inefficiencies, and a lack of leadership. The magnitude of the work envisioned – effecting change on a global scale – demands organizational efficiency, innovation, collaboration, knowledge sharing, and the generosity of both people and organizations. By aggregating information and resources, the GCOE enhances collaboration and knowledge sharing and reduces current inefficiencies that occur because of reinvention, unknown outcomes, and a failure to learn.

With strong support and commitment to collaboration by key stakeholders, the GCOE would become the focal point for funding sources. The GCOE would promote collaborative approaches to funders, as well as seek to expand opportunities for funder collaboration, which solidifies a common purpose in order to address complex problems. “Consistent with our ‘capacity to think big,’ collaboration has been one means to allow us to take on larger social agendas, tougher issues, and longer-term challenges while knowing we are in deliberate coordination with others,” said Carol Larson, president and CEO, the David and Lucile Packard Foundation (Huang & Seldon, 2014), speaking on the importance of funder collaboration.

Too often, an aid agency or NGO starts a new program or activity without the benefit of an overarching plan or input from other partners in the region. Individual efforts simply are not enough to increase the number of biomedical equipment technicians around the globe significantly. Pooling resources – time, energy, and money – will contribute to positive outcomes and accountability. It will offer funders, sponsors, and governments a central point of contact and increasing economies of scale.

3. **Supporter of Training Programs.** The GCOE would support training programs as a provider of technical assistance, training, and training certifications, thereby elevating the quality of the training programs, technicians, and the profession overall. The GCOE would organize both peer support and expert assistance for various programs. Today, it is conceivable that people can offer training programs in low-resource settings using the trainers and materials of their choice without regard for efficiency or efficacy. While such trainers may be qualified, stakeholders shared anecdotes about training failures and trainers lacking basic trainer skills. There is no evidence of shared agreements on what constitutes a qualified training program, trainer, curriculum, or best practices because no entity currently reviews materials, independently assesses outcomes, or catalogs adverse events on a comprehensive scale. The GCOE would provide order and organization that is lacking in the current environment. It would use its knowledge base to engage a cadre of experts who would provide technical assistance and train-the-trainer training at the national, regional, or local levels, as needed. It would use its role as convener and aggregator to develop collaboratively needed standards for training programs and technicians in low-resource settings. Eventually, the GCOE would offer program accreditation and trainer certifications.
4. **Communicator of Information.** The GCOE would serve as the global training community’s independent communicator of the information collected through its other essential roles of convener, aggregator, and supporter. By communicating to, among, and about the community, the GCOE would raise awareness among current and potential stakeholders and create a call to action for organizations and individuals to act collectively to generate solutions. The biomedical equipment technician community understands the technician role and realities, as well as the risk factors associated with use and non-use of high-quality technicians. The GCOE would be in a position to create a consolidated medium and message to raise global awareness of these significant issues outside the profession. It would also help overcome the reality that “a large number of medical devices acquired by developing countries remain idle, suboptimally, or inappropriately used” (Petkova, 2010).

Serving as the communicator for the global training community, the GCOE articulates the value and role of the biomedical equipment technician and its contribution to efficiency and patient safety to administrators, health professionals, governments, manufacturers, NGOs, public health advocates, patients, and the community at large.

Creating a training model and training more technicians is not alone enough to cause social, political, economic, medical, and commercial systems to see the value of the biomedical equipment technician role and its importance in the safety of patients. Nor will these accomplishments cause those who control financial resources for healthcare to choose to expend them on training more technicians rather than on other needs. The choices are difficult. A concerted communication effort is needed to advocate for trained biomedical equipment technicians as an integral part of a system of safe patient care and operational efficiency. Further, efforts must focus on engaging stakeholders in conversations about optimizing resources that include the entire life cycle of technology. Communication needs to occur with multiple stakeholders to bring about a variety of changes:

- Governments to affect policies and resource allocations
- Healthcare providers to further the acceptance of the role and promote collaboration
- Lawyers to affect decisions about allowing access to equipment service and user manuals
- NGOs and medical equipment donors to affect decisions about what is donated, where, and when, so that low-resource settings do not become dumping grounds for inoperable or obsolete equipment and specify which peripherals, parts, consumables, and manuals must accompany each donation
- Training programs to affect the quality of the student and outcomes of the programs
- Educational campaigns targeting traditional healers where the treatment tends to be more holistic and eschews technology.

The profession must change the narrative so that administrators and government regulators see the complementarity of medical equipment even in low-resource settings. Yes, administrators face seemingly impossible resource decisions daily, but the response must not be *we can’t buy parts because we need to spend the funds on something else or we didn’t budget for parts or consumables*. Medical equipment and technology must gain status and understanding among administrators and clinicians similar to of pharmaceutical products.

Not only must the Community seize the narrative, it must help clinicians do their jobs better through education and advocacy, communicating the benefits of medical technology as well as
critical concerns or cautions. This need is particularly critical in low-resource settings, where the appropriate use of the technology may not be well understood. The Community should not wait until a report like *To err is human*, which shined a bright light on medical errors and the woeful state of patient safety in U.S. hospitals. No patient should enter a healthcare facility for a simple broken bone and have their entire body exposed to radiation, because the x-ray machine was operating incorrectly and used anyway.

Serving as an advocate and communicator, the GCOE would coalesce the profession and champion biomedical equipment technicians and the role they play in safe and effective patient care.

Figure 5 illustrates how the four roles of a Global Center of Excellence would deliver outcomes that comprise effective and sustainable training programs.

![Figure 5. Global Center of Excellence Role Contributions](image)

**Developing the Global Center of Excellence**

At a practical level, Figure 6 demonstrates the framework around which the GCOE would be developed. The cycle of development begins with the commitment of time, energy, and money by interested stakeholders; moves to the creation of a vision, mission, and strategy on which leaders in the Community agree; and results in the development of an infrastructure through which, work is accomplished and goals achieved. The vision described earlier in this report serves as a starting point for the implementation of the GCOE.
The GCOE would create a platform and a governance structure to standardize processes, policies, and curricula; share best practices and learnings; establish a common method and set of techniques for managing and sharing information; streamline resources; eliminate redundancies and reduce costs overall; and, harness existing and future knowledge. Further, it would create, develop, and promote a pool of subject matter experts, thus contributing to the creation of new knowledge through research, evaluation, and development that ultimately would lead to the increased credibility and sustainability of the profession.

Throughout, this report calls for high levels of collaboration and, certainly, collaboration has its challenges. Huang and Seldon (2014) identified five collaboration models ranging from low to high levels of integration, beginning with exchanging knowledge. Two moderate forms of collaboration include coordination of funding and co-investing, and the highest level of integration includes creating a new entity or initiative and funding another funder. They also offer five key lessons from their study of funder collaborations. First, weigh the costs-benefits, including the opportunity cost of collaboration. Second, apply rigor to decisionmaking regarding the collaboration’s structure. Third, establish clear roles, required investment, milestones, evaluation, and feedback loops. Fourth, adapt based on new information coming into the system. Lastly, start with the end in mind by having an exit strategy in place.

The global community of biomedical equipment technicians can and must learn from others on how to collaborate effectively and then diligently and tirelessly commit to doing so.

Global Center of Excellence Participation

A four-tiered participatory development model (Figure 7) similar in concept to the Labs for Life, for example, could be developed. Labs for Life is a five-year, $20 million public-private partnership established through a cooperative agreement between the U.S. President’s Emergency Plan for AIDS Relief (PEPFAR), U.S. Centers for Disease Control and Prevention (CDC), and Becton Dickinson, a medical technology manufacturer.

The Labs for Life program works with laboratories at different stages of development to increase the quality of laboratories, their processes, and procedures; offer training and development and curriculum development; improve quality to attain national, regional, or international accreditation; and strengthen local capacity and promote country ownership and sustainability through collaboration.

Biomedical equipment technician training programs housed at a university, polytechnic, teaching hospital, or NGO program, would apply to join the GCOE. Assessment materials would allow individual
programs and the GCOE to compare those programs to the criteria (processes and outcomes achieved) established by peer advisory groups. This comparison would determine the program tier, ranging from substantial expertise and assistance needed (Foundational) to high levels of sophistication achieved (Exemplar). The process would be similar to the ones used for standard setting.

An advisory group would determine the actual number of tiers, as well as define the competencies, qualities, and expectations of each tier based on the needs of the global medical equipment technician community needs. For example, a brand new training program would enter at the Foundational level, whereas a program like the U.S. Military biomedical equipment training program at the Medical Education & Training Campus (METC) would likely be an Exemplar.

Participating programs would have access to a core curriculum, training materials, best practices, experts, and technical assistance, ideally through a peer review program. The focus would be on continuous improvement upward through the tiers of the model, recognizing that different programs with varying levels of sophistication will enter at different levels. This allows the programs to start where they are, just as a successful teacher knows that teaching to a student’s starting point for learning enables success.

Eventually, the GCOE might support the efforts of independent associations or develop councils or special interest groups for networking and continuing education purposes at the country or local level; a centralized and virtual marketplace for skilled technicians and trainers; and further professionalization of the field through micro-credentialing to acknowledge an individual’s completion of noncredit courses, seminars, or other professional learning.

The GCOE is aligned tangentially with WHO’s (2011b) call for standardizing healthcare technology by reducing the range of makes and models of equipment. Similarly, normalization of training will enhance the collective capacity of biomedical equipment technicians around the world. To continue the current haphazard course is not sustainable. Working together in a coordinated fashion, stakeholders can achieve far more by connecting the programs and bringing together a dedicated team of leaders, managers, and technical experts to provide leadership, training, resources, support, best practices, and research.

The GCOE model can leverage the collective wisdom and expertise of the Community, reduce overhead by organizing virtually, and build the profession. The model provides an efficient alternative to the current fragmented approach to training biomedical equipment technicians.

Realities of Time, Money, and Collaboration

The goal of creating a workable model that is scalable, replicable, and sustainable in 3 to 5 years seems intended to create a sense of urgency rather than setting forth a true mandate. The GE Foundation’s Global Health Director Asha Varghese recently said about the timeline, “We must do something. We must make progress.” To the GE Foundation’s credit, it is willing to push the community and itself to make something happen, and it has provided the initial funding to foster the conversation.

Achieving this initiative’s vision in 3 to 5 years will be a challenge. The timeframe may prove impossible to meet. It is important to keep in mind, however, that a vision statement describes a future successful state, often 10 or 20 years into the future. A well-crafted vision statement is inspirational and aspirational. It creates a mental image of what its creators want to achieve. It challenges and inspires the community to act. If this assessment is accurate then what can the Community realistically accomplish? Actually, with appropriate funding, it can accomplish quite a bit in the first two years.
1. Create a virtual Global Center of Excellence that serves as the overarching infrastructure and frames the activities to be accomplished by whom, on what timeline, and with what resources.

2. Create small technical advisory groups for planning and addressing topical issues.

3. Identify organizations and individual stakeholders for collaboration, awareness building, and leadership development.

4. Begin to systematically engage those stakeholders and enroll them as early champions.

5. Begin cataloging existing curriculum, funders, funding, best practices, evaluations, and research.

6. Begin sharing aggregated information and developing knowledge.

7. Determine what evaluations and research studies are needed and by whom.

8. Create a core curriculum for a global training program.

9. Create core competencies in a tiered structure for training programs in low-resource settings.


11. Create core competencies for graduating students in low-resource settings.

12. Create an initial set of trainer aids

13. Survey programs and trainers about their training and technical assistance needs.

14. Begin shaping a communications strategy to increase awareness of the biomedical equipment technician role.

Within the first two years, some efforts will just begin to achieve the desired goals and others will be considerably further along. A small, strong, and adequately supported team of dedicated individuals can achieve these goals.

Realism is required concerning the amount of collaboration, cooperation, and time that a GCOE would require to establish a governing body, bring the key players together, create a vision and strategic plan, identify how the work would be accomplished, and create a long-term business model. This would be a complex effort to bring together the right people, processes, and systems to create a solid foundation.

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**Advantages of a Global Center of Excellence Model**

Advantages of the GCOE model include enhanced efficiency and accountability, reduced risk and costs, increased programmatic support, and collaboration, among others.

**Enhancing Efficiencies**

- Creates a centralized knowledge platform and shareable expertise that is predicated on consistent, repeatable processes, and sharing products, staff, resources, and best practices across geographically distributed teams

**Reducing Risk**

- Improves consistency, quality, and reliability of all services supporting patient care
- Reduces risk to facilities by eliminating over-reliance on one technician or inoperable equipment
- Increases credibility of the profession

**Reducing Costs**

- Encourages shared infrastructure and tools
- Creates defined, shared skill sets
- Identifies and eliminates redundant or inefficient processes through collaborative process
- Consolidates training, testing, and planning and development with fewer resources

**Providing Programmatic Support**

- Provides leadership, administrative, marketing, fundraising, evaluation, and research support to programs, while decreasing frustration and disorganization
- Increases faculty and trainer skills
- Standardizes processes to improve communications and productivity
- Provides professional development and career advancement opportunities for graduates, faculty, and trainers
- Enhances capabilities across all programs
- Demonstrates improvements through shared knowledge and visibility of quality metrics
- Shares best practices and standardized processes to shorten the learning curve for testing new projects, services, and methodologies
- Acknowledges key performers and service offerings
- Tracks faculty and trainer success through evaluations and assessments
with a flexible and adaptable structure. It will take time to gather resources and buy-in, build the team, and allow the GCOE to mature. Nonetheless, it is the Community’s best chance to come together for the benefit of all. Building a GCOE is an achievable and worthwhile goal that can begin on a realistic scale by leveraging existing resources and then expanding its capabilities to prove its value.

The 2015 stakeholders have already shown that magic can happen when a committed community simply begins talking about changes. Other unplanned and unanticipated changes begin to emerge, in part because there is excitement and a shared belief that change can actually occur. Who wouldn’t want to be a part of that kind of synchronicity!

**KEY RECOMMENDATIONS:**

1. Create a virtual Global Center of Excellence for Healthcare Technology Management (HTM), which serves to promote cross-functional collaboration, coordination, integration, and efficiency, and implement many of the recommendations in this report.

   The GCOE would serve four primary roles: convener, aggregator, supporter, and communicator. As does its work, the GCOE would raise the profile of the biomedical equipment technician profession and related topics and strategically engage stakeholders, funders, and policymakers in discussions about investment, innovation, and long-term sustainability. It also would serve as a focal point for change by identifying, developing, and connecting strong champions and networks of champions and experts.
RECOMMENDATIONS: FUNDING STRATEGIES

Training program representatives described the challenges they face in securing funds for biomedical equipment technician training. These difficulties are due, in part, to funders’ lack of awareness of the profession, lack of understanding of the importance of the biomedical equipment technician role, and focus on other needs deemed more pressing. Training programs are in the business of training, and their staffs may lack the necessary fundraising skills, contacts, or approach to be successful at fundraising. Finally, there is significant competition for funding of any sort.

This section identifies several fundraising strategies and provides general information about fundraising.

The existing funding mechanisms for biomedical equipment technician training include grants or other non-financial contributions from foundations and NGOs; corporate funding; government funding; international aid; hybrid funding (public-private partnerships); tuition; and other school fees. In addition to these existing strategies, Table 5 describes other potential mechanisms that could conceivably provide funding for biomedical equipment technician training. Appendix E describes several other options in more depth, including social funding/crowdfunding, public-private partnerships, microfinancing, micro-franchising, social impact investing, and remittance payments.

<table>
<thead>
<tr>
<th>Table 5. Future Funding Options by Type</th>
<th>Donor Type</th>
<th>Potential Funding Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governments:</td>
<td>• Charging for services to governments now provided for free (train-the-trainer, internships, consulting to hospitals)</td>
<td></td>
</tr>
</tbody>
</table>
| Healthcare Facilities:                 | • Tying equipment donations and BMET training to hospital financing  
                                         • Charging local facilities for services now provided for free (train-the-trainer, internships, consulting to hospitals, oxygen plants, water filtration plants) |
| Trainers:                              | • Fee-based training workshops |
| Students:                              | • Fee-based tuition through private and public stipends, bursaries, or scholarships  
                                         • Fee-based tuition for internships/attachments |
| Community:                             | • Crowdsourcing within communities  
                                         • Matching funds  
                                         • Remittance donations |
| NGOs:                                  | • Equipment donations with donor assuming cost of training  
                                         • Crowdsourcing or fundraising with membership or donor groups |
| Private Sector:                        | • Manufacturer equipment fees (taxes, equipment discounts free up training funds)  
                                         • Tax breaks to incentivize vendors to finance BMET training  
                                         • Local private sector funding or investment  
                                         • Social impact investing (oxygen plants, water filtration plants, general and specific repair shops) |
| Partnerships:                          | • Public-private partnerships (PPP)  
                                         • National and regional HTM service centers |
| Business Services:                     | • Fees for repair service  
                                         • Fees for renting test equipment  
                                         • Fees for consulting  
                                         • Fees for use of workshop-based centers of excellence  
                                         • Fees from the creation and operation of general and specific repair shops |
| Associations:                          | • Fees from membership to professional associations and groups  
                                         • Funds from grants  
                                         • Fees from offering opportunities to expats and others (volunteer vacations)  
                                         • Fees from offering team building, corporate responsibility project opportunities  
                                         • Fees from lobbying access |
Funding Basics

All funding strategies require a two-pronged approach that 1) focuses on both targeted donors and populations and 2) knows and communicates the needs of the settings served. A successful fundraising strategy will include a mix of funders, including individual donors from both low- and high-wealth settings, as well as corporate, philanthropic, family, and association foundations. Direct personal appeals can be productive, but the process is time consuming. Reaching wealthy donors requires key players with access to those individuals. Donors themselves can also open doors to other donors, making a “donor get a donor” strategy highly effective. The axiom, the closer you are to the prospective donor, the more likely you are to receive a gift demonstrates this reality. At the same time, it is often difficult to find a champion or an “angel” donor willing to commit the necessary time, energy, money, and contacts.

Small donors have proven to be effective for charities, nonprofits, and political campaigns, but they require strong engagement strategies. Two ways to access those donors are by creating a social media campaign using crowdfunding technologies or by working a list of donors who have contributed previously to other similar efforts and who may become possible donors through calls, letters, and/or visits. Both require a list of potential donors, but obtaining and/or building lists is often difficult. Any list requires a substantial investment of time for the list to become productive. Just like creating a successful business plan, running a successful fundraising program is time intensive, requiring initial funding, a plan, a compelling and evidence-based story, and most importantly, a dedicated and skilled staff.

A compelling funding proposal will: 1) summarize information about the goals and objectives of the requesting organization and its initiative; 2) identify how it aligns with the goals of prospective funders; 3) make a persuasive argument for the competence of the organization to achieve the stated goals; and 4) propose a plan for revenue generation and movement toward financial independence.

Typically, an organization writes a concise “Case Statement” that identifies the need or problem, and clearly defines the target population and geographic service areas. Typically, it is a narrative written with an emotional appeal. Additionally, each funder-specific iteration of the Case Statement specifies the solutions to the stated problem; shows how its initiative addresses the need or problem; and, suggests why the potential funder might want to commit its resources to support the task.

“The greatest danger for most of us is not that our aim is too high and we miss it, but that it is too low and we reach it.”
— Michelangelo Buonarroti

Funding This Initiative

Funders are most inclined to make donations when an entity makes a compelling and evidence-based case using demonstrable outcomes that align with the funders’ goals. A compelling case for biomedical equipment technician training has not been made clearly enough. There is not currently accessible data on demonstrated outcomes, nor is there a network of key and connected stakeholders and funders who are currently raising awareness about the need for trained biomedical equipment technicians and its critical impact on patient care. Raising awareness of these needs is a critical first step in the creation of a plan to acquire needed funding.

The GCOE could develop a plan for what is needed to sufficiently raise awareness and acquire needed funding. This does not imply that the GCOE become a fundraiser for the training programs. Significant funding sources must be identified that are willing to provide adequate funding to achieve the goals outlined herein and those subsequently developed by the GCOE.
As noted earlier, the Labs for Life program is a useful model to illustrate what it takes in terms of a significant funding sources and long-term commitment to success. While there are too many unresolved variables to create a budget for the initiative at this point, significant resources are needed. A price tag that is two times the amount of the Labs for Life program; $40 million may be a good starting point. However, the estimate is likely to be low, given the vision, need, and variability between settings.

Using traditional fundraising efforts will undoubtedly take too much effort and time, given funding cycles and proposal requirements to meet the 3-5 year time horizon. On the other hand, the medical device technology industry should have the greatest interest in funding this initiative, particularly since the global medical technology market is growing rapidly. The market was valued at $512 billion in 2010. Lucintel (2014) expects the market to grow at a compound annual growth rate of approximately 7 percent to reach $764 billion by 2017.

The medical technology market is also likely to keep growing, because of key drivers, including a growing and aging population, increasing life expectancy, increasing government expenditures on healthcare, growing awareness of health improvements, and expanding infrastructure. The major challenges include risks to intellectual property, price constraints, regulatory pressures, and intense competition with high degrees of consolidation. The top 10 companies account for approximately 60 percent of the market share, but there are few barriers to entry. These companies may have a short-term financial interest in selling new equipment to replace equipment that “doesn’t work,” and they should have a long-term interest in supporting the training of the technicians who are in a position to keep their equipment running, support safe patient care, and enhance the reputation of their brands.

Issues to be Worked Out

The recommendation for funding for this collaborative effort will likely be the most difficult part of this report for the Community to accept. That is natural; the competition for funding is real and significant. The GCOE’s initial conveners will need to help assess what funding is available for start-up activities and work from there. Most importantly, a coordinated and collaborative effort is essential. Funding siloed programs in small scattered or sporadic amounts – dribs and drabs – will not achieve the magnitude or the quality of outcomes envisioned.

KEY RECOMMENDATIONS:

1. Write a compelling Case Statement to present to potential funders.
2. Identify sources of funding most likely to support the initiative.
3. Identify types of funding most likely to support the initiative in the specified timeframe.
4. Seek funding.
RECOMMENDATIONS: GCOE SCALABILITY, REPLICABILITY, & SUSTAINABILITY

The theoretical, academic world of theory-making appears to make recommendations easily. However, making recommendations does not mean the ideas can be implemented easily or at all – or that they will conform to the stated goals of the initiative. This section explains how the GCOE recommendations in this report align with the initiative’s integral goals of scalability, replicability, and sustainability.

Experts in social entrepreneurship from Duke University and Harvard Business School warn social entrepreneurs, foundation officers, and policymakers to take a strategic and systematic approach to spreading social innovation. “Too often, they frame the problem in terms of either ‘replication,’ the diffusion and adoption of model social programs, or, more recently, ‘scaling up,’ which commonly entails significant organizational growth and central coordination. While neither of these concepts is inherently ill-conceived, failure to place them within a broader strategic framework can blind social sector leaders to promising options and bias them toward a limited set of strategies” (Dees, Anderson, & Wei-Skillern, 2004). The GCOE will provide a broad enough strategic framework to achieve the initiative’s vision.

Looking through the Lens of Scalability

Scaling requires sharing an effective program, practice, or idea so that others might benefit. Dees, Anderson, & Wei-Skillern (2004) state that there are few examples of nonprofit programs that have been successfully scaled up, in part because what works in one location may not work in another. Further, scaling, simply put, is complex. To have any chance of success, a great deal of planning and implementation work is necessary, along with 1) clarity that scaling is indeed needed and why; 2) an understanding of how the process will work; and, 3) a clear vision of the desired outcome. These inputs help assure the outputs of an effective implementation plan and budget.

Scaling starts with both the growth and development of a program or idea and proof that a solution works. “Then the next stage is to grow your reach in a direct and controlled manner in order to understand the process as well as the transferability of your solution” (Tayabali. 2014). In a corporate environment, scalability is the potential to multiply revenue based on a proven product and a proven business model allowing successful expansion into new geographies and markets.

Tayabali (2014) suggests that organizations first must determine whether their product or service is robust enough to scale and whether the organization is ready to scale. The GCOE should answer key questions before scaling a training model. First, what makes the approach distinctive? Second, are the goals clear and well defined? Third, is the design applicable, once scaled? Fourth, is the model systematized and transferable? Fifth, what is essential to success? Lastly, what internal or external factors play critical supporting roles? Once there is agreement on the answers to these questions, the GCOE must determine the framework for a model of operation for scaling: organizational, programmatic, or principle. An Organizational Model is an overarching structure for mobilizing people and resources to serve a common purpose. McDonald’s provides a highly structured franchise experience at every restaurant. A Principles-based Model operates on general guidelines and values to serve a given purpose. The Women’s World Banking global network bases its decisions on its mission to expand low-income women’s economic participation and power. A Program Model is an integrated set of actions to serve a specific purpose. These three models overlap conceptually and are not mutually exclusive.

The 2015 GEF-AAMIF meeting stakeholders identified perceived barriers to achieving scalability in biomedical equipment technician training programs.
Barriers to Scalability Identified by Stakeholders

- Lack of a uniform body of knowledge, curriculum, and standards of practice
- Lack of individualized approach: different settings, different needs
- Lack of a coordinated approach that uses local and distance learning tools
- Lack of knowledge about career and skills development, HTM approach
- Lack of institutional buy-in from governments, facilities, and NGOs
- Lack of networking, not as simple as joining professional associations

The GCOE as recommended would address these barriers through means such as the following:

- Developing a set of core competencies and an adaptable core curriculum and standards of practice
- Serving as the knowledge repository for the community
- Developing materials and processes with adaptability and local flexibility as a core value
- Coordinating approaches through stakeholder groups
- Communicating existing information about careers, skills development, and HTM approach
- Developing professional development programs and opportunities for a global audience, fostering networks through the GCOE, and, eventually, a chapter-based or special interest group system
- Advocating for local institution buy-in and support

The GCOE promotes scalability through a principles-based and an organizational model of operation.

Looking through the Lens of Reproducibility, Not Replicability

Replicability comes from science and the desire to reproduce experiments with the same results (Bradach, 2003). Programmatically, the GCOE may want to reproduce a program, but always with changes that are responsive to local needs. For the purpose of this initiative, it is more accurate to look at reproducing a program with the intent of modifying it as necessary to respond to unique local environment or needs.

For reproduction to occur and for proven ideas to spread, strong organizations are required at both the local level and at the overarching or convening level. Yet, for the most part, current funding patterns of the nonprofit sector - small grants, short durations, focused on program work - have the effect of conspiring against building the capacity of organizations and any hope of reproduction.

Stakeholders at the 2015 GEF-AAMIF meeting were sensitive to other challenges to achieving replicability. They identified multiple current barriers that must be addressed to achieve this goal.

Barriers to Replicability Identified by Stakeholders

- Lack of knowledge of key elements of a replicable model, inability to replicate program within countries
- No set of core competencies post-training; Lack of community engagement to set core competencies
- No menus of standardized courses from which to choose and adapt
- Curriculum that does not cover the whole life cycle of equipment
- Lack of standardized terms
- No common script/training tool kit
- No system of professional development to maintain a community of BMETs
- Lack of recognition by international bodies and certification of training programs regardless of country, and a lack of national policies on BMET training
- Lack of resources (HR, teaching resources and structure, political structure)
- Under-appreciation of BMET role by ministries of health
- Resistance to excesses of standardization; desire to maximize flexibility
- Low levels of literacy (English, French, and/or local languages)
The proposed GCOE offers multiple means to address the barriers to replicability and reproducibility:

- Sharing knowledge about replicability, the purpose, pitfalls, and models of success
- Developing agreed-on or adaptable core curriculum and competencies
- Serving as the knowledge repository for the community
- Developing materials and processes with adaptability and local flexibility as a core value
- Coordinating approaches through stakeholder groups
- Communicating existing information
- Developing professional development programs and opportunities for a global audience and fostering networking through both the GCOE and its council-based system
- Advocating for institutional buy-in and support

Coordinated, collaborative models for developing common programmatic elements should work well in this Community since training programs are not simply seeking to duplicate training models, but rather to reproduce programs that are flexible and responsive to local needs.

**Looking through the Lens of Sustainability**

Participants at the 2015 stakeholder meeting identified many barriers to the creating sustainable programs.

<table>
<thead>
<tr>
<th>Barriers to Sustainability Identified by Stakeholders</th>
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<tbody>
<tr>
<td>Lack of a clear definition and shared meaning of sustainability</td>
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<tr>
<td>Inaccessible financial planning tools (budgeting, benchmark data)</td>
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<tr>
<td>No culture of continuous process improvement</td>
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<tr>
<td>A lack of community of professionals to routinely serve as mentors, collaborators, problem solvers</td>
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<td>Lack of assessments that determine whether the training provided matches local needs</td>
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<tr>
<td>No steady, consistent pool of trainers with the right level of skills, practical, &quot;hands-on&quot; experience</td>
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<tr>
<td>Need to build local trainer capacity, including hospital and practical, hands-on experience</td>
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<tr>
<td>Need mechanisms to identify aptitude and test for competency of students and trainers</td>
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<tr>
<td>Training programs do not provide a continuum of training at multiple career points</td>
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<tr>
<td>A lack of training standards</td>
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<tr>
<td>Failure of local training facilities to own training and outcomes</td>
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<tr>
<td>Lack of ownership of training and outcomes by ministries of health</td>
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<tr>
<td>Lack of NGO partnerships with local training programs that are capable of generating funds</td>
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<tr>
<td>Lack of a strategic alliance between academic institutions and healthcare facilities (linkages between schools of engineering, hospitals, and teaching institutions)</td>
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<td>Lack of local champions, leadership, and planning processes</td>
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<tr>
<td>No articulation of the needs of the local environment and continually involving local champions</td>
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<tr>
<td>Lack of communication with stakeholders in the HTM field (academia, private sector)</td>
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<tr>
<td>No country-based alliances</td>
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<tr>
<td>A need to convene government stakeholders in relevant ministries of health and education</td>
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<tr>
<td>Lack of mobilization of resources for developing and maintaining training programs</td>
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<tr>
<td>Few employment opportunities for graduates at a livable wage</td>
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<tr>
<td>No career path for global biomedical equipment technicians</td>
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<tr>
<td>A need to share success stories as a means of encouragement</td>
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<tr>
<td>Few shared examples of business models where technicians have become entrepreneurs and leaders</td>
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<tr>
<td>The current profile and status of biomedical equipment technicians</td>
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<tr>
<td>A lack of research and evaluations to demonstrate need, reliance, and outcomes</td>
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<tr>
<td>A lack of advocates to promote the need for and of biomedical equipment technicians at the local, national, and international levels and for policies, certification and regulation of the HTM field</td>
</tr>
<tr>
<td>A lack of recognition of the need for public policy at the highest levels</td>
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</tbody>
</table>
The stakeholders seem to know, quite clearly, what sustainability is not. The Oxford dictionary defines sustainable as the ability “to be maintained at a certain rate or level.” Yet Hanson, Salmoni, and Volpe (2009) in their study of 40 participants in three demonstration sites found significant variation within and between demonstration sites in defining the word “sustainability.” They analyzed 14 studies, half of which defined sustainability as a continuation of a program. The remaining definitions related to maintaining programs, transferring programmatic responsibility, improving practices, converting capacity to performance, mobilizing and allocating appropriate and sufficient resources, providing access to services, and integrating a program, practice, or policy into an existing or parent organization. Without guidance and a clear and shared understanding of the term, it is difficult to achieve sustainability.

During the 2015 stakeholder meeting, the facilitators were similarly interested in learning what factors these participants believe make a biomedical equipment technician training program sustainable. The facilitators purposefully did not define sustainability in order to elicit a greater range of possible factors. The participants were asked to consider factors beyond funding, including, for example, stakeholders, champions, infrastructure, socio-political stability, political systems, public-private partnership successes, faculty/trainers, technological orientation, literacy, biomedical equipment technician role, access to jobs, access to parts, behavior change, culture change, and so on. Stakeholders said that the following factors encourage sustainability:

- Engaging the right participants to create responsive, accountable local training
- Nurturing the development of the biomedical equipment technician profession and its members
- Securing and developing qualified, high quality trainers
- Utilizing broad stakeholder support and engaging Ministries of Health in assuring sustainability.

Each of the factors encouraging sustainability is incorporated into the roles and outcomes proposed for the GCOE. It is also significant that functions envisioned for the GCOE – convener, aggregator, communicator, and supporter – could contribute to resolving the barriers that stakeholders perceive to scalability, reproducibility (not replicability), and sustainability.

When looked at through each of these critical lenses, the proposed GCOE achieves this desired future.

**CLOSING: LOOKING AHEAD**

This report summarizes the findings of stakeholder interviews, site visits, reports, articles, and research. It recommends a model designed to provide leadership and overarching support and specifically recommends the key actions.

Operating under the principles of collaboration, stakeholder involvement, and shared resources, a virtual GCOE would focus on four primary roles: convener, aggregator, supporter, and communicator. The Center’s responsibilities would include, among other things:

- Convening stakeholders
- Aggregating and developing knowledge, including evaluations and research
- Sharing resources and best practices
- Offering training and providing technical assistance to training programs and trainers
- Communicating the value and importance of the biomedical equipment technician role
- Advocating for and raising awareness of the biomedical equipment technician profession globally
Additional recommendations include the following:

**Training Programs**
- Establish standards for training programs and compare programs against standards
- Assess trainers and students regularly
- Implement continuous process improvement efforts
- Determine appropriate numbers of students to be trained

**Trainers**
- Identify trainer competencies
- Evaluate trainers against the competencies
- Collect and develop training aides
- Provide continuing education and support

**Students**
- Identify student competencies
- Evaluate students against the competencies
- Identify students with the greatest aptitude and potential for success
- Provide training aides to students
- Develop a pipeline of future students

**Technicians**
- Identify global technician competencies
- Provide continuing education and support

If enacted, the future proposed in this report will offer the following desired outcomes to participants:

- **Training Programs** will receive technical assistance, communications, fundraising, and other professional support, and networking opportunities.
- **Trainers** will have access to training aids, continuing education, certification, professional support, and networking opportunities.
- **Students** will graduate from valued and sustainable training programs with an opportunity to give back to the training program as a champion, referral source, or possibly as a trainer.
- **Graduates** will have access to continuing education, professional support, and networking opportunities.
- **Governments, industry, and donors** will have a single point of contact and the ability to share their needs, concerns, and offers of assistance efficiently.
- **Patients, families, and clinicians** will benefit from having equipment that is operable, in good repair, and ready to support the diagnosis and treatment of health conditions.

Fortunately, there are helpful models for change vetted by experienced change leaders that can offer the Community directions for addressing such a large task. John Kotter (1996), emeritus professor of leadership at Harvard Business School, identifies an eight-step iterative model to implement change that
aligns powerfully with perceived needs identified by this initiative, its shared vision of a desired future, and the recommendations in this report. Kotter suggests the following:

1. **Create urgency.** Identify the threats, examine opportunities, engage in open and honest dialogue, and strengthen the efforts by continuously engaging stakeholders.

2. **Form a powerful coalition.** Identify a team with a good mix of people, leaders, and stakeholders alike who can commit their hearts and minds, as well as their time, energy, and money. People willing to work together and understand the importance of trust, open communication, and teambuilding.

3. **Create a vision for change.** Determine the values on which to build the initiative. Create a vision and a strategy to execute the vision. Check regularly to ensure the team and stakeholders can describe the vision.

4. **Communicate the vision.** Develop clear key messages and communicate frequently, powerfully, and unapologetically.

5. **Remove obstacles.** Solicit and be open to obstacles as a path toward continuous improvement. Seek to understand and then address or remove the obstacles.

6. **Create short-term wins.** Create early successes. Celebrate early wins, but do not fall into the trap of declaring, “mission accomplished” too soon.

7. **Build on the change.** Keep the momentum going and bring in new leaders and fresh ideas.

8. **Anchor the change in the culture.** Solidify the changes achieved and work to instill the change in the community and within stakeholder communities. Find and build champions who will help anchor the success.

Clearly, these steps do not offer quick fixes. Instead, they suggest that the large-scale change of the sort envisioned will take time. This likely will be a multi-year, and perhaps a multi-decade, iterative effort. The level of change necessary and actions necessary to achieve the vision must not be minimized.

Each success must be analyzed, along with each misstep and failure, in order to understand and document what worked or not, and what can be improved, recognizing that sometimes the mistakes suggest the best path forward to achieving the vision and building a culture of continuous improvement.

As the GE Foundation’s Chief Medical Officer David Barash, MD, pointed out during the 2015 stakeholder meeting, our real failure would be being afraid to launch until we believe our idea is perfect. Voltaire would agree. We should pilot many projects, learn from them, and keep what works, what Dr. Barash referred to as “failing fast” – essentially, *plan, do, study,* and *act* – nothing less than a call for continuous improvement that starts now.

There is a clear and present opportunity to articulate the value and demonstrate the worth of biomedical equipment technicians locally and globally. The Community must roll up its sleeves and work toward these critically important goals together – collaboratively – and present and market biomedical equipment technicians as integral and important players in healthcare solutions, not just some “techie” in the basement.
ACKNOWLEDGEMENTS

Some two hundred individuals and organizations provided their time and expertise in support of this initiative. They attended meetings and site visits, showed the authors around their facilities, offered advice and suggestions, reviewed documents, and showed their support for this initiative in a myriad of ways. The authors offer a special note of gratitude to the 55 individuals who participated in the June 2015 stakeholder meeting, many who traveled a great distance and those individuals behind the scenes who made the meeting happen so quickly. They are listed in Appendix F. Many thanks go to the following individuals who supported this effort, especially Robert Bell, Ed Hutton, Benin Joshua, Billy Teninny, and Edward Tonkin always ready to lend a hand.

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Conclave Tumuroro, On-the-Ground Coordinator, BMET Rwanda, Engineering World Health
Robert Van Hook, FASAE, CAE, Principal, Transition Management Consulting, Inc.
RIRASA Joan Marie Vinneoye, Division Manager, MTI, Rwanda Ministry of Health
Dr. Justin Wane, Head of Treatment and Diagnostic Support, King Faisal Hospital
Nathan Williams, Association for the Advancement of Medical Instrumentation
and many, many more...
### ACRONYMS AND KEY RELATED ORGANIZATIONS

#### General Terms
- **ATD**: Association for Talent Development
- **BES**: Biomedical engineering specialist or biomedical equipment specialist
- **BMES**: Biomedical engineering specialist or biomedical equipment specialist
- **BMET**: Biomedical equipment technician or biomedical equipment technologist
- **BTA**: Biomedical technician assistant
- **GIIN**: Global Impact Investing Network
- **HTM**: Health technology management
- **LRC**: Low-resource country
- **MoH**: Ministry of Health
- **T&D**: Training and development
- **TOT**: Train-the-trainer (sometimes referred to as TTT or T³)
- **TVET**: Technical and vocational education and training

#### Nongovernmental Organizations (NGOs)
- **METC**: U.S. Military Medical Education & Training Campus

#### Government, Intergovernmental, Aid, and Development Agencies and Programs
- **AECID**: Spanish Agency for International Development Cooperation, [http://www.aecid.es/ES](http://www.aecid.es/ES)
- **CDC**: US Centers for Disease Control and Prevention, [http://www.cdc.gov/](http://www.cdc.gov/)
- **IDB**: Inter-American Development Bank, [http://www.iadb.org/](http://www.iadb.org/)
- **WHO**: World Health Organization, [http://www.who.int/](http://www.who.int/)
REFERENCE LIST


(Note: AAMI expects to publish an updated set of core competencies in late 2015.)


http://dhtlab.pratt.duke.edu/sites/dhtlab.pratt.duke.edu/files/An%20Evidence-Based%20Curriculum%20for%20Biomedical%20Technician%27s%20Assistants%20in%20Resource-Poor%20Settings.pdf


http://apps.who.int/iris/bitstream/10665/70457/1/WHO_HSS_EHT_DIM_10.6_eng.pdf


http://steinhardtapps.es.its.nyu.edu/create/courses/2174/reading/smith_ragan_1_2.pdf

http://www.oxforddictionaries.com/us/definition/american_english/sustainable


http://apps.who.int/iris/bitstream/10665/44568/1/9789241501408_eng.pdf

APPENDIX A – ABOUT GE FOUNDATION AND AAMI FOUNDATION

GE Foundation

The GE Foundation (GEF) (http://www.gefoundation.com/), the philanthropic organization of GE, is committed to building a world that works better. GEF empowers people by helping them build the skills they need to succeed in a global economy; equipping communities with the technology and capacity to improve access to better health and education; and elevating ideas that tackle the world’s toughest challenges to advancing economic development and improving lives. The generosity and talent of GE’s employees supports the work of the GE Foundation.

The Developing Health Globally™ (DHG) program is GEF’s signature philanthropic program. The program aims to improve access to quality healthcare for some of the world’s most vulnerable populations. Established in 2004, the DHG program strengthens healthcare systems in the developing world by upgrading equipment and infrastructure, and providing ongoing training and support to ensure success and sustainability. GEF creates sustainable impact through smart investing and leveraging of GE expertise and engaging committed partners. DHG works to enable the delivery of quality healthcare to more people around the world by strengthening the health systems that serve them.

In partnership with Engineering World Health and Developing World Healthcare Technology Laboratory at Duke University, DHG is developing local biomedical technology training programs for biomedical equipment technicians to identify trainers and local infrastructure to create in-country (local) training to cultivate a professional community of biomedical technicians. In resource-poor settings, DHG is developing local biomedical technology training programs; collaborating with Ministries of Health to identify trainers and local infrastructure to create in-country training; and providing ongoing coaching and mentoring resources to cultivate a professional community of biomedical equipment technicians. To date, these efforts have trained 200 biomedical equipment technicians in four countries: Cambodia, Ghana, Honduras, and Rwanda.

DHG is actively working to further the impact of its biomedical equipment technician program and develop a more expeditious, scalable, and cost-effective model for global implementation.

AAMI Foundation

The Association for the Advancement of Medical Instrumentation (AAMI) and the AAMI Foundation (http://www.aami.org) are leaders in supporting the healthcare technology management (HTM) field by providing training and professional certifications (e.g., CBET), and nationally respected and recognized credentials. AAMI has assessed the needs and gaps in education and brought respected leaders together to determine ways of improving medical device safety and support and to improve and standardize the training and skillset for individuals working with medical devices. AAMI also has made it a priority to bring recognition to the field through a number of initiatives.

In 2011, AAMI convened a group of experts at a “Future Forum I” meeting to develop a shared vision of the field and activities that would help move the field forward. Efforts continued in 2012 at “Future Forum II” as AAMI worked to advance the field and establish a vision. Combined, the Future Forum meetings resulted in

- establishing a unifying name for the field, “Healthcare Technology Management” (HTM), which includes clinical engineers, biomedical equipment technicians, clinical equipment specialists,
biomedical equipment specialists, laboratory technicians, imaging technicians, and others who manage healthcare technology;

- identifying both opportunities and challenges for the field and the professionals working in it; and
- developing and implementing a business plan to support the continuing evolution and growth of the HTM field as a profession.

In 2013, AAMI launched the “I am HTM” campaign (http://www.aami.org/iamhtm/), a major initiative to promote the value of the HTM field to hospital executives, clinicians, information technology personnel, and prospective students. The campaign includes marketing materials to promote the field. All of these materials are available free of charge on AAMI website.

Other outcomes of the Future Forum meetings include:

- Developing career ladders.
- Developing core competencies for BMET training to guide BMET education programs in developing core curriculum and helping BMETs and their employers with career planning, hiring, and development opportunities.
- Developing promotional materials for outreach to external audiences.
- Developing standardized job descriptions.
- Establishing a robust website (www.aami.org/htmconnect).
- Publishing HTM Levels Guide: A Program Planning Tool for HTM Departments.

In 2014, AAMI convened Future Forum III, a two-day expert meeting to identify the education and training gaps of U.S.-based clinical engineers and BMETs. The outcome was the identification of steps to bridge those gaps. Jackie Eder-Van Hook, PhD, of Transition Management Consulting, Inc., the lead consultant on this joint GE Foundation-AAMI Foundation initiative, facilitated Future Forum III.

The AAMI Foundation offers annual scholarships to BMET and clinical engineering students as one more way to support the ongoing growth and professionalism of the HTM field overall.

AAMI has continued to focus its efforts with strategic plan goals to strengthen the skillsets, credentials, academic experiences, stature, and recognition of HTM professionals in healthcare delivery and to increase its training programs worldwide to keep up with the current trend of globalization. AAMI also has several programs and initiatives aimed at attracting a diverse membership.

AAMI is pursuing opportunities to hold training courses abroad and provide easier access to healthcare professionals seeking more in-depth training from an industry leader. Foundational elements of all of these efforts and other strategic priorities are advancing the safety of healthcare technology, improving patient outcomes, and saving lives.
APPENDIX B – ABOUT THE TEAM

**Jackie Eder-Van Hook, PhD** has 25+ years of senior management experience, most recently as the president of Transition Management Consulting, Inc., where she consults with CEOs and association and NGO governing bodies.

Previously, Jackie led healthcare technology associations and coalitions: Advanced Initiatives in Medical Simulation; Center for Telehealth and E-Health Law/Center for Telemedicine Law; Home Care Technology Association of America, a NAHC organization; coalition for Consumer Health Access through Technology (Intel Corporation); and the National Health Policy Council. She served as interim executive for associations, charitable nonprofits, and a public-private agency.

Jackie served as a senior official at the U.S. Agency for Health Care Policy and Research where U.S. Health and Human Services Secretary Donna Shalala, AHCPR Administrator John Eisenberg, MD, and the U.S. Office of Personnel Management recognized her change management and innovation efforts.

She is a respected author with 40+ writings on management, leadership, and healthcare, including this report (2015), “A model for training biomedical equipment technicians in low-resource settings.” She was a principal investigator on advanced initiatives in medical simulation for the U.S. Army Medical Research and Materiel Command, lead author on Medicaid policies for telehealth services, and a peer reviewer for the OD Institute journal (international) and Academy of Management.

Jackie earned a doctorate in Human and Organizational Systems, and a Master of Arts in Human Development from Fielding Graduate University, Master of Science in Organization Development from American University (AU/NTL), and Bachelor of Arts degree in Political Science from San Diego State University. She is a graduate of the GIC/GISC International Organization and System Development Program and the Newfield Network, international consulting and coaching programs.

**Christine “Chris” T. Love, MSOD, MH** has consulted to healthcare, nonprofit, educational, community, and corporate clients for over 25 years, specializing in positive change methodologies. She is president of Chris Love Associates, LLC, a leadership and management consulting firm. Chris offers reflective leadership retreats for healthcare, education, clergy, nonprofit, and other service professionals through her affiliation with the Center for Courage and Renewal. She is co-leading Center facilitators in the development of a national program entitled Aging with Courage and Wisdom.

Chris previously worked for the national consulting firm Alan Newman Research as a qualitative market research project manager and for The Martin Agency as a direct response account supervisor.

She has published articles about her work in the journal *New Directions for Teaching and Learning* and online and wrote numerous medical publications for professional and lay audiences while employed by the Mayo Comprehensive Cancer Center. While writing and editing for English language publications in Europe and Asia for five years, Chris published dozens of news, medical and feature articles. She has worked in the Middle East in post-secondary education and refugee resettlement and has taught technical writing at the college level.

Chris earned a Master of Science in Organization Development from American University (AU/NTL) and a Masters of Arts in Humanities degree from The University of Richmond. She is a Phi Beta Kappa graduate of the College of William and Mary, where she received a Bachelor of Arts in English. She was trained in Appreciative Inquiry by Dr. David Cooperrider at the Taos Institute.
Robert “Bob” T. Van Hook, MSPH, FASAE, CAE, principal and co-founder of Transition Management Consulting, Inc. is an association executive and consultant with over 30 years’ experience leading complex organizations at national, state, and local levels.

Bob started his career in healthcare, becoming an expert in rural and public health. He has held numerous roles, including as a medical group administrator, primary care executive, and program director in a state health department leading primary care and black lung programs. He has been a social worker and performed environmental health work in a community health center.

Bob is a highly skilled transition leader, having completed over a dozen interim executive assignments with American Geophysical Union, American Institute of Architects, Washington Center for Psychoanalysts, Council for Landscape Architectural Registration Boards, Association of State and Provincial Policy Boards, Center for American Nurses, Association for Healthcare Philanthropy, American Nurses Credentialing Center, Society of Vascular Technology, and Society of Interventional Radiology. Bob achieved significant outcomes during these engagements, as well as during his service as executive director and national health policy leader for two national associations.

A skilled communicator, Bob has appeared on “The Today Show” and “Good Morning America” and has published numerous articles on healthcare, association management, and executive transitions.

Bob became a Certified Association Executive (CAE) in 1988. In 2001, the American Society of Association Executives (ASAE) selected Bob as a Fellow, a designation conferred on only ~300 association executives worldwide.

Bob earned a Master of Science in health administration (MSPH) from the University of North Carolina at Chapel Hill and a Bachelor’s degree in American Studies from the University of South Florida.

Additional contributors to this initiative include Michael Eder, Mary Logan, and Nathan Williams.
APPENDIX C – SUMMARY OF KEY RECOMMENDATIONS

Operating under the principles of collaboration, stakeholder involvement, and shared resources, a virtual GCOE would focus on four primary roles: convener, aggregator, supporter, and communicator. The Center’s responsibilities would include, among other things:

- Convene stakeholders
- Aggregate and develop knowledge, including evaluations and research
- Share resources and best practices
- Offer training and providing technical assistance to training programs and trainers
- Communicate the value and importance of the biomedical equipment technician role
- Advocate for and raise awareness of the biomedical equipment technician profession globally

Additional recommendations include the following:

**Training Programs**
- Establish standards for training programs and compare programs against standards
- Assess trainers and students regularly
- Implement continuous process improvement efforts
- Determine appropriate numbers of students to be trained

**Trainers**
- Identify trainer competencies
- Evaluate trainers against the competencies
- Collect and develop training aides
- Provide continuing education and support

**Students**
- Identify student competencies
- Evaluate students against the competencies
- Identify students with the greatest aptitude and potential for success
- Provide training aides to students
- Develop a pipeline of future students

**Technicians**
- Identify global technician competencies
- Provide continuing education and support
APPENDIX D – TRAINING ADULT LEARNERS

Malcolm Knowles (1980, 1984) wrote extensively on adult education and popularized the concept of “andragogy,” the art and science of helping adults learn (in contrast to “pedagogy,” the art and science of helping children learn). Knowles theorized that an adult learner moves from dependency to self-directedness as she or he matures and is able to direct her or his own learning. Presumably, this learning occurs in tandem with an increasing confidence level. Knowles suggests that learning programs move from more to less structure, from less to more responsibility, and from more to less direct supervision that challenges the student without overloading the student. Self-directed learning is an important characteristic of sustainability for this initiative. Knowles identified six principles of adult learning. Adult learners: 1) are internally motivated and self-directed; 2) bring life experiences and knowledge to learning experiences; 3) are goal oriented; 4) are relevancy oriented; 5) are practical; and 6) like to be respected.

<table>
<thead>
<tr>
<th>Comparison of Pedagogical and Andragogical Concepts of Learning</th>
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</thead>
<tbody>
<tr>
<td><strong>Pedagogy</strong></td>
</tr>
<tr>
<td>Learner</td>
</tr>
<tr>
<td>Learner dependent on instructor for learning</td>
</tr>
<tr>
<td>Instructor is responsible for what is taught and how it is</td>
</tr>
<tr>
<td>learned</td>
</tr>
<tr>
<td>Instructor evaluates learning</td>
</tr>
<tr>
<td>Learner’s Experience</td>
</tr>
<tr>
<td>Learner has little useful experience to tap for learning</td>
</tr>
<tr>
<td>The instructor’s experience is most influential</td>
</tr>
<tr>
<td>Didactic method is used</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Readiness to Learn (RTL)</td>
</tr>
<tr>
<td>Students are told what to learn in order to advance</td>
</tr>
<tr>
<td>to the next level of mastery</td>
</tr>
<tr>
<td>Standardized curriculum</td>
</tr>
<tr>
<td>Learning Orientation</td>
</tr>
<tr>
<td>Acquiring prescribed subject matter</td>
</tr>
<tr>
<td>Content is sequenced according to the logic of the subject</td>
</tr>
<tr>
<td>matter (organized by subjects)</td>
</tr>
<tr>
<td>Learning Motivation</td>
</tr>
<tr>
<td>Primarily motivated by external pressures</td>
</tr>
<tr>
<td>(competition for grades, consequence of failure)</td>
</tr>
<tr>
<td>Source: Malcolm Knowles, 1980, 1984</td>
</tr>
</tbody>
</table>

Adult learners are most successful when they are involved, actively participate, and understand how the training will unfold. Instructors present information in new and different ways that are not always linear. Information is reinforced and repeated. Knowles (1984) believed that instructors are most successful when they set a cooperative climate for learning in the classroom; assess the learner’s specific needs and interests; and develop learning objectives based on learners’ needs, interests, and skill levels. Activities should be designed sequentially to achieve the objectives; and the adult educator must work collaboratively with the learner to select methods, materials, and resources for instruction. Further, instructors should provide opportunities for learning exchanges between students, and between students and instructors, in which the student shares knowledge and experiences and the instructor facilitates the learning process, provides structure, and shares knowledge and experience. Finally, the instructor should evaluate the learning experience, make adjustments, and assess future learning needs.
APPENDIX E – FINANCING AND FUNDING

There are many types of fundraising and financing mechanisms, ranging from well-developed and understood to new, complex, and innovative strategies. This section describes a range of funding mechanisms and explains which strategies might be useful to consider in the immediate timeframe.

Funding strategies must take a two-pronged approach focusing on targeted populations (why) and targeted donors (who). Funding requests should demonstrate creative ideas, a clear rationale, a reasonable potential for success, and a commitment to a philanthropic end. Funds raised through any mechanisms can fund projects (how) ranging from training curriculum development to student tuition and fees reduction to smartphone app development.

A successful fundraising strategy usually will include a mix of donors, both individual donors with low and high wealth and foundations, including corporate, philanthropic, family, and associations. Direct personal appeals can be productive, but they are time consuming and require key individuals to gain access to those individuals. Donors can open doors to other donors. A “donor get a donor” strategy is highly effective, but it requires champions. Small dollar donors have proven extremely effective for charities, nonprofits, and political campaigns on a relatively small level. One way to access those donors is through a social media campaign using crowdfunding technologies.

**Microfinance**

Bangladeshi Professor and Nobel Peace Prize winner Muhammad Yunus began the first microcredit institution in 1976 with the goal of reducing poverty by providing small loans to the country’s rural poor. Microcredit, now referred to as microfinance, is a general term to describe financial services to low-income individuals or to those who do not have access to typical banking services. Microfinance has evolved and now provides credit to the poor, along with a number of other services including savings, insurance, remittances, financial literacy training, and skills-development programs.

According to the review by Duvendack, Palmer-Jones, Copestake, Hooper, Loke, and Rao (2011), there have been four major reviews examining impacts of microfinance. These review concluded that rigorous quantitative evidence on the type and scale of microfinance impact is scarce and inconclusive. Proponents of microfinance say it provides low-income individuals access to financial services and an opportunity to lift themselves out of poverty. Opponents, however, estimate that it adds to the burden of debt for people without business skills, causing much of the borrowed money to go toward daily living (food, water). It does not represent a capital investment.

Opponents of microfinance, such as Jason Hickel (2015), also say, “When micro-loans are used to fund new businesses, budding entrepreneurs tend to encounter a lack of consumer demand. After all, their potential customers are poor and low on cash. What little money they have to spend, they spend on food and other necessities. In this context, new businesses end up displacing already-existing ones, yielding no net increase in employment and incomes. That is the best of the likely outcomes. The worst – and much more likely – is that the new businesses fail, which then leads, once again, to vicious cycles of over-indebtedness that drive borrowers even further into poverty.” Recently, investigations into microfinance lenders have raised the possibility that companies are using heavy-handed tactics that have resulted in a number of suicides.
One of the elements of a micro-loan is that the borrower is seeking funds from her or his neighbors. The connection to community and peer pressure induces or some say coerce borrowers to repay their loans. It is difficult to envision the use of microfinancing for funding biomedical equipment technician training because of the inherent poverty in these communities. Skills migration is also a concern. For example, the goal to train biomedical equipment technicians to work in public facilities in low-resource settings is a worthy one. Although training programs and governments can provide incentives for graduates to stay put, the reality is that once trained, the technicians may choose to relocate to higher wage locales. If the technician departs, she or he may not feel an obligation to repay the loan, causing an unintended local consequence of further indebtedness and poverty.

*Microfranchising*

Microfranchising is a business model that applies elements and concepts of traditional franchising to small businesses in the developing world. It refers to the systemization and replication of small-scale enterprises.

Every country has some number of individuals with the resources to invest in a worthwhile business model. After graduating from a biomedical equipment technician program, graduates interested in creating their own independent repair businesses could take additional courses to learn business skills. With support and encouragement from organizations, donors, private investors (equipment manufacturers, parts suppliers, and related industries), capital might be made available for local projects. A challenge associated with this strategy is competition by existing service repair organizations.

Additionally, according to stakeholders, corruption is an issue in many countries. It would be important to understand the local reality and business climate at the micro level. Again, this is a time-consuming strategy, but it could help to address long-term sustainability.

*Public-Private Partnerships*

According to the World Bank, public-private partnerships (PPP) (2015) are typically medium- to long-term arrangements between public and private sectors that enable governments to procure and implement public infrastructure and/or services by using the resources and expertise of the private sector. The partnerships are based on clear agreement of shared objectives. The public and private sectors each provide skills and resources and share the risks and responsibilities of the project. The partnership enables governments to benefit from private sector expertise, allowing them to focus instead on policy, planning, and regulation by delegating day-to-day operations.

One public-private venture spawned the development of a commercial-sized oxygen plant at the Musanze District Hospital, Rwanda. The hospital now produces its own oxygen and sells it to neighboring hospitals and suppliers. The partners included Health Builders, the GE Foundation, UNICEF, the Center for Global Safe Water at Emory University, the Rwandan Ministry of Health, and others.

*Aid and Development Finance Institutions*

Biomedical equipment training programs have received funds from aid and development agencies, including the German Technical Cooperation Agency (GTZ, pronounced GT Zed) and Japan International Cooperation Agency (JICA).
The biomedical equipment training community should consider engaging government agencies and exploring the feasibility and desirability of creating wrap-around programs that support other current healthcare efforts. For example, training goals might be tied to broader programs such as AIDS/HIV, Ebola, child and maternal health, and workforce issues. These programs comprise a competitive funding arena largely dominated by funds paid to implementing agencies to perform specific tasks.

**Remittance Payments**

Remittance payments or remittance transfers are common to migrants worldwide who send money electronically to their countries of origin through remittance transfer providers. The funds serve a variety of purposes, including, for example, paying school tuition for children studying abroad, or providing support to family members, addressing emergency needs, paying for online purchases, or purchasing real estate.

Some transfers are paid to businesses, but many or most of transfers are paid to friends and relatives abroad. Approximately six million households in the U.S. alone send personal transfers each year each averaging between $200 and $400, though a substantial number may be much higher; and some households make transfer more frequently than once a year. Clear data is lacking, but researchers estimate that payments range from $12 billion to more than $50 billion annually (Consumer Financial Protection Bureau, 2011).

Globally, the World Bank (2011) estimates that remittance transfers are significantly larger than the flow of official development aid. “Despite a modest decline in remittance inflows to developing countries, these flows have remained more resilient compared with private debt and equity flows and foreign direct investment.” There are several reasons for the resilience of remittances: 1) they are not reliant on only new migrants; 2) remittances are a small part of migrants’ incomes; 3) anti-immigration sentiments and tighter border controls are on the rise, which reduces travel and economic opportunities; and 4) Remittances may be used for investment purposes if the person were to return home.

With a well-crafted marketing campaign to create awareness of the need of biomedical equipment technicians, remittance payees could be asked to donate funds at the point of remittance. Remittance transfer providers could be asked to donate their services as a gesture of goodwill, which they might be willing to do because of a recent focus on the industry by the U.S. consumer watchdog agency, Consumer Financial Protection Bureau.

Given the size of the remittances, even small donations would add up. Consider, for example, 6 million households who make remittance payments averaging $300 per transaction and totaling $1.8 billion dollars. If the initiative were able to capture 0.01 percent of those funds, it would take in $18 million, and at 0.05 percent, $90 million. Put another way, 0.05 percent of $12 billion industry, the low end of the estimated value of the industry would equal $120 million at 0.01 percent and $600 million at 0.05 percent. These amounts would be accrued in the U.S. alone. The numbers worldwide are staggering. The International Fund for Agricultural Development (IFAD) (2006) estimates that 150 million migrants worldwide sent some $300 billion to their families in developing countries during 2006 in more than 1.5 billion separate financial transactions. IFAD suggests that increased efforts should be undertaken to leverage remittance flows for greater development impact.
Social Funding, Crowdfunding

Massolution’s Crowdfunding Industry Report states that the crowdfunding industry raised $2.7 billion in 2012, across more than one million individual campaigns globally. In 2015, the industry is projected to raise over $5 billion. The largest campaign to date purportedly raised $8.6 million from 63,416 backers in less than a month, although the median amount raised is less than $5,000 per campaign.

There are two main models or types of crowdfunding, donation-based and investment-based. First, donation-based funding allows funders to donate toward a collaborative goal based on a return of products, benefits, or rewards. This was the original idea behind crowdfunding. The second and more recent model is investment crowdfunding, which allows businesses that seek capital to sell ownership stakes online in the form of equity or debt. In this model, individual funders become owners or shareholders and have a potential for financial return, unlike in the donation model. In some instances, investors receive a product from the company in which they invest. There are as many as 800 crowdfunding sites and more come online all the time. Each has its own business model, fee structure, and focus. The ones listed here focus on nonprofits and startups.

<table>
<thead>
<tr>
<th>Site Name</th>
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<th>Type</th>
<th>Purpose and/or Target Audience</th>
</tr>
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<tbody>
<tr>
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<td>Investment</td>
<td>Tech startup</td>
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<tr>
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<td>Donation</td>
<td>Causes and charities</td>
</tr>
<tr>
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<td>Donation</td>
<td>Donations to easy to help students in need</td>
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<tr>
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<td>Donation</td>
<td>Nonprofit fundraising site</td>
</tr>
<tr>
<td>Fundable</td>
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<td>Investment</td>
<td>Start-ups raising investor capital</td>
</tr>
<tr>
<td>GiveForward</td>
<td><a href="http://www.giveforward.com/">http://www.giveforward.com/</a></td>
<td>Donation</td>
<td>Nonprofit fundraising</td>
</tr>
<tr>
<td>GoFundMe</td>
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<td>Donation</td>
<td>Causes, charities, personal campaigns</td>
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<td>Indiegogo</td>
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</tr>
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<td>Kickstarter</td>
<td><a href="http://www.kickstarter.com/">http://www.kickstarter.com/</a></td>
<td>Donation</td>
<td>Creative projects, not businesses or causes</td>
</tr>
<tr>
<td>Kiva</td>
<td><a href="http://www.kiva.org/">http://www.kiva.org/</a></td>
<td>Micro-lender</td>
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<tr>
<td>Quirky</td>
<td><a href="https://www.quirky.com/">https://www.quirky.com/</a></td>
<td>Donation</td>
<td>Collaboration site for crowdfunding projects</td>
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<tr>
<td>Razoo</td>
<td><a href="http://www.razoo.com/">http://www.razoo.com/</a></td>
<td>Donation</td>
<td>Causes, nonprofits, or charities</td>
</tr>
<tr>
<td>YouCaring</td>
<td><a href="http://www.youcaring.com/">http://www.youcaring.com/</a></td>
<td>Donation</td>
<td>Compassionate crowdfunding website</td>
</tr>
</tbody>
</table>

Crowdfunding is a low-cost fundraising tool for fund generation. In all instances, a comprehensive and engaging fundraising pitch is essential. The initial target audience begins with a circle of influencers. Using social media and direct appeals, the audience expands out, collecting supportive donors along the way. This type of funding requires a campaign strategy, business plan, a concise pitch, a well-managed campaign, and near constant communications with the network.

Social Impact Investing and Social Impact Bonds

According to the Global Impact Investing Network (GIIN), “Impact investments are investments made into companies, organizations, and funds with the intention to generate a measurable, beneficial social or environmental impact alongside a financial return.” The first priority is to create a measurable social impact, coupled with the potential for a financial return on investment (ROI). Proponents believe that market-based mechanisms (capital to small businesses and social enterprises) can contribute scalable solutions to a number of global problems.
A socially responsible investment strategy offers a bridge between philanthropic donations and risk adjusted, profit-seeking investments. Credit Suisse’s Gregory Fleming (2012), states, “Approaches to philanthropy seem to be changing, with people like Bill Gates, Richard Branson, and George Soros increasingly relying on entrepreneurial approaches to tackling various social and environmental issues.” To date, social impact investing has been limited to large private clients, family offices, and foundations.

Social Impact Bonds, a type of impact investing, operates under a “Pay for Success” model through which investors invest and manage public projects. The goal of these projects is to improve social outcomes for at-risk countries in the hope of reducing government spending in the end (Hartley, 2014).

One type of social impacting investing is the government-issued Diaspora Bond, which target investors who left their homes to live in other countries. For example, Italy sells bonds to Italians living abroad or of Italian descent. Thus far, governments have not been successful in using Diaspora Bonds to fund programs, in part because of the lack of information and education about the bonds. Using Diaspora Bonds to fund training is remotely possible. Given the level of remittance payments made by individuals living abroad to their home countries, that strategy may be more fruitful.

Social impact investing and impact bonds are time-consuming strategies. If successful, however, they might help to address long-term programmatic sustainability. They might be worthwhile strategies to engage in when training programs are at a more mature point, particularly after the Community conducts more research and demonstrates success.

In closing, the specifics of any particular idea are not as important as the potential to think creatively about funding sources and mechanisms.
APPENDIX F – 2015 STAKEHOLDER MEETING SUMMARY

The *BMETs in low resource countries: 2015 stakeholder meeting summary* is attached in its entirety. The original pagination of the summary is retained.
2015 Stakeholder Meeting Summary

BMETs in Low Resource Countries

Prepared for the
The GE Foundation and the AAMI Foundation
FINAL 07/31/15

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TABLE OF CONTENTS

EXECUTIVE SUMMARY ........................................................................................................................... 3
BACKGROUND .............................................................................................................................................. 5
GE FOUNDATION INITIATIVES .............................................................................................................. 5
AAMI FOUNDATION INITIATIVES ......................................................................................................... 6
CONVENING THE 2015 STAKEHOLDER MEETING ............................................................................. 7
STAGE SETTING ........................................................................................................................................ 8
NETWORKING DINNER ............................................................................................................................ 8
INITIAL VISION ......................................................................................................................................... 9
INTERVIEW SUMMARY .......................................................................................................................... 9
ADVICE FROM THE CHIEF MEDICAL DIRECTOR .............................................................................. 10
PARTICIPANT WORK GROUPS ............................................................................................................... 10
MEETING FINDINGS .................................................................................................................................. 10
SETTING THE AGENDA: DEFINING SUCCESS .................................................................................. 10
IDENTIFYING THE CURRENT STATE: SWOT ANALYSIS ................................................................ 11
IDENTIFYING CRITICAL FACTORS OF SCALABILITY, REPLICABILITY, AND SUSTAINABILITY .... 14
STRATEGY DEVELOPMENT: CREATING THE FUTURE .................................................................... 19
ACTION PLANNING ............................................................................................................................... 19
NEXT STEPS ............................................................................................................................................ 22
ACKNOWLEDGEMENTS ....................................................................................................................... 22
CONCLUSION ........................................................................................................................................... 22
APPENDIX A – PARTICIPANT ROSTER ............................................................................................... 24
APPENDIX B – ABOUT PROJECT CONSULTANTS ............................................................................. 29
APPENDIX C – STAKEHOLDER MEETING AGENDA ........................................................................... 30
EXECUTIVE SUMMARY

Without technology that supports diagnosis and treatment, patients are vulnerable to needless pain and suffering, poor health outcomes, and even death. Timely access to emergency care and the use of diagnostic and therapeutic tools reduces patient mortality. Yet much of the available equipment in low resource countries is not functional. The World Health Organization (WHO) estimates that in Sub-Saharan Africa alone, as much as 70 percent of all laboratory and medical equipment is partially or completely out of service at any given time. A 2011 study by Perry and Malkin estimates the number is closer to 40 percent. However, the GE Foundation’s Chief Medical Officer David Barash, MD, points out that even one piece of equipment out of service is too many for any patient. A primary cause of this significant problem is the lack of skilled biomedical equipment technicians1 (BMETs) able to analyze, maintain, repair, and upgrade the equipment used to diagnose and treat patients. This problem is particularly acute in low resource countries.

In response to this issue, the GE Foundation and the AAMI Foundation are collaborating to develop recommendations for training models in low resource countries that are scalable, replicable, and sustainable within the next 3-5 years. The key goals of the joint project are 1) training more BMETs overall; 2) training BMETs more quickly; and, 3) creating a system of ongoing professional support and development for trained BMETs.

As a part of the data gathering phase for this project, the GE Foundation and the AAMI Foundation convened a group of 55 international stakeholders interested in training and supporting BMETs in low resource countries. This report summarizes the findings from the June 11-12, 2015, meeting held in Toronto, Canada and creates a call to action for medical, engineering, academic, philanthropic, and development communities to collaborate to address the critical need for trained BMETs in low resource countries.

Participants stated that an ideal training model that is scalable, replicable, and sustainable would include a requirement that training programs build partnerships and engage a network of interested people and organizations across academia, hospitals, governments, funders, NGOs, associations, communities, and other targeted groups to garner funding and other necessary resources.

Further, training programs should focus on vetting, developing, and continuously evaluating trainers to ensure that students are receiving appropriate training by competent trainers. Program faculty must possess both theoretical and practical knowledge and experience; be able to bridge the gap between theory and practice; and have an understanding of pedagogical approaches and learning strategies. Further, faculty must understand and know how to address complex infrastructure challenges that require fitting trained BMETs into a low resource system that has its own challenges that, when not addressed, impact the success of trained BMETs; and be committed to developing and empowering students.

1 A Biomedical Equipment Technician, also referred to as a Biomedical Engineering Technician/Technologist (BMET) or Biomedical Equipment/Engineering Specialist (BES or BMES), is typically an electro-mechanical technician who ensures that medical equipment is well maintained, properly configured, and safely functional. In hospital or clinical environments, BMETs often work with Clinical Engineers. http://www.aami.org/productpublications/ProductDetail.aspx?ItemNumber=924
committed to their own growth and development. Ideally, the trainers will be local, able to converse in the local language, understand local customs, and have a local network on which to rely.

The programs also must focus on the student life cycle from pre-admission to professional BMET. They must recruit and admit students with the greatest likelihood of success in the training program and profession, both in terms of aptitude and attitude. Pre-assessment and routine evaluations are critical factors to success.

The healthcare technology management (HTM) field\(^2\) should advocate for and raise awareness of the global HTM profession by collecting success stories and then communicating those stories broadly. Further, they need to take responsibility for developing a core curricula based on valid research and international standards on which local training programs can rely. Additional research on health outcomes is necessary to demonstrate the impact of the work BMETs do and support the technician’s credibility among their peers.

Meeting participants recognize the significant work required in order to build a scalable, replicable, and sustainable BMET training model. This meeting revealed a core group of committed individuals who are willing to contribute to doing that work and address the pressing need for trained BMETs in low resource countries.

The participants identified six strategies as critical next steps, including:

1. Create an international advisory body to assure quality of BMET training based on core competencies.
2. Create a global alliance that focuses on the promotion of the HTM profession in low resource countries.
3. Ensure the strict selection of BMET trainees and trainers.
4. Engage multiple stakeholders and funders to promote BMETs.
5. Create sustainable, scalable funding strategies for BMET training to improve public health outcomes.
6. Define metrics for BMET health impact and outcomes.

The six strategies identified by the participants provide the impetus for further discussions. While the community can address some tasks quickly, others will require considerable time and effort. To date, securing funding for training has not been easy, and funding for community building will likely be more difficult to garner. Nonetheless, the work done in the field thus far must continue, and it must be better organized and supported. Creating a training model that is scalable, replicable, and sustainable in low resource countries requires the entire stakeholder community to work together for this common purpose.

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\(^2\) Healthcare technology management (HTM) is the official name of the professional field responsible for managing the selection, maintenance, and safe and effective use of medical equipment and systems. The field includes biomedical equipment technicians, clinical engineers, clinical equipment specialists, biomedical equipment specialists, imaging equipment specialists, laboratory equipment specialists, and others who protect patient safety, and reduce healthcare costs related to technology. http://www.aami.org/productpublications/ProductDetail.aspx?ItemNumber=924
BACKGROUND

Without technology that supports diagnosis and treatment, patients are vulnerable to needless pain and suffering, poor health outcomes, and even death. Timely access to emergency care and the use of diagnostic and therapeutic tools reduces patient mortality. Yet much of the available equipment in low resource countries is not functional. The World Health Organization (WHO) estimates that in Sub-Saharan Africa alone, as much as 70 percent of all laboratory and medical equipment is partially or completely out of service at any given time. A 2011 study by Perry and Malkin estimates the number is closer to 40 percent. However, GE Foundation’s Chief Medical Officer David Barash, MD, points out that even one piece of equipment out of service is too many for any patient. A primary cause of this significant problem is the lack of skilled biomedical equipment technicians (BMETs) able to analyze, maintain, repair, and upgrade the equipment used to diagnose and treat patients. This problem is particularly acute in low resource countries.

In response to this issue, the GE Foundation and the AAMI Foundation are collaborating to develop recommendations for the creation and deployment of an efficient and scalable training model in low resource countries within the next 3-5 years. The key goals of the joint project are 1) training more BMETs overall; 2) training BMETs more quickly; and, 3) creating a system of ongoing professional support and development for trained BMETs.

As a part of the data gathering phase of this project, the GE Foundation and the AAMI Foundation in June 2015 convened a group of 55 international stakeholders interested in training and supporting BMETs in low resource countries. This report summarizes the findings from the June 11-12, 2015 meeting held in Toronto, Canada, and creates a call to action for medical, engineering, academic, philanthropic, and development communities to collaborate to address the critical need for trained BMETs in low resource countries.

GE Foundation Initiatives

The GE Foundation (GEF) (http://www.gefoundation.com/), the philanthropic organization of GE, is committed to building a world that works better. GEF empowers people by helping them build the skills they need to succeed in a global economy; equipping communities with the technology and capacity to improve access to better health and education; and elevating ideas that tackle the world’s toughest challenges to advancing economic development and improving lives. The generosity and talent of GE’s employees supports the work of the GE Foundation.

The Developing Health Globally™ (DHG) program is GEF’s signature philanthropic program that aims to improve access to quality healthcare for some of the world’s most vulnerable populations. Established in 2004, the DHG program strengthens healthcare systems in the developing world by upgrading equipment and infrastructure, and providing ongoing training and support to ensure success and sustainability. GEF creates sustainable impact through smart investing and leveraging of GE expertise and engaging committed partners. DHG works to enable the delivery of quality healthcare to more people around the world by strengthening the health systems that serve them.

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4 The World Bank Atlas methodology defines low resource countries for fiscal year 2016 as low-income economies with a gross national income (GNI) per capita of $1,045 or less in 2014; middle-income economies are those with a GNI per capita of more than $1,045 but less than $12,736; high-income economies are those with a GNI per capita of $12,736 or more. Lower-middle-income and upper-middle-income economies are separated at a GNI per capita of $4,125.
In partnership with Engineering World Health and Developing World Healthcare Technology Laboratory at Duke University, DHG is developing local biomedical technology training programs for BMETs to identify trainers and local infrastructure to create *in-country* (local) training to cultivate a professional community of biomedical technicians. In resource-poor settings, DHG is developing local biomedical technology training programs; partnering with Ministries of Health to identify trainers and local infrastructure to create in-country training; and providing ongoing coaching and mentoring resources to cultivate a professional community of biomedical technicians. To date, these efforts have trained 200 BMETs in four countries: Cambodia, Ghana, Honduras, and Rwanda.

DHG is actively working to further the impact of the BMET program and develop a more expeditious, scalable, and cost-effective model for global implementation.

**AAMI Foundation Initiatives**

The Association for the Advancement of Medical Instrumentation (AAMI) and the AAMI Foundation (http://www.aami.org) are leaders in supporting the healthcare technology management (HTM) field by providing training and professional certifications (e.g., CBET), and nationally respected and recognized credentials. AAMI has assessed the needs and gaps in education and brought respected leaders together to determine ways of improving medical device safety and support and to improve and standardize the training and skillset for individuals working with medical devices. AAMI also has made it a priority to bring recognition to the field through a number of initiatives.

In 2011, AAMI convened a group of experts at a “Future Forum I” meeting to develop a shared vision of the field and activities that would help move the field forward. Efforts continued in 2012 at “Future Forum II” as AAMI worked to advance the field and establish a vision. Combined, the Future Forum meetings resulted in

- establishing a unifying name for the field, “Healthcare Technology Management” (HTM), which includes clinical engineers, biomedical equipment technicians, clinical equipment specialists, biomedical equipment specialists, laboratory technicians, imaging technicians, and others who manage healthcare technology;
- identifying both opportunities and challenges for the field and the professionals working in it; and
- developing and implementing a business plan to support the continuing evolution and growth of the HTM field as a profession.

In 2013, AAMI launched the “I am HTM” campaign (http://www.aami.org/iamhtm/), a major initiative to promote the value of the HTM field to hospital executives, clinicians, information technology personnel, and prospective students. The campaign includes marketing materials to promote the field. All of these materials are available free of charge on AAMI website.

Other outcomes of the Future Forum meetings include

- Developing career ladders.
- Developing core competencies for BMET training to guide BMET education programs in developing core curriculum and helping BMETs and their employers with career planning, hiring, and development opportunities.
- Developing promotional materials for outreach to external audiences.
- Developing standardized job descriptions.
- Establishing a robust website (www.aami.org/htmconnect).
• Publishing *HTM Levels Guide: A Program Planning Tool for HTM Departments*.

In 2014, AAMI convened Future Forum III, a two-day expert meeting to identify the education and training gaps of US-based clinical engineers and BMETs. The outcome was the identification of steps to bridge those gaps. Jackie Eder-Van Hook, PhD, of Transition Management Consulting, Inc., the lead consultant on this joint GE Foundation-AAMI Foundation project, facilitated Future Forum III.

The AAMI Foundation offers annual scholarships to BMET and clinical engineering students as one more way to support the ongoing growth and professionalism of the HTM field overall.

AAMI has continued to focus its efforts with strategic plan goals to strengthen the skillsets, credentials, academic experiences, stature, and recognition of HTM professionals in healthcare delivery and to increase its training programs worldwide to keep up with the current trend of globalization. AAMI also has several programs and initiatives aimed at attracting a diverse membership.

AAMI is pursuing opportunities to hold training courses abroad and provide easier access to healthcare professionals seeking more in-depth training from an industry leader. Foundational elements of all of these efforts and other strategic priorities are advancing the safety of healthcare technology, improving patient outcomes, and saving lives.

**Convening the 2015 Stakeholder Meeting**

As part of its role in the joint GE Foundation-AAMI Foundation initiative to enhance BMET training and support in low resource countries, the AAMI Foundation is seeking to understand the current state of BMET training in low resource countries and to build a broader global HTM community by identifying and interviewing key stakeholders. Toward that end, in April 2015 the AAMI Foundation identified and invited approximately 75 individuals to attend a stakeholder meeting to coincide with the 2015 IUPESM conference, an international professional meeting held in Toronto, Canada in June 2015. The purpose of the meeting was to solicit data from key stakeholders to answer the question, “In three to five years, how can we create a scalable, replicable, and sustainable BMET model that trains and employs quality biomedical technicians in low resource nations around the world?”

This report summarizes the discussions and findings from that meeting. It also creates a call to action from the collective voice of the attendees for medical, engineering, philanthropic, academic, governmental, and development communities to collaborate to address the lack of trained BMETs in low resource countries.

Despite the short lead-time, distance, cost, and visa requirements, 55 stakeholders attended the meeting. Participants expressed that, although they had a shared passion for the subject and many of them knew one another, they had not ever come together for this common purpose.

Overall, participants expressed a strong sense of gratitude and support for the convening of the meeting and its outcomes. There was an audible “buzz” at the pre-meeting dinner and throughout the meeting itself with strong positive feedback. The broadly-held genuine interest in, commitment to, and concern for in the topic was evidenced in part, by the fact that participants who had to leave for other conference
obligations during the meeting returned once those obligations were completed. Most participants, many of whom had spent the week attending the 2015 IUPESM conference, and some of whom attended the 2015 AAMI annual conference the prior week, stayed until the stakeholder gathering ended on a Friday afternoon. A participant roster is included in Appendix A.

The participants provided critical information to create a fuller understanding of the system in which HTM professionals now operate in low resource countries. Perhaps even more significant outcomes of this stakeholder meeting were convening the international stakeholder community, garnering project buy-in, and setting the stage for future activities to occur.

Overall, participants wanted to understand both the obstacles that prevent people, governments, and organizations from training more BMETs and the requirements for the achievement of measurable and sustainable improvements in outcomes. They specifically wanted to develop a vision, identify educational needs and opportunities, develop core curricula, and create action plans.

Participants were clear in their desire for the development of a vision to create a realistic, adaptable, and sustainable training model that builds BMET capacity; creates shared responsibilities on the clinical care team; and improves patient outcomes in low resource countries.

Over the course of the meeting, the need to articulate and document the current global environment for BMETs also became clear. Each participant seemed to have a unique understanding of one aspect of the system. For example, one person may understand the student cycle (identification, recruitment, training, support, development, and graduation), while another person understands the intricacies of public policy and regulations. Prior to this meeting, the various communities have not interacted in any formal way to share their perspectives. Identifying additional stakeholders and articulating their needs and requirements is a critical aspect of the joint initiative.

### STAGE SETTING

#### Networking Dinner

Meeting participants gathered for a networking reception and dinner on June 11. Mary Logan and Asha Varghese welcomed the participants, delivered opening comments, and described the project goals: 1) training more BMETs overall; 2) training BMETs more quickly; and, 3) creating a system of ongoing professional support and development for trained BMETs. Ms. Logan introduced the project lead, Jackie Eder-Van Hook, PhD who introduced her co-facilitator Chris Love. Consultant bios are included in Appendix B.
Initial Vision

At dinner, Eder-Van Hook began her remarks by stating that conducting BMET training in low resource countries sounds so simple, but, in reality, it is quite complex. She then presented an initial project vision statement, to which there was widespread agreement by participants.

In three to five years, we have a scalable BMET model that trains and employs quality biomedical technicians in low resource nations around the world. The BMETs are respected members of the clinical care team and hospital staff and have access to a system of ongoing professional support and development. Equipment is available and appropriately utilized for positive patient outcomes.

Interview Summary

Eder-Van Hook then shared the highlights of more than 30 hours of interviews she conducted to learn about the issues surrounding BMET training in low resource countries, inform the agenda setting, and, ultimately, the development of the model. Interviewees included BMETs, trainers, and individuals from academia, government, NGOs, associations, and the private sector. Eder-Van Hook briefly summarized what she had heard from interviewees focusing on the students, faculty, graduates, and facilities.

Students come from diverse backgrounds. A few have technical backgrounds, although most do not. Some have attended school, but in Cambodia, for example, the students may only have 5-9 years of education. Some speak English, but most are not fluent and some are unable to comprehend technical instructions in English. Some are not fluent in the local language, and may not be literate in their own language. Few have technical skills, although some arrive with mechanical skills such as those who served as the hospital “handyman” or those who had been electronics technicians outside of healthcare. Students arrive at the trainings with limited skills in math, computers, and rarely have budget, management, or soft skills (communications). Students face challenges and significant pressures in attending the trainings, and yet they find a way to participate overcoming resource needs, language, literacy, family and community support, transportation, and lodging.

Skilled Trainers and Faculty. Skilled trainers are lacking in most of the countries mentioned. In some instances, even after completing a Train-The-Trainer course, they may lack hands-on skills needed to demonstrate how to repair a piece of equipment. One interviewee described a trainer taking two class sessions to demonstrate a repair and still being unsuccessful. Undoubtedly, it was frustrating for the trainer and students. Some of the trainers strive to become university professors once they have gained more experience, a fact that reduces the number of in-country trainers and effects the ability of training programs to expand the number of graduates and achieve programmatic sustainability.

Graduates. Program graduates may find it difficult to find wage paying jobs. They may not be paid any more than when they served as the hospital handyman, a demoralizing situation for one graduate in Honduras. There is limited upward mobility for the graduates. They may not receive the respect or support of health care providers in their facilities. Culturally, they may find it difficult to educate doctors and nurses on issues such as operator or use errors.
Clinical Facilities. Facilities may be operating under centralized health systems giving staff inadequate control. They may not know that BMETs exist, have a budget to hire BMETs, or pay for parts, if, in fact, they are able to order parts. BMETs are often left to figure out their roles, how to make things work with makeshift resources and tools/parts, and with an expectation that they do many other tasks beyond managing healthcare technology simply because of their technical skills.

Interviewees described the students, trainers, and graduates as talented, bright, and motivated people. They spoke of them with admiration, affection, and even amazement at what they are able to accomplish under difficult and low resource conditions.

Advice from the Chief Medical Director

GE Foundation’s Chief Medical Officer, Dr. David Barash spoke briefly to participants about the global need for BMETs. He encouraged them to tackle the issue of inoperable equipment. He challenged them to work to get as close as possible to zero pieces of inoperable equipment. He suggested that the group take a four-step approach to creating a BMET training model. First, do simple stuff. Second, fail fast – implement simple pilot projects and if they do not work, try something else. Third, demonstrate leadership. Lastly, find and work with partners.

Participant Work Groups

The stakeholder meeting was designed in part around three key issues. First, each participant has an important piece of information about current BMET training and/or knowledge of what is missing from that training. The meeting was an opportunity to pull out that information. Second, networking among this group is of critical importance. While some participants are acquainted, conversations of this type and scale have not occurred previously. Lastly, given the length of the meeting and the number of participants, it was important to keep the participants engaged and moving from group to group.

To aid in addressing these issues, the facilitators modified a structured conversation methodology, known as World Café for the meeting. World Café is a creative process for leading collaborative dialogue, sharing knowledge, and creating possibilities for action in groups. The agenda was divided in six major parts, agenda setting, SWOT analysis, identifying critical factors, strategy development, action planning, and next steps. The agenda is included in Appendix C.

MEETING FINDINGS

Setting the Agenda: Defining Success

To begin the full day of work together, participants offered their ideas of what success might look like at the end of the meeting. Interestingly, the visions of success put forward could be seen as a sequence of progressive steps that move beyond the scope of the day well into the future.

- Understand the current situation, gaps, challenges, and scope of the need by critically looking at the environment in which BMETs operate, including public policy, infrastructure challenges, stakeholders, and resources.
- Create a vision, training model, and action plan with SMART goals applicable in low resource settings that are realistic, adaptable, and sustainable with a regional or country approach.

5 SMART goals are specific, measurable, attainable (or assignable), relevant (or results-oriented), and time-bounded.
• Engage and collaborate with stakeholders.
• Utilize consensus building at the local level and beyond.
• Share and learn from each other’s experiences.
• Identify chief challenges, such as what works in the same way in different environments and countries, and what is unique.

The exercise highlighted both the participants’ short- and long-term hopes and set the tone for the day.

**Identifying the Current State: SWOT Analysis**

In an effort to define the current state, participants working in small groups created a SWOT analysis to identify the strengths, weaknesses, opportunities, and threats inherent in current BMET training efforts. They focused on key areas of training, BMET profession, stakeholders and community expertise, funding and other resources, government, communications, and research.

<table>
<thead>
<tr>
<th>Training</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths:</strong></td>
<td>• Students’ desire to learn</td>
</tr>
<tr>
<td></td>
<td>• Quality of expatriate trainers</td>
</tr>
<tr>
<td></td>
<td>• Clinical mentoring and training</td>
</tr>
<tr>
<td></td>
<td>• Curriculum (availability; graphics, design, and organization, quality of materials)</td>
</tr>
<tr>
<td></td>
<td>• Local accreditation</td>
</tr>
<tr>
<td></td>
<td>• Training reflective of local realities, recognition of need to adapt to local conditions</td>
</tr>
<tr>
<td><strong>Weaknesses:</strong></td>
<td>• Accessibility, cost and availability of training (post basic, continuing, practical)</td>
</tr>
<tr>
<td></td>
<td>• Lack of training infrastructure and support</td>
</tr>
<tr>
<td></td>
<td>• Existing structure and systematic approach; top down approach</td>
</tr>
<tr>
<td></td>
<td>• Isolated programs and successes, lack of common approach</td>
</tr>
<tr>
<td></td>
<td>• Lack of quality of teachers in-country</td>
</tr>
<tr>
<td></td>
<td>• Low number of trainees (qualified applicants, low female enrollment)</td>
</tr>
<tr>
<td></td>
<td>• Linguistics</td>
</tr>
<tr>
<td></td>
<td>• Long distance communications</td>
</tr>
<tr>
<td><strong>Opportunities:</strong></td>
<td>• New trainee sources (pre-enrollment education, willingness to learn, demand)</td>
</tr>
<tr>
<td></td>
<td>• Training innovations (mobile technology; virtual; standardized curricula)</td>
</tr>
<tr>
<td></td>
<td>• Availability of academic and training facilities</td>
</tr>
<tr>
<td></td>
<td>• bridge departments (engineering, health science, medical, dental)</td>
</tr>
<tr>
<td></td>
<td>• Develop accreditation standards</td>
</tr>
<tr>
<td><strong>Threats:</strong></td>
<td>• Lack of structured system to support training</td>
</tr>
<tr>
<td></td>
<td>• Lack of linkages to in-country decision-makers</td>
</tr>
<tr>
<td></td>
<td>• Lack of program accreditation</td>
</tr>
<tr>
<td></td>
<td>• Turf wars over standards and who sets the standards</td>
</tr>
<tr>
<td></td>
<td>• Lack of core competencies, complacency resulting in failing competencies</td>
</tr>
<tr>
<td></td>
<td>• Lack of training facilities; no local schools</td>
</tr>
<tr>
<td></td>
<td>• Lack of trainers, externally developed and delivered content</td>
</tr>
<tr>
<td></td>
<td>• Sub-standard practical training component</td>
</tr>
<tr>
<td></td>
<td>• Lack of leadership, management, and finance skills to make business case to c-suite</td>
</tr>
</tbody>
</table>

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6 SWOT analysis is a tool enabling organizations to identify its Strengths and Weaknesses considered internal and controllable factors as well as Opportunities and Threats considered external and uncontrollable factors.
### BMET Profession

<table>
<thead>
<tr>
<th>Strengths:</th>
<th>Local BMETs feel responsible to improve conditions</th>
</tr>
</thead>
</table>
| Weaknesses: | - Weak standards and guidelines  
- Undefined scope of practice  
- Low number of BMETs  
- Poor compensation/incentives (wage scale, compensation, incentives entry/retention)  
- Lack of awareness of need for BMETs (value proposition, health impact, HTM)  
- Few jobs (lack of standardized jobs, job poaching)  
- No career ladder  
- Lack of BMET identity, credibility, and recognition of BMET work  
- Lack of international certification  
- Limited body of knowledge  
- Technology transfer |

| Opportunities: | Demonstrate leadership  
- Abundant volunteers; invite retirees to teach abroad  
- Recruit more female BMETs  
- Links to governments, NGOs, and associations |

| Threats: | Cost of tuition vs. likelihood of employment  
- Incentives leads to migration and “brain drain” from public sector hospitals  
- No defined career path, limited job satisfaction |

### Stakeholders and Community Expertise

| Strengths: | Interest by WHO, GEF-AAMIF 2015 Stakeholder Meeting, and others  
- Goodwill of organizations and NGOs that are willing to support efforts  
- Increased public concern; strong NGO community  
- Creative, innovative use of resources, passion, resourcefulness, community pride  
- Stakeholder buy-in and support (GEF-AAMIF 2015 Stakeholder Meeting; IFMBE CED; WHO, PAHO; ACCE, biomed societies; HTM leaders/ambassadors)  
- Government infrastructure  
- Financial support  
- Access to faculty, trainers, and volunteers  
- Political capital  
- Capacity building focus  
- Talent, motivation  
- Knowledge  
- Expertise in developed countries  
- Existing technical training institutions (Teninty’s 2-year training program)  
- Women in BMET |

| Weaknesses: | Curriculum issues (quality, languages barriers, lack of standardization)  
- Inter-professional training needed for medical and dental profession and BMETS  
- No links between biomedical engineering schools and hospitals |

| Opportunities: | Capacity building  
- Create global community of HTM professionals; find and develop champions  
- Foster cooperation; foster networks for networking, learning, and sharing  
- Increase awareness among major international players; engage corporations  
- Create a level playing field (“World is Flat”) |

| Threats: | Lack of stakeholder buy-in; lack of appreciation by USA medicine  
- Weak linkages (between education and clinical institution, corporations)  
- Lack goodwill of organizations and NGOs that are willing to support efforts  
- Diversity of cultures |
### Funding and Other Resources

**Strengths:**
- None Specified

**Weaknesses:**
- Limited awareness of funding opportunities
- Dependence on donor cycles
- Reliance on unpredictable government budgeting
- Lack of NGO sustainability
- Limited financing
- National training programs
- Limited training resources (materials, tools, resources post training, training facilities)
- Shortage of equipment, parts, tools, and consumables
  - Weak logistics
  - Documentation, access to service and owner’s manuals
  - Lack of availability of leasing or renting equipment
  - Difficult acquisition of equipment, parts, tools, and consumables
  - Lack of financial planning for equipment, parts, tools, and consumables

**Opportunities:**
- Public-private-academic partnerships
- Emerging markets
- Foundation-funded training
- Global web training

**Threats:**
- Lack of training program funding
- Lack of tuition funding
- Lack of availability of short-term funding
- Lack of funded posts
- Shrinking budgets
- Resource availability (service and user manuals, equipment, parts)
- Lack of cultural and language resources
- Lack of associations
- Shortage of equipment, parts, tools, and consumables
  - Difficulty procuring parts and consumables
  - Proprietary equipment complexity (code sharing, software availability)
  - Lack of available technology
  - Vendor restrictions on BMET repairs

### Government

**Strengths:**
- None Specified

**Weaknesses:**
- Various government policy and regulations

**Opportunities:**
- None Specified

**Threats:**
- Social instability, conflict, wars, political instability
- Low political support, buy-in, collaboration
- Insufficient coordination between education and health sectors
- Poor communications
- Abrupt changes in funding and policies
- Corruption, greed, apathy
- Procurement challenges
- Inadequate policy direction

### Communications

**Strengths:**
- None Specified

**Weaknesses:**
- Lack of coordination, centralization of information, shared information

**Opportunities:**
- Share experience and knowledge
- Publish successful cases
- Communicate need for BMETs generally and specifically in low resource countries
- Create jobs
- Improve quality of life

**Threats:**
- None Specified
Identifying Critical Factors of Scalability, Replicability, and Sustainability

Working in small groups, participants reflected on the factors that make BMET training programs scalable, replicable, and sustainable.

**Scalable**

Participants answered the question, “What key factors make a BMET training program scalable?” In answering the question, they considered those programs that have successfully increased the number of students trained and the factors that inhibited the scalability of BMET training programs. They identified essential factors that create a scalable training model, including a strong, adaptable hands-on curriculum taught by skilled trainers, and effective collaborations with essential stakeholders.

**Strong, Adaptable, Hands-On Curriculum Taught by Skilled Trainers**
- Building a strong foundation (body of knowledge, core curricula, and standards of practice).
- Training conducted by skilled trainers who possess both theoretical and practical knowledge and experience; are able to bridge the gap between theory and practice; have an understanding of pedagogical approaches and learning strategies; are committed to developing and empowering students; and are committed to their own growth and development.
- Providing students with a hands-on internship for BMET skills development.
- Integrating evaluation into the systems to drive ongoing improvements.
- Recognizing and appreciating the different needs of countries, regions, populations, and facilities.
- Emphasizing collaboration between engineering and health sciences departments.

**Effective Partnerships with Essential Stakeholders**
- Creating, developing, and fostering partnerships and engagement strategies with and for key stakeholders at the highest levels in each country, while supporting ownership at the local level.
- Creating, developing, and fostering strategic alliances and public-private-academic institutions for greater transparency (less prone to corruption) and legitimacy.
- Fostering institutional buy-in (governments, hospitals, universities, NGOs, associations).

Participants also said that the resources necessary for scalability include access to international standards and best practices, material resources, and support for professional development.

**Access to International Standards and Best Practices**
- Accessing local and international associations, especially in the US, UK, and Canada that are relevant to BMETs for information sharing, training, and networking.
- Creating a global BMET/HTM community for sharing best practices.
- Supporting the creation of “health technology” oversight committees that include BMETs, physicians, and other health leaders.
Access to Material Resources
- Accessing clearly defined set of resources (financial, expertise, information; predictable flow of resources for budgeting purposes).
- Accessing an ongoing continuum of resources to support growth and improvement.
- Accessing local and regional infrastructure necessary to support local efforts.
- Accessing equipment, tools, parts, and consumables.

Access to Support for Professional Development
- Creating a road map for learning (skills development) and career progression.
- Recognizing and receiving support from human resource departments for the role of BMET, the field of HTM, and the leadership it provides.
- Accessing human resources support (continuing education, mentoring, program development, networking, and technological support (computerized maintenance management system (CMMS)).

Participants also identified specific barriers to scalability.

<table>
<thead>
<tr>
<th>Barriers to Scalability</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Students and Faculty/Trainers:</td>
<td>Moving people around</td>
</tr>
<tr>
<td></td>
<td>Lack of knowledge about career and skills development, HTM approach</td>
</tr>
<tr>
<td>Stakeholders:</td>
<td>Lack of institutional buy-in from governments, facilities, and NGOs</td>
</tr>
<tr>
<td></td>
<td>Lack of networking, not as simple as joining professional associations</td>
</tr>
<tr>
<td>Policies:</td>
<td>Lack of a uniform body of knowledge, curriculum, and standards of practice</td>
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<tr>
<td></td>
<td>Lack of individualized approach; different settings, different needs</td>
</tr>
<tr>
<td></td>
<td>Lack of a coordinated approach that uses local and distance learning tools</td>
</tr>
</tbody>
</table>

Replicable

Participants answered the question, “What key factors make a BMET training program replicable in another location (site, region, or country)?” In answering the question, participants considered BMET training programs that have replicated their training programs successfully and the factors inhibiting the replicability of training programs (cultural, social, geographic, students, faculty, literacy, jobs, etc.).

Participant descriptions of factors that support replicability clustered around enhancing training content and trainers, assessing local and country ways and needs, and resolving financial and resource challenges.

Enhancing Training Content and Trainers
- Creating two separate categories of BMET training. One program for technicians already working in hospitals and another to provide initial BMET training. Identifying common/basic elements.
- Establishing regional training hubs equipped with clinical equipment.
- Considering life cycle concepts.
- Identifying HTM core competencies and incorporating into curriculum (technical, communications, physiology, medical terminology, etc.).
- Providing continuing professional development.
- Creating common standards.
- Creating process/roadmap of the steps to develop a BMET program.
- Developing train-the-trainers as champions for BMETs.
- Identifying an international body to recognize BMET programs and gain recognition.
Assessing Local/Country Ways and Needs

- Understanding institutions, especially Ministries of Health by country (differences, regulatory bodies, advocacy groups, educational institutions, clinical).
- Pre-assessing local/country needs (survey training needs, gain lists of non-functional equipment, and other indicators, as appropriate).

Resolving Financial and Resource Challenges

- Addressing compensation issues and identifying retention strategies.
- Acquiring resources to procure tools and test equipment; list of standardized tools.
- Overcoming procurement obstacles.

Participants also identified specific barriers to replicability.

<table>
<thead>
<tr>
<th>Barriers to Replicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training:</td>
</tr>
<tr>
<td>• Lack of vertical replicability within a country</td>
</tr>
<tr>
<td>• Lack of knowledge of key elements of a replicable model</td>
</tr>
<tr>
<td>• Curriculum that does not cover the whole life cycle of equipment</td>
</tr>
<tr>
<td>• Lack of standardized terms</td>
</tr>
<tr>
<td>• Lack of core set of competencies to be achieved at end of training</td>
</tr>
<tr>
<td>• No open menus of standardized courses from which to choose from and adapt</td>
</tr>
<tr>
<td>• Lack of community help to achieve core set of competencies</td>
</tr>
<tr>
<td>Stakeholders:</td>
</tr>
<tr>
<td>• Lack of understanding by the Ministry of Health, key players by country and program</td>
</tr>
<tr>
<td>• No system to maintain community of BMETs</td>
</tr>
<tr>
<td>Policies:</td>
</tr>
<tr>
<td>• Unmet need for work with international bodies to recognize and certify training programs regardless of country</td>
</tr>
<tr>
<td>• No core set of competencies</td>
</tr>
<tr>
<td>• Lack of national policies on BMET training</td>
</tr>
<tr>
<td>Resources:</td>
</tr>
<tr>
<td>• Lack of resources (HR, teaching resources and structure, political structure)</td>
</tr>
<tr>
<td>• No common script/training tool kit</td>
</tr>
<tr>
<td>Other:</td>
</tr>
<tr>
<td>• Low levels of literacy (English, French, and/or local languages)</td>
</tr>
<tr>
<td>• Resistance to one size fits all; flexibility</td>
</tr>
</tbody>
</table>

Sustainable

Participants answered the question, “What factors make a BMET training program sustainable?” In answering the questions, participants considered funding, stakeholders, infrastructure, literacy rates, technological orientation, political-social stability, public-private partnership successes, political systems, champions, knowledge of the role of BMETs, entry level and advanced jobs, faculty/trainers, access to parts, behavior change, culture change, etc.

Responses to this question described many essential qualities of sustainable BMET training. Response themes included engaging the right participants to create responsive, accountable local training. Nurturing the development of the BMET profession and its members is also critical. Other themes that emerged were securing and developing quality trainers, utilizing broad stakeholder support and getting Ministries of Health directly involved in assuring sustainability. Participants consciously considered topics beyond the obvious need for securing financial resources. They discussed funding separately.

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7 Sustainable means the ability to maintain the training at a certain rate or level.
Engaging the Right Participants to Create Responsive, Accountable Local Training

- Providing mechanisms to identify aptitude and test for competency.
- Selecting the “right” local training institute or center of excellence capable of generating funds.
- Utilizing assessments, including a mechanism for feedback between education and health sectors to match the needs on the ground with the training provided.
- Establishing a strategic alliance between academic institutions and healthcare facilities, including a link between schools of engineering and hospital/teaching institutions.
- Fostering training programs that grow along a continuum of training.
- Developing local champions, leadership, and a planning process.
- Articulating the needs of the local environment, involving local champions in the entire process.
- Ensuring ownership of training and outcomes by the Ministry of Health and local training facility.
- Assuring a growing, living, and continuous process improvement environment.

Nurturing the Development of the BMET Profession and its Members

- Delineating public vs. private.
- Describing business models whereby BMETS are entrepreneurs and leaders.
- Providing professional advocacy for BMETs.
- Establishing a career path for BMETs.
- Raising the profile and status of BMETs.
- Establishing a career ladder from BMET to PhD.
- Articulating employment opportunities for graduates, including career progression.
- Creating success stories as encouragement.
- Creating a community of professionals who serve as mentors, collaborators, and problem solvers.
- Exhibiting leadership.
- Raising awareness and demonstrating evidence.
- Using science fairs to educate youth and increase awareness of the professional path of BMETs.

Securing and Developing Quality Trainers

- Identifying trainers.
- Vetting potential trainers, ensuring right level of skills and experience, including “hands-on.”
- Building the capacity of local trainers, ideally with hospital and practical, hands-on experience.
- Developing quality standards of training.

Utilizing Broad Stakeholder Support and Collaboration

- Containing a mix of stakeholders with bodies to advocate, certify, and regulate.
- Identifying key stakeholders (HTM, Ministry of Health/Education, academia, private sector).
- Providing networking, including access to BMET societies and creating a support network; providing access to BMETs in the USA, Canada, Europe, etc. for advice and knowledge.
- Creating country-based alliances.

Involving Ministries of Health Directly

- Recognizing the need for public policy at the highest levels.
- Providing definitions of “sustainable” training programs.
- Establishing ownership of training and outcomes by Ministry of Health and training facilities.
Planning for and Accessing Financial Resources

- Utilizing financial planning and resources.
- Mobilizing resources for maintaining the training programs.

Funding

Participants answered two questions. First, “How are BMET training programs currently funded?” Second, “How might BMET training programs be funded in the future?” In answering the questions, participants considered current funding models as well as potential models to fund BMET training. Some ideas offered for consideration included, tuition, hospital/facility paid training fees, school fees, government funding, government aid, foundation funding, corporate initiative, social funding/crowdfunding, micro-financing, micro-franchising, social impact investing, manufacturer fee, or remittance fee.

One training program described the challenges they faced in securing funds for training BMETs in part because of the lack of awareness of BMETs as a profession, the lack of understanding of the importance of and need for BMETs, and other needs deemed more pressing by funders. During the interviews, a staff member from an international aid agency appreciated the need, but was clear that aid was not available unless the project fits within their existing portfolio. However, she did suggest that framing the needs within the existing portfolio might be a successful strategy.

Participants identified the current funding mechanisms for BMET training, including the following:

- Grants or other non-financial contributions from foundations, NGOs
- International aid organizations
- Government funding
- Hybrid funding model (NGOs and government)
- Tuition, other school fees

Participants also offered innovative ideas for potential future funding sources.

<table>
<thead>
<tr>
<th>Future Funding Ideas by Type</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Governments:</td>
<td>Charge government for services now provided for free (e.g., train-the-trainer, internships, consulting to hospitals)</td>
</tr>
<tr>
<td>Facilities:</td>
<td>Tie equipment donations and BMET training to hospital financing&lt;br&gt;Charge local facilities for services now provided for free (e.g., train-the-trainer, internships, consulting to hospitals)</td>
</tr>
<tr>
<td>Trainers:</td>
<td>Training workshops</td>
</tr>
<tr>
<td>Students:</td>
<td>Tuition fee-based through private and public stipends</td>
</tr>
<tr>
<td>Community:</td>
<td>Crowdsourcing within communities&lt;br&gt;Matching funds</td>
</tr>
<tr>
<td>NGOs:</td>
<td>Equipment donations with donor assuming cost of training</td>
</tr>
<tr>
<td>Private Sector:</td>
<td>Manufacturers equipment fees (taxes, equipment discounts free up training funds)&lt;br&gt;Tax breaks to incentivize vendors to finance BMET training&lt;br&gt;Local private sector</td>
</tr>
<tr>
<td>Partnerships:</td>
<td>Public-private partnerships (PPP)&lt;br&gt;National and regional HTM service centers</td>
</tr>
<tr>
<td>Fee for Service:</td>
<td>Repair services&lt;br&gt;Rental services of test equipment&lt;br&gt;Consulting fees</td>
</tr>
</tbody>
</table>
Strategy Development: Creating the Future

Working in small groups, participants reviewed the initial vision and identified strategies they considered necessary to create this future.

The participants considered current strengths, weaknesses, opportunities, threats; current and future funding models; scalability, replicability, and sustainability; stakeholders and champions; cultural issues; and external factors.

The groups identified nine initial strategies of importance.

1. Establish a forum to share, learn, and discuss common challenges and opportunities in order to reach agreement on a standardized, but flexible BMET training.
2. Create a global alliance.
3. Create an HTM alliance.
4. Ensure this group of experts remains cohesive.
5. Engage multiple stakeholders and funders to promote BMETs.
6. Ensure countries cooperate to achieve a scalable BMET model.
7. Create unified accreditation standards, international certification (expand AAMI standards).
8. Select trainees by gaining stakeholder consensus, and agree on entry level (pre-qualifications), mechanisms of assessment and selection (interview, experience) and assessment (attitude, aptitude, and compare to existing workers).
9. Define metrics for health outcomes.

Action Planning

From among the strategies identified, participants chose to merge related strategies and restate others. The six remaining or restated strategies appear in the following tables. Working in small groups, participants developed an Action Plan for each strategy by identifying the relevant tasks to be completed (responsible parties, target dates, available resources, resource needs, and cost of each task.) Due to time constraints, however, not all tasks were completed for each strategy. For example, the stakeholders working on Strategy 1 did not identify who would be part of the core team or advisory board.

The six strategies and related information (responsible parties, target dates, resources, and cost) reflect the collective wisdom of the stakeholder group. In the final report to the GE Foundation, these strategies might be enhanced or replaced based on what is learned subsequently about training BMETs in low resource countries.

The six strategies included the following:

1. Create an international advisory body to assure quality of BMET education through defining core competencies.
2. Create a global alliance that focuses on the promotion of the BMET profession in low resource countries.
3. Ensure the strict selection of BMET trainees/trainers.
4. Engage multiple stakeholders and funders to promote BMETs.
5. Create sustainable, scalable funding strategies for BMET training to improve public health outcomes.
6. Define metrics for BMET health impact/outcomes.

| 1 | Create an international advisory body to assure quality of BMET training based on core competencies. *(Estimated Time: 9 Months)* |
|---|---|---|---|---|
| **Decisions/Steps/Tactics Needed** | **Responsible Parties** | **Target Dates** | **Available Resources** | **Needs/Costs** |
| Identify experts (advisory board) from the field who are willing to advise and recruit them | Core team | Mid-Sept. 2015 |  | Contacts, full-time staff |
| Seek support from established bodies for credibility purposes (WHO, AAMI, IFMBE) | Core team | Jan. 2016 |  |  |
| Identify key stakeholders from the countries (MOH, MOE, schools/universities) | Core team; advisory board | Jan. 2016 |  |  |
| Identify vendors and manufacturers |  | Mid-Sept. 2015 to Jan. 2016 |  |  |
| Create list of core competencies |  | Mid-Sept. 2015 to Jan. 2016 |  |  |
| Send draft core competencies to peers for external review | Advisory board network | Jan. 2016 |  |  |
| Buy-in from every organization/individual working in the field: "We agree to implement the core competencies in our work" |  | June 2016 |  |  |

| 2 | Create a global alliance that focuses on the promotion of the BMET profession in low resource countries. *(Estimated Time: >9 Years)* |
|---|---|---|---|---|
| **Decisions/Steps/Tactics Needed** | **Responsible Parties** | **Target Dates** | **Available Resources** | **Needs/Costs** |
| Identify alliance members and funders and engage them | GEF-AAMIF Participants | 6 months |  |  |
| Share experiences, challenges, materials, and curricula |  | 1 year June 2016 |  |  |
| Determine what works, where, and why (gap analysis) |  | 1 year June 2016 |  |  |
| Build compelling case for BMETs as a recognized profession (targets; indicators; recommend country-level scalability plan) |  | 2-3 years |  |  |
| Agree on compatible, flexible, BMET training |  | 2-3 years |  |  |
| Identify outcomes based on pilots |  | 3 years |  |  |
| Create and roll-out of modular model(s) in various languages |  |  |  |  |

| 3 | Ensure the strict selection of BMET trainees/trainers. *(Estimated Time: 1 Year)* |
|---|---|---|---|---|
| **Decisions/Steps/Tactics Needed** | **Responsible Parties** | **Target Dates** | **Available Resources** | **Needs/Costs** |
| Gain consensus on entry and exit levels |  | Year 1 |  |  |
| Gain consensus on mechanics of assessment/selection, e.g., references; direct interview, equivalency (recognition of prior learning or experience or academic) |  | Year 1 |  |  |
| Assess applicants against code of conduct, behaviors as entry level requirements |  | Year 1 |  |  |
| Gain consensus on how to accommodate existing workers alongside trainees |  | Year 1 |  |  |
### 4 Engage multiple stakeholders and funders to promote BMETs

<table>
<thead>
<tr>
<th>Decisions/Steps/Tactics Needed</th>
<th>Responsible Parties</th>
<th>Target Dates</th>
<th>Available Resources</th>
<th>Needs/Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify country needs and priority areas</td>
<td>Core stakeholders</td>
<td>1-2 months</td>
<td>Volunteer network</td>
<td>1 staff, travel, logistical support</td>
</tr>
<tr>
<td>Identify potential funders</td>
<td></td>
<td>3 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Figure out a pitch with data and tailored messaging</td>
<td></td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify stakeholders (international and local) to deliver message/pitch</td>
<td></td>
<td>1 month</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Media coverage, promotion/education campaigns</td>
<td></td>
<td>2-3 months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 5 Create sustainable, scalable funding strategies for BMET training to improve public health outcomes

<table>
<thead>
<tr>
<th>Decisions/Steps/Tactics Needed</th>
<th>Responsible Parties</th>
<th>Target Dates</th>
<th>Available Resources</th>
<th>Needs/Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify legal form/entity (purpose, governance, hosted, legal seat, operating funding source)</td>
<td>AAMI, WHO, Stakeholders</td>
<td>End 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define “asks” for contributions</td>
<td></td>
<td>End 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop messages/outreach to address different potential donors</td>
<td></td>
<td>End 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implement transparent accountability mechanisms</td>
<td></td>
<td>End 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection criteria for projects to fund</td>
<td></td>
<td>End 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop near and mid-term outcome measures</td>
<td></td>
<td>End 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst for development of professional development criteria, terms of reference, curricula, training materials and technologies</td>
<td>End 2015</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6 Define metrics for BMET health impact/outcomes

<table>
<thead>
<tr>
<th>Decisions/Steps/Tactics Needed</th>
<th>Responsible Parties</th>
<th>Target Dates</th>
<th>Available Resources</th>
<th>Needs/Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form group to create gold standards: to answer the question, “What is the health impact if 100% of available equipment is in service?”</td>
<td>Epidemiology, economist, HTA; Clinical (ER, OR, OB); Engineer; BMET, BME, sciences, etc.</td>
<td>6 months</td>
<td>2 staff Potential Funders: GEF, World Bank, IMF</td>
<td>2 staff</td>
</tr>
<tr>
<td>Pilot study</td>
<td>Multiple countries and continents</td>
<td>1 year</td>
<td>2 staff and 1 graduate student</td>
<td>2 staff and 1 graduate student</td>
</tr>
<tr>
<td>Study paper</td>
<td>MOH, hospitals (district and up)</td>
<td>3-4 years</td>
<td>2 staff and 1 graduate student</td>
<td>2 staff and 1 graduate student</td>
</tr>
</tbody>
</table>

The six strategies provide a good starting point for considering goals involved in creating a training model that is scalable, replicable, and sustainable in low resource countries. The participants pointed out that some tasks can be undertaken quickly, while others, such as engaging stakeholders and conducting research, will have a long time horizon.

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8 Promoting the awareness of BMETs should occur simultaneously with training BMETs.
NEXT STEPS

The final project report describing a BMET training model that is scalable, replicable, and sustainable is due to the GE Foundation in October 2015. It will build on the data collected at the stakeholder meeting and described in this meeting summary along with other data gathered outside the stakeholder meeting, including input collected during interviews and meetings with corporations, NGOs, and other stakeholders. The data will be analyzed and result in a set of recommendations included in the final report to the board of directors of the GE Foundation. At this point, the GE Foundation anticipates distributing the final report to stakeholders.

As a direct result of this meeting, AAMI created a listserv for the virtual and ongoing convening of the meeting participants. The listserv site will include additional stakeholders and materials, as identified in support of this effort.

ACKNOWLEDGEMENTS

The GE Foundation and the AAMI Foundation would like to acknowledge the help and support of Tony Easty, the 2015 IUPESM World Congress leaders, Anna Worm, Adriana Velazquez Berumen, Tom Judd, Antonio Hernandez, Nathan Williams, and many others who helped to make the GEF-AAMIF 2015 Stakeholder Meeting a success. Further, the GE Foundation and the AAMI Foundation extend their gratitude to all of the participants, many of whom traveled long distances, for their commitment and passionate contributions.

CONCLUSION

Participants identified the most critical needs necessary to build a scalable, replicable, and sustainable BMET training model taking into consideration existing training programs, trainers, students, stakeholders, and the HTM field. An ideal training model would include training programs that build partnerships and engage a network of interested parties across academia, hospitals, governments, funders, NGOs, associations, communities, and targeted groups to garner funding, expertise, support, and other necessary resources.

The programs should vet, develop, and continuously evaluate trainers to ensure that students are appropriate prepared by competent trainers. Program faculty must possess both theoretical and practical knowledge and experience; be able to bridge the gap between theory and practice; have an understanding of pedagogical approaches and learning strategies; and be committed to developing and empowering students and committed to their own growth and development. Ideally, the trainers will be local, able to converse in the local language, understand the local customs, and have a local network on which to rely.
The programs also must focus on the student life cycle from pre-admission to professional BMET. They must recruit and admit students with the greatest likelihood of success in the training program as well as the profession, in terms of both aptitude and attitude. Pre-assessment and routine evaluations are critical factors to success.

The HTM field should advocate for and raise awareness of the global HTM profession by collecting success stories and then communicating those stories broadly. Further, they need to take responsibility for developing a core curricula based on valid research and international standards on which local training programs can rely. Additional research on health outcomes is necessary to demonstrate the impact of the work of BMETs and support the technician’s credibility with their peers.

Clearly, meeting participants recognize the significant work required in order to build a scalable, replicable, and sustainable BMET training model. This meeting revealed a core group of committed individuals who are willing to contribute to doing that work and address the pressing need for trained BMETs in low resource countries.

The participants identified six strategies as critical next steps, including:

1. Create an international advisory body to assure quality of BMET training based on core competencies.
2. Create a global alliance that focuses on the promotion of the BMET profession in low resource countries.
3. Ensure the strict selection of BMET trainees/trainers.
4. Engage multiple stakeholders and funders to promote BMETs.
5. Create sustainable, scalable funding strategies for BMET training to improve public health outcomes.
6. Define metrics for BMET health impact/outcomes.

The six strategies identified by the participants provide the impetus for further discussions. While the community can address some tasks quickly, others will require considerable time and effort. To date, securing funding for training has not been easy, and funding for community building will likely be difficult to garner. Nonetheless, the work done in the field thus far must continue, and it must be better organized and supported. Creating a training model that is scalable, replicable, and sustainable in low resource countries requires the entire stakeholder community to work together for this common purpose.
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APPENDIX B – ABOUT PROJECT CONSULTANTS

Jackie Eder-Van Hook, PhD

Jackie Eder-Van Hook has 25+ years of senior management experience, most recently as the president of Transition Management Consulting, Inc., a national consulting firm, where she serves as a consultant and trusted advisor to governing bodies and CEOs.

Previously, Jackie led health care technology associations and coalitions, Advanced Initiatives in Medical Simulation, Center for Telehealth and E-Health Law/CTL, Home Care Technology Association of America/NAHC, Consumer Health Access through Technology/Intel coalition, and the National Health Policy Council. She served as interim executive for membership associations, charitable nonprofits, and a public-private agency.

From 1996-2000, she was a senior official at the Agency for Health Care Policy and Research (now AHRQ), where she was recognized for management innovation by US Health and Human Services Secretary Donna Shalala and AHCPR Administrator John Eisenberg, MD, and again by the US Office of Personnel Management.

Jackie is a well-respected writer with 40+ published articles on management, leadership, and healthcare and served as a peer reviewer for the international section of the OD Journal and reviewed presentations for the Academy of Management.

Jackie earned a doctorate in Human and Organizational Systems and a Masters of Arts in Human Development from Fielding Graduate University, a Masters of Science in Organization Development from American University (AU/NTL), and Bachelor of Arts in Political Science from San Diego State University. She is a graduate of the GIC/GISC International Organization and System Development Program and the Newfield Network, an international coaching program.

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Chris Love, MSOD, MH

Chris Love has consulted to healthcare, nonprofit, educational, community, and corporate clients for over 25 years, specializing in positive change methodologies. She is president of Chris Love Associates, LLC, a leadership and management consulting firm.

Chris offers reflective leadership retreats for healthcare, education, clergy, nonprofit, and other service professionals through her affiliation with the Center for Courage and Renewal. Currently, she co-leads the organization’s work to develop a national program called “Aging with Courage and Wisdom.”

Chris previously worked for the national consulting firm Alan Newman Research as a qualitative market research project manager and for The Martin Agency as a direct response account supervisor.

She has published articles about her work in the journal New Directions for Teaching and Learning and online, and has published a newsletter for oncology nurses for the Mayo Comprehensive Cancer Center. As a writer and editor for English language publications in Europe and Asia for five years, Chris published dozens of news and feature articles. For nearly two years, she worked in the Middle East in post-secondary education and refugee resettlement. Chris has also taught technical writing at the college level.

Chris earned a Masters of Science in Organization Development from American University (AU/NTL) and a Master of Arts in Humanities degree from The University of Richmond. She is a Phi Beta Kappa graduate of the College of William and Mary, where she received a Master of Arts in English. She was trained at the Taos Institute in Appreciative Inquiry by David Cooperrider.

Chris’ volunteer contributions include chairing and serving on the boards of at-risk youth homes in Montana and providing cross-cultural awareness leadership for Youth Homes Montana.

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APPENDIX C – STAKEHOLDER MEETING AGENDA

2015 Stakeholder Meeting
BMET Training in Low Resource Countries

AGENDA

Thursday, June 11

6:00 - 7:00 p.m.  Welcome Reception
E11even Restaurant - 15 York Street

7:00 - 9:00 p.m.  Opening Remarks: Mary Logan, AAMI Foundation, Asha Varghese, GE Foundation, Dinner
E11even Restaurant - 15 York Street

Friday, June 12

8:00 - 8:40 a.m.  Breakfast & Networking
Metro Toronto Convention Center, 222 Bremner Blvd., South Building, Room #501

8:40 – 8:50 a.m.  Welcome Remarks: Mary Logan, AAMI Foundation

8:50 – 9:40 a.m.  Activity #1: Defining Success - Jackie Eder-Van Hook, PhD
If we are successful here today, what will we have accomplished by the end of this meeting?

9:40 – 10:00 a.m.  Remarks and Q&A - David Barash, MD, GE Foundation

10:00 – 11:15 a.m.  Activity #2: Considering the Vision – Stakeholders
1) Identify the key factors that make BMET training programs scalable.
2) Identify the key factors that make a BMET training program replicable in another location.
3) How are BMET training programs currently funded and how might they be funded in the future?
4) Identify the key factors that make a BMET training program sustainable.

11:15 – 12:30 p.m.  Activity #3: SWOT- Jackie Eder-Van Hook, PhD
Identify the Strengths, Weaknesses, Opportunities, and Threats of current efforts to train BMETs

12:30 – 1:15 p.m.  Networking Lunch

1:15 – 2:35 p.m.  Activity #4: Creating the Future - Jackie Eder-Van Hook, PhD
Identify the strategies that we must embrace now to create this future.

2:35 – 2:50 p.m.  Break

2:50 – 4:15 p.m.  Activity #5: Action Planning & Implementation – Chris Love
Identify the activities and resources that are necessary to achieve the identified strategies.

4:15 – 4:30 p.m.  Wrap-Up, Next Steps, and Closing - Jackie Eder-Van Hook, PhD, Mary Logan, and Asha Varghese