BIOMEDICAL ENGINEERING IN GHANA

Richard Quansah Amissah, BSc

Albert Kwesi Atchurey

Loretta Appiah

Elvis Kofi Fiakumah

Emmanuel Gyapong-Korsah

John Boadu

Emmanuel Tetteh

Emmanuel Offei

Elsie Effah Kaufmann, PhD

Department of Biomedical Engineering, Faculty of Engineering Sciences,

University of Ghana, Legon, Accra, Ghana

Abstract

Even though Biomedical engineering contributes significantly to health care delivery, its full potential is yet to be comprehended and appropriated by the health sector in Ghana. This paper therefore provides a comprehensive description of Biomedical engineering in Ghana as of November, 2011 and makes recommendations based on the situation in Ghana and some developed countries.

Biomedical engineering in Ghana started in the late 1990s thanks to the combined efforts of the pioneering stakeholders in the field. Since then, the country has seen a steady increase in the number of institutions engaged in educating and employing biomedical engineers. Though Bioinstrumentation is the dominant subspecialty in Ghana, it employs less than half the graduates of the field annually. Regulatory bodies for medical devices and consumables exist in the country, though not operating at full capacity.

For Biomedical engineering to be firmly established in Ghana there should be a massive campaign to educate the public on its relevance. Educational institutions should strive to supply well trained biom

edical engineers to meet increasing demands, while the government provides funds for the necessary logistics for such a cause. To avoid redundancy in the roles each identified regulatory body should have clearly defined and differentiated tasks.

Keywords: Biomedical engineering, stakeholders and Bioinstrumentation

Introduction

Healthcare has always been a primary concern for all men. In ages past doctors and nurses were the dominating figures in healthcare delivery. Recent times have necessitated the involvement of many more professionals who directly or indirectly influence health care delivery in the world. These include physicists, physiotherapists, radiotherapists and biomedical engineers.

Prior to 1900 technology had little to offer medicine and the delivery of health care. As technology developed, by the early 1900's there were first advances in medical diagnostics and imaging. For instance the X-ray machine was developed by Roentgen in 1896 and was initially used for the diagnosis of bone fractures (Bronzino, 2000). In fact certain innovations that took place were likened to the work of biomedical engineers, some of which were not recorded by historians. One known example captured by historians is that of the wooden implant found on ancient Egyptian mummies exhumed by archaeologists (BME Central, 2012).

Biomedical Engineering (BME) has evolved to be defined as: 'the application of concepts, knowledge, and approaches of virtually all engineering disciplines to solve specific health care problems' (Bronzino, 2000). Today BME has grown into a multibillion dollar industry in advanced countries, designing and producing devices, processes and equipment to serve millions across the globe. Some examples of these products include pacemakers, infusion pumps, the heart-lung machine, artificial organs such as the dialysis machine, implants, artificial limbs, corrective lenses, facial prosthetics, biliblankets, etc. Recent advancement in Tissue Engineering hopes to make possible tissue regeneration using stem cell technology.

Ghana, a country with one of the fastest growing economies in Africa (Al-Bader et al, 2010), has witnessed a steady advancement in the health and well-being of her citizenry over the last decade by the employment of BME efforts that have positively impacted the healthcare industry. Such beneficial outcomes include improved diagnosis and treatment of diseases like typhoid, malaria and the detection of heart defects using the Electrocardiogram. The Dental School of the University of Ghana, the Accident and Orthopaedic Centre and the

National Cardiothoracic Centre of Korle-Bu Teaching Hospital are some of the well-known units that are involved in the use of BME products. The Biomedical Engineering Unit (BEU), under the auspices of the Ministry of Health (MoH), acquired two Mobile Clinics to assist in the provision of health care to remote parts of the country (Ocran A., personal communication, November 2011).

In this paper we provide results from research on BME in Ghana. The research was undertaken to provide documentation on the development of BME in its totality spanning the education providers to the practitioners and employers. The research focused on tertiary institutions offering BME related training at the undergraduate level. The employers were defined in a broader sense and were identified to include companies that provide medical products with after sales services and maintenance and institutions that require and employ the services of trained biomedical engineers. The purpose of the paper is to examine and discuss the emergence of BME as a field in Ghana taking into consideration identified stakeholders who have been, are and would contribute in various ways to the establishment and shaping of the field. This paper may also be beneficial to developing countries like Nigeria and Benin who are striving to introduce BME, probably due to the realization of the significant impact of BME on the health sector, by making suggestions and recommendations based on the current situation in Ghana and other developed countries. The paper is the first of its kind in a nation where the field is in its infancy. This shortcoming particularly constrained the scope and coverage of the research.

History of BME in Ghana

BME as an academic discipline in Ghana sprouted in the years between 2004 and 2008.The notable and leading institutions in the training of biomedical engineers in Ghana currently are University of Ghana whose undergraduate program was started in the year 2004 (Biomedical Engineering Department, UG, 2011), followed by All Nations University College in 2006 (Danquah Amoah E. D., personal communication, October 2011), then Kwame Nkrumah University of Science and Technology (KNUST) in 2008 (Yacub A., personal communication, September 2011). Valley View University is one of the few institutions in the country offering pseudo-biomedical engineering programs.

Dr. Elsie Effah Kaufmann, the immediate past head of the Department of Biomedical Engineering, University of Ghana, is widely regarded as one of the pioneers of BME education in the country. This is largely due to her relentless effort in the establishment of the first Bachelor's degree program in BME in Ghana. Another pioneer of BME in Ghana is Dr.

Polycarp Reccy Asman, the Chief Executive Officer of The Mediwise International Company Limited, the first Ghanaian owned BME firm in Ghana (MediWise International, 2012).

All the universities aforementioned, with the exception of Valley View University, offer a four-year Bachelor of Science degree program in BME. Valley View University offers a two-year Diploma in Biomedical Equipment Technology which is awarded after intensive training. A comparative study of the mission statements of the programs at the various universities reveals that all these universities have their mission focused on producing graduates who will be able to use basic engineering principles to the benefit of the medical field in the country. The departments of BME in these universities have courses that are purported to train students to design and implement systems, devices and processes that have the potential to affect the emerging BME related industries and the country's health delivery system. Most of the courses taught in universities offering BME in Ghana revolve around Bioinstrumentation, Biomaterials, Medical imaging, Tissue engineering, Microbiology, Numerical analysis and Engineering Mathematics. The curricula are designed to provide knowledge of some aspects of Medicine, Engineering and Biology. A number of these universities have gone further to introduce courses like Sociology, Psychology, Accounting, Economics, Management and Entrepreneurship in their curriculum to give students a broad array of skills. So far there is no running postgraduate program in the country.

Ghana relies heavily on foreign technology to drive its industries leading to less significant improvement in indigenous technology in the country. The Ghanaian health sector has not been an exception. Although the sector has been a priority for all the past governments, it can in no way compare to the level of advancement made by the western and European nations in terms of practical application of technology. BME has provided the ingenuity to transform medicine to a more contemporary state where technology has become integral in health delivery, so much to the point that biomedical engineers, in these developed countries, have rightfully claimed their status as indispensable.

Since 2004, there has been a significant increase in the number of companies offering BME services, notable among them is a Mediwise International Company Limited established in 2008. These companies were originally involved in the sales and repairs of medical equipment and mostly employed the services of technicians and electricians in their activities. Now, many have evolved to provide services like maintenance and installation of medical equipment and rely on the services of the biomedical engineers they have recently started employing.

Worldwide hunt for biomedical engineers has been on the increase with US employment researchers speculating that BME jobs are going to be on the increase in the coming years (Money Careers, 2012). A market survey conducted by the Valley View University revealed that 85% of hospitals in Ghana need the services of biomedical engineers. In addition, in January 2011 the Korle-Bu Teaching Hospital placed an advertisement for biomedical engineers in the Daily Graphic, Ghana's most widely read newspaper. This was one of the many advertisements of BME vacancies by a number of institutions in Ghana for the year 2011.

Methods

A case study research methodology was used in this study. Data was collected through thorough review of available academic literature. As documented material was not readily available open-ended and face-to-face interviews were conducted by graduates, employees and a number of stakeholders in the field of BME in Ghana. Interviewees were identified based on a number of criteria. The first criterion was experienced in the field while the second had to do with the relevance of the line of work and its contribution to the field of BME in Ghana. Graduates of the department of BME, University of Ghana who were interviewed had either spent more than half a year in the industry, were preparing for employment or preparing to further their education. The government industries involved in this research are long standing establishments who make policies and set standards for regulations. A total of twenty five people were interviewed in all. This includes graduates of the Department of BME (n=12), government agencies (n=5), companies (n=5) and academia (n=3). The data obtained was gathered over a period of three months from September, 2011 to November, 2011.

Results and Discussion

National Demand

Currently, there seems to be a high demand for biomedical engineers specialized in Bioinstrumentation. These engineers are needed for the installation, maintenance and repair of medical equipment in healthcare institutions all over the country. The services of biomedical engineers with specialties other than Bioinstrumentation such as Tissue Engineering, Bioinformatics, etc. are relatively not in high demand. This may be attributed to the fact that most of the BME industries in Ghana, currently, are Bioinstrumentation related. The scarcity of institutions/industries that require the services of biomedical engineers with specialties other than Bioinstrumentation may be due to a lack of funds, technical personnel, or simply entrepreneurial skills on the part of employers and/or biomedical engineers in the country.

Is Training Meeting Demand?

A survey conducted by the team on the status of some graduates of the department of BME, University of Ghana yielded interesting results. Of all the graduates involved in the survey less than 30% were actually applying their skills and expertise in BME in their current line of work, a little over 20% were in graduate school and a staggering 50% were teachers or assistants in institutions ranging from Junior High School to the University. This news is quite alarming, prompting researchers to ask the question "is the country really ready for this profession?" Though some professionals like Mr. Edward Essah, a biomedical engineer and Managing Director of Mediwise International Company Limited, claims there are various opportunities available to biomedical engineers, few biomedical engineers in the country are gainfully employed in fields related to their profession.

Interviews conducted with graduates of the University of Ghana revealed a need for further studies before working in the industry. The team got to know that employees with a bachelor's degree in Ghana have a net annual salary of $6000. 00, those with master's degrees earn $12000. 00, while those with doctorate degree earn $18000. 00. However, their colleagues in the developed countries earn salaries ranging from $43,570 to $119,000 depending on the level of education (Biomedical Engineer Salary, 2012). The difference in salaries between the developed and developing countries is present for other professions and may be due to the fact that the economy in the developed countries are more favorable compared to that in the developing countries. All the same, the disparity raised a number of questions, which were further explored. Through personal interactions it was discovered that there is a school of thought among employers that since BME was originally a postgraduate program run in universities abroad for lawyers and other professionals, an undergraduate is simply not a suitable biomedical engineer to work with. Another school of thought is that a bachelor's degree in BME would make an individual better placed in a postgraduate program in BME. The course being charted by graduates of BME in Ghana seems to be inclined towards the first school of thought as can be inferred from the results obtained from the survey of employed students from the University of Ghana, Department of BME.

The Dominating Bioinstrumentation

It is only recently that key players in the Ghanaian health sector have realized the need for biomedical engineers in their quest to compensate for the technological gap between Ghana and the western countries. The health sector had relied on the services of inadequately skilled personnel such as electricians and technicians to install and maintain its imported medical equipment (Ocran A, personal communication, September 2011). The call for the

services of better skilled personnel was sparked by the increased influx of complex and sophisticated medical equipment and the increased rate of breakdown of these equipment in various health institutions across the country. As a result of this, Bioinstrumentation became a prominent field, so much so that the Ministry of Health (MoH), with the assistance of Dr. Asman, a man knowledgeable in Bioinstrumentation, established the Biomedical Engineering Unit (BEU), Korle-Bu, to serve the nation.

The BEU was established in the early 1990s. The unit is purported to be the main advisory body to the MoH in relation to BME matters. The services provided by the unit include repairs, installation and maintenance of medical equipment for both government and privately owned hospitals and institutions. The unit was started with a workforce comprising a handful of professional biomedical engineers and a number of technicians and artisans.

A survey was conducted into prominent BME companies in Ghana to find out the services being provided currently in the country. Most of the industries visited are established companies in the country identified by the team as major providers of services related to BME in the country. The industries visited include Mediwise International Company Limited (Dzorwulu, Accra), Philips Medical Systems (Airport, Accra) and Benco Hospitex Ghana Limited (Korle - Bu, Accra).

It can be concluded from the data gathered that Bioinstrumentation is the main focus of most BME industries in the country since these companies are actively involved in the sales and marketing of hospital equipment. Mediwise International Company Limited is one of the few companies also involved in the installation, maintenance and repairs of hospital equipment. This domination of Bioinstrumentation has both positive and negative impact on biomedical engineers in the country. On the one hand, it serves as the major source of employment for graduates of BME programs, who are interested in Bioinstrumentation, produced annually by the educational institutions in the country. On the other hand, knowing that biomedical engineers who specialize in Bioinstrumentation are in high demand, most graduates opt to work in these companies rather than striving to establish the other subspecialties of BME like Biomaterials, Tissue engineering, Medical imaging, etc., which might serve as a source of employment for future generations of biomedical engineers interested in the other subspecialties of BME. This might make Bioinstrumentation the only possible source of employment for biomedical engineers in Ghana leading to the loss of interest in the other fields of BME in the country.

Regulation in BME

Before the inception of BME in Ghana, longstanding government institutions existed to serve the nation's regulatory functions; the Ghana Standards Board (GSB), now the Ghana Standards Authority (GSA) which is the national regulatory body established by the standards decree, 1967 (NLCD 199) and the Food and Drugs Board (FDB) established by the food and drug law in 1992, (PNDCL 305B) are the most notable among them. Shortly afterwards, the BEU was established which was later rivalled by a newly established Clinical Engineering Unit (CEU) of the Ghana Health Service (GHS), an autonomous executive agency responsible for implementation of national policies for health delivery with special emphasis on primary healthcare at regional, district and sub-district levels (Ghana Health Service, 2012). The above mentioned institutions have the overwhelming responsibility of regulating, developing and maintaining standards of BME activities and products in the country, predominantly medical devices and consumables.

The GSA, specifically the Scientific Metrology Department, has among its authorized tasks the calibration, verification and inspection of weighing and measuring instruments (Ghana Standards Authority, 2012). As of September, 2011, there was no biomedical engineer in this department though there are mechanical and chemical engineers. However the department works well to meet international standards and have three of its laboratories accredited to the International Standards Organization (ISO) standard of Germany and serves both government and private institutions.

The FDB has under its purview the control, manufacture, importation, exportation, distribution and advertisement of medical devices. The Cosmetic, Household Chemicals and Medical Devices Unit under the Drug Evaluation and Registration Department of the FDB functions to develop and review guidelines for the evaluation of medical devices and consumables among others. Once again, this department lacks the expertise of biomedical engineers. The task of regulation of medical devices is hardly achieved and testing of medical consumables is the responsibility of pharmacists and chemists.

The BEU and the CEU perform similar roles. However, while the mission of the CEU, is to "ensure the availability of effective and efficient managerial and technical support for healthcare equipment and availability and maximum utilization of all healthcare equipment at all levels of healthcare delivery" within the GHS, the BEU serves a more extended consumer base including public hospitals and establishments and is pushing to be mandated with the regulation of BME supplies by sending a petition to parliament (Ocran A., personal communication, September 2011).

A common and major problem faced by all four institutions is the lack of both human and financial resources. The situation reduces greatly the comprehensiveness of regulation of a field which is among the most heavily regulated industries in the developed countries. This precludes optimum application of the trade in local healthcare delivery resulting in poorer health service to Ghanaians. For the same reason, attempts to reduce gross wastage of medical equipment are only partly realized. On the bright side, the situation creates a potential job market for the increasing number of BME graduates in the country.

The Future of BME

BME would undoubtedly continue to develop globally as the demand for improved healthcare persists. Ghana would remain reliant on foreign BME technology but would also see further development of the field locally. The prospect of a diversified field in the near future would be dependent on the contributions of two major players: the government, in the form of policy making, funding and regulation, and the education providers who would provide the personnel to drive the industry.

Currently, even though BME in the country is Bioinstrumentation biased, a number of BME companies/institutions have been identified to be involved in subspecialties other than Bioinstrumentation. One such institution is the Orthopaedic Training Centre, located at Adoagyiri–Nsawam. The facility manufactures orthopaedic appliances needed for the physically challenged of Ghana and is currently capacitated to manufacture shoes, shoe prostheses, leg braces, artificial limbs, splints and so on for the over 6000 patients seen at the centre yearly. The workshop, as of November, 2011, had 26 skilled workmen in areas that include shoe making and designing with personnel ranging from chief technicians to artisans. The center, lacking the expertise of biomechanical engineers, relies on the ingenuity of its employees who learn their trade on the job.

The diversification of the field of BME in Ghana may, in the near future, depend on such small scale industries. The major setback currently is the inability of these industries to employ professional biomedical engineers, making them over-reliant on indigenous, non-modern technology. As demand yields production, the growth of such small scale industries would call for the grooming of more professional biomedical engineers with varying specialties. It would then be up to education providers to meet the demand.

The education providers have a larger role to play than just serving the needs of potential employers. For the field of BME in the country to grow and have a solid foundation, it would depend on the education providers. Current training by major universities like University of Ghana and Kwame Nkrumah University of Science and Technology, aim to

provide graduates with diverse capabilities and a reasoning power to solve diverse health problems. This would, in the near future, lead to an abundance of biomedical engineers in a country with a wide variety of unsolved health problems, marking the beginning of a blossoming field.

The possibility of the above predicted future becoming a reality heavily relies on government policies and funding. Science and Technology based research in the country received less than 0.5% of the government's annual budget (Adarkwa K. K, 2010 & United Nations Conference on Trade and Development, 2003). This has slowed down the rate of development of science and technology in the country, hence a slow development of BME.

Conclusion

To ensure the continued growth of the BME profession in Ghana the following recommendations are put forward for consideration:

First of all, the current biomedical engineers in the country should embark on a massive campaign to create mass awareness of the field in Ghana. This campaign should introduce the general public to the need for biomedical engineers and the benefits that would be reaped from the services of biomedical engineers. This campaign should also target the lesser known subspecialties of BME such as Biomaterials and Tissue Engineering, Bioinformatics, etc. in order to create a more diverse field of BME in Ghana. The campaign may include the exhibition of products and designs developed by biomedical engineers where local and international industrial partners and the general public are invited to interact with these engineers.

Secondly, the educational institutions in the country should strive to provide a steady supply of well trained and adequately skilled biomedical engineers who will be tasked with the responsibility of identifying and solving the country's health care problems. Even though training biomedical engineers with specialization in Bioinstrumentation may be paramount due to the enormous demand, training biomedical engineers with specialization in the other subspecialties of BME is equally important. This would help to develop the other aspects of the field in order to serve as a source of employment for the future generation of prospective biomedical engineers in the country. Educational institutions should also make the effort to establish postgraduate programs to provide much needed academic staff to help in the production of highly skilled and competent engineers who will help in the growth of the field. These institutions should partner with local and international industries to provide students with practical experience and knowledge through collaborations for research, internships and employment during and after school. Through these partnerships, competitions can be

organized to identify talented students who may be given incentives such as scholarships to further their education or develop prototypes for solving identified problems in Ghana and the world as a whole.

Thirdly, the government should recognize BME as necessary for provision of local health solutions in all areas of healthcare delivery other than in just Bioinstrumentation and provide the necessary logistics for such a cause. This should be accompanied by efforts in the form of policies and actions to execute a full but gradual integration of the trade into the Ghanaian health system. To support the increased demand for biomedical engineers that would result, expansion of the capacity of associated educational institutions should be considered and their academic programs should be enriched to meet international standards, particularly in the practical aspects of the program.

Finally, it is clear that there are conflicting roles in the mandated tasks of the BME regulatory institutions. To avoid redundancy there should be clearly defined and differentiated tasks among the regulatory bodies. The BEU and the CEU particularly should be charged with tasks directly related to BME since they have among their ranks skilled biomedical engineers and in-depth knowledge of the field. However due to lack of resources and to prevent the likelihood of the two institutions being overwhelmed, the GSA and the FDB could be supporting institutions in BME regulation. In addition, to enjoy the full benefits of the adoption of the profession into our local health care system, regulation should be prioritized. Provision of necessary logistics like funding and availability of modern laboratory equipment and skilled personnel would greatly enhance the activities of regulatory institutions and yield maximum benefit.

List of Stakeholders Interviewed

1. Mr. Anyagre Ocran, Biomedical Engineering Unit, Ministry of Health (MoH), Administrative Manager.
2. Mr. Ekow Dennis Danquah Amoah, All Nations University College, Lecturer.
3. Dr. Yacub Ahmed, Kwame Nkrumah University of Science and Technology, Lecturer.

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