Tony Blair Institute for Global Change
Trinity University, Lagos, Nigeria
Harmarth Global Educational Services
FAIR Forward – Artificial Intelligence for All
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Society for Multidisciplinary & Advanced Research Techniques (SMART)

Accra Bespoke Multidisciplinary Innovations Conference (ABMIC)

Tracking of Biomedical Equipment using IoT Embedded Technologies: Its attendant impact in Healthcare Delivery in South-Eastern Nigeria.

Obinna A. Eneh[1], Deborah U. Ebem[2], Agatha N. Aballa[1] and John N. Ngene[3]
[1]Department of Biomedical Engineering, Federal College of Dental Technology and Therapy.
[2]Department of Computer Science, University of Nigeria, Nsukka.
[3]Department of Computer Science, Enugu State University of Science and Technology.
E-mails: eneh.obinna@fedcodtten.edu.ng; deborah.ebem@unn.edu.ng*;
     aballaagathankechi@fedcodtten.edu.ng; john.ngene@esut.edu.ng,
Phones: +234 703 267 4979, +234 805 281 0722, +234 703 877 2345,   +234 803 393 0987

ABSTRACT

In this work, we highlighted the merits of IoT in tracking of Biomedical Equipment during and post the Covid-19 era. When the healthcare industry is poorly equipped, and the available medical equipment are not put in optimal use, it results in high mortality rate and low life expectancy of the population. In the beginning of this COVID-19 pandemic, lots of hospitals in developing nations were poorly equipped to contain the rise in COVID infected patients. Tracking of some medical equipment for prompt use became a problem as those that were not in regular use were difficult to be located to attend to patients. A visit to many hospitals in south-eastern Nigeria shows that there are a lot of obsolete and non-functional equipment in some healthcare facilities. Some of the equipment developed minor fault, but the institutions lacked experienced technicians with adequate skills to fix them back to working state. One of the ways to reverse this trend of lack of medical equipment in some hospitals is by managing them properly in order to locate and efficiently make the use of the available ones. This can be done by tracking the equipment for adequate repairs or overhauling and efficiently utilizing them for the purpose they are meant for. IoT technologies such as barcodes, Radio Frequency Identifications (RFIDs), Global Positioning System (GPS) Asset tracking and Near Field Communication (NFC) tracking are possible solutions to the existing poor health technology management conditions in our hospitals. This will put a stop to theft of hospital equipment, reduce wastage of time in locating those equipment in the hospital, optimize routine servicing of the equipment, which subsequently means a reduction in expenditure; as well as trigger a signal for decommissioning of the equipment when it has elapse its full life cycle. Tracking of biomedical equipment in our hospitals using IoT embedded technologies will assist to optimize the use of the available ones. This will ensure adequate health technology management operations in our hospitals, and help in the forecast for developmental budgets in the health sectors of the states in the country; which will result in robust policy making and implementation in the health sector.

Key words: Hospital Equipment, Tracking, Healthcare Technology Management, Healthcare Service

1. Background of study

A healthy lifestyle is one of the essential necessities of life. This supports the adage that says that "Health is wealth". Adequate healthcare delivery is one of the fundamental rights of every Nigerian citizen. But it's not practicable at the moment due to the present poor state of the Nigerian economy. The present trend of poor healthcare delivery has transcended to high mortality rate and low life expectancy (Sen, 1998) among our population. This is in agreement with (Schäferhoff, Suzuki, Angelides, & Hoffman, 2015).

The budget on health sector is inadequate to cater for our teeming population as seen in the 2021 budget of some Eastern Nigeria states. For example, Imo state 2021 budget is to spend about 2.7% of its capital expenditure total sum on the health sector – a very low percentage to cater for its population of about 5 million (Ministry Of Budget, Economic Planning And Statisti, 2021). This results in the poor funding of our hospitals. The tradition of medical tourism among our elites and government officials to foreign hospitals depicts the poor state of our healthcare centers, which are poorly equipped with both drugs, medical equipment, and necessary infrastructures (Abubakar, et al., 2018). Some of the equipment available are either obsolete, non-functional or the operational expertise of its utility is scarce due to lack of human capacity training. In some hospitals the equipment may be available but due to poor health technology management they are not put to use. According to (MGM Solutions, 2018), nurses in the UK use 6,000 hours per month looking for misplaced equipment. These are more reasons why medical equipment tracking becomes inevitable. By the above reasons the need to keep an accurate inventory of our scarce medical equipment and keep a track on the available ones so as to assist in forecasting development budgets, planning and equipping technical workshops.

 Also to determine required staff training needs as well as plan for spare parts and consumables use, as well as planning for disasters and emergencies. The recent scourge of covid-19 exposed the weakness of our healthcare institutions especially in the south-eastern Nigeria where most of our hospitals were discovered to be poorly equipped to contain the spread of the disease. Effective vendor supply-chain tracking and management of the available biomedical equipment will be helpful in the decision of procurement, installation, operation, maintenance, withdrawal and thrashing of medical equipment in our hospitals, which will drastically reduce the challenge of inefficient Health Technology Management in our healthcare centers. The remaining part of this work is organized as follows: statement of the problem, objectives of the study, scope of the study, significance of the study. Section 2 is the review of related literatures, section handles Methods of Biomedical Equipment Tracking. In section 4 internet of things asset tracking is treated and section 5 is conclusion and recommendation.

1.1 Statement Of The Problem
Nigeria has well trained medical practitioners who are qualified in the practice of their choice profession. However, the major bane to carrying out their task effectively is lack of adequate medical equipment. In some other cases, it is the non-functioning of these equipment. This has caused a distrust in the healthcare system of Nigeria and thus, made medical tourism abroad highly demanded. A visit to many hospitals in the southeastern part of Nigeria shows that there are a lot of obsolete and non-functional equipment in their facilities. Some equipment developed a minor fault but no technician with adequate skills was available to fix them back to working state. The situation in the government owned hospitals were complicated as most times the equipment were bought from the open market and not from the vendors/manufacturer directly.

This situation should be discontinued so as to save millions of scare resources invested in the purchase of these equipment.

1.2   Objectives Of The Study
The objective of this research is to discover how tracking platforms for the biomedical equipment in our hospitals in south-east can assist in developing a mechanism by which the obsolete medical equipment can be withdrawn by the vendors that produced or supplied them, and replaced with the ones with modern technology at a minimal cost, thereby ameliorating the scarcity of essential medical equipment in the south-eastern healthcare centers.

1.3   Scope Of The Study
The scope of this research is limited to;
1. Biomedical equipment vendor and tracking
2. Study location which is within South Eastern part of Nigeria.

1.4   Significance Of The Study
The outcome of this study will help improve tracking of biomedical equipment that is faulty for easier and faster repairs. The overall effect is that the healthcare system will be boosted for efficiency. This study will help in promoting the need for direct procurement of biomedical equipment from the manufacturers instead of the open market, who before the installation of the equipment, will have to train the staff of the client that will handle the operation and maintenance of the equipment on how to properly operate and maintain them efficiently without the use of roadside servicing agents; which some of them end up destabilizing the equipment.. When the medical equipment in our health institutions are properly managed, the quality of healthcare delivery will improve effectively and the culture of health tourism to foreign countries by our citizens will be reduced. The study will as well help to identify the areas where manpower development is necessary in order to have skilled staff on standby as a long-run solution to inviting vendors/OEMs each time the equipment are faulty.

2. LITERATURE REVIEW

Health Technology Management which can also be referred to as clinical engineering, is a branch of biomedical engineering that involves planning, carrying out needs assessment, selection, procurement, taking inventories, installation and maintenance of medical equipment, training of staff for the safe and efficient use of these equipment and the eventual decommissioning (WHO, 2015).

Each of these areas has a wide range of activities for its proper functioning. Such activities include provision of technical service, monitoring of contracts, supply chain, decommissioning and disposal, managing workshop facilities, managing staff, record-keeping, managing the inventory, stock control of parts, consumables, managing waste, implementing safety protocol, planning and cost work, and project management. Figure 1 below shows an overview of the area involved in health technology management.

Health technology management deals with improvement of quality healthcare delivery, control of cost, access to this quality healthcare system through the correct deployment of technological innovations. Allocations within the healthcare system involves investing a large pull of resources to procurement and management of capital assets, which often times requires purchasing new medical equipment as technology improves.

In order to ensure quality management of the investment, it is important to develop and run a medical technology management programs that needs planning for effective management. This is in line with the aim of this study which seek to keep track of biomedical equipment and the vendors who manufactured/supplied them, this will ensure the efficient use of resources to attain maximum utility.

With that in place, clinical engineers will be able to identify technological solutions that matches the objectives of their health institutions. As stated by (David & Jahnke, 2005), They can review their institution's overall technological position, determine strengths and weaknesses, develop equipment-selection criteria, supervise installations, train users and monitor post procurement performance to assure meeting of goals.
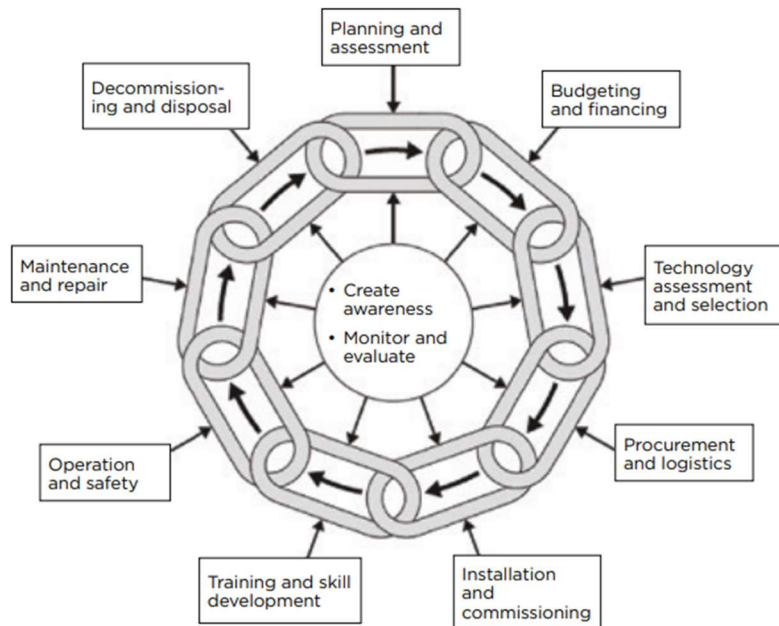

Figure 1: Functions in the healthcare technology management cycle
Source: (WHO, 2015)

Summarily, the essence of healthcare technology management is to ensure that health service assets used effectively and efficiently, and this will lead to improvements in the quality and quantity of healthcare delivered, without an increase in costs. It is good to note that the health service's most valuable assets which must be managed are its human resources, physical assets, and other resources such as supplies (Lenel , Temple-Bird, Kaur, & Kawohl, 2004). Physical assets such as facilities and healthcare technology are the greatest capital expenditure in any health sector

Hospitals operate with a huge quantum of expensive medical equipment and allied assets which need to be monitored and tracked. Asset tracking is an important aspect of any hospital's functional financial accountability. The main objective of an asset tracking system is to maximize asset efficiency and minimize operational loss. Hospitals need to track their equipment because it is a lot of hi-tech and they are very expensive.

Additionally, tracking equipment helps nurses to locate the equipment quickly, minimizing time wastage, tracked for maintenance purposes, tracked for budget planning, tracked for replacement as at when due, tracked to ensure re-stock or replacement of disposable ones, tracked to have enough information for staff training and manpower development.

Summarily, the following are the benefits of biomedical equipment tracking:
1. Extended Life Cycle: Asset tracking provides regular updates for any asset or equipment for its functional maintenance. As a result, the life of the asset is effectively extended.
2. Minimizing Asset/Equipment Loss: When the Operations management commands all the information about assets and equipment in the system, the chances of loss or theft can be considerably reduced.
3. Precise Asset Information: Tracking the asset brings up crucial information on the asset like its owner and its current state, where is it located, and much more. Such precise information greatly enhances the decision making process.
4. Saving on Time and Money: If a machine is not working properly, it implies it requires maintenance. Machine maintenance demands time and costs money. As such, an unplanned maintenance can disrupt the operations and impact productivity. Therefore, the organization needs to not only track the assets and equipment of the hospital but also analyze their performance in order to avoid unexpected downtime.
5. Scheduled maintenance: The system will trigger alerts and notifications for planned asset maintenance. This does away with a lot of worry about maintenance activity, as its scheduling is managed by the system. There is no need to keep separate records manually as the asset management system does it all for the organization.
6. Maximized Asset Efficiency: Proper maintenance of an asset not only enhances asset efficiency but also reduces the risk of its sudden breakdown. Consequently, the life cycle of the asset as well as its functional efficiency gets a major boost.

3. METHODS OF BIOMEDICAL EQUIPMENT TRACKING

1. Barcode Asset Tracking
Barcodes have become the classic method of asset tracking. They enable regular updates while being attuned to the latest technological landscape. The biggest advantage of Barcodes is economic feasibility. They are cheaper to use and are helpful in tracking small-sized and low-value items. Barcodes can be read by both handheld scanners as well as smartphone cameras. The codes are available in a variety of choices in shape, size, color, and material. The organization can select the type of barcode that suits its industry type. Barcode tag are widely recognized and trusted among numerous industries due to unique identification, barcode technology is affordable and massively scalable. Barcode tags or QR codes are attached to equipment items allowing for quickly scanning the item with a mobile phone or scanner which automatically updates the software records (Bahrynovska & Rosil, 2021). However, to scan and retrieve information, barcodes have to be aligned in a straight line with scanning devices or scanned individually. Barcode is a great solution for low-value assets.

2. RFID Asset Tracking
RFID is an acronym for "Radio Frequency Identification". They are much more advanced than barcodes. In RFID technology, digital data are encoded in RFID tags or smart labels. These can then be captured by the reader or scanner through radio waves. RFID has a wider capture region by radius for its operation. It can thus be used where assets are not easily accessible.

Being expensive to implement, RFID tracking system is not so suitable for small businesses. However, it is suitable for biomedical equipment tracking since those equipment are expensive.
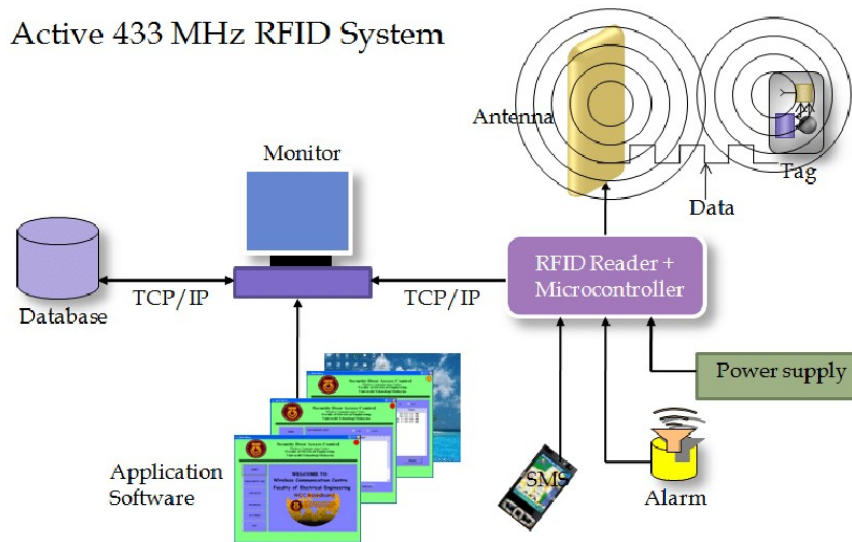

Figure 2: RFID Asset Tracker Working Principle
Source: (Kadir, Rahman, & Rahim, 2013)

3. GPS Asset Tracking

Geo tagging is the process of adding geographical identification to media as a geo tagged photograph. This data includes latitude and longitude coordinates. These tags are used to send location alerts to the server continuously so that the inventory can be tracked. The modern tracking technology owes its advancement to signal transmission that allows enough signal strength reception from the GPS satellite system which can then be reported. However, it is very expensive and so is recommended for only the big-sized corporations.

Figure 3: GPS Asset Tracking

4. NFC Asset Tracking

NFC stands for Near-field communication. NFC technology tracks assets by tapping into them and getting their details. Its cost is low and durability very high. NFC Tags are faster, you just need to bring your phone close to one NFC Tag to record the monitoring. All controls are updated in real-time. The entire information is stored in the Cloud. Enterprises can, therefore, export reports for their customers or for business intelligence at a fast pace. NFC has almost the same functionalities as RFID technology. It differs from RFID by the NFC tag which needs to be in close proximity with the reader, however, you do need to focus a scanner on the tag that can be located on any side of the item.

Figure 4: NFC Asset Tracking
Source: (https://www.assetinfinity.com/blog/rfid-vs-nfc-asset-tracking)

4. INTERNET OF THINGS (IoT) ASSET TRACKING

Internet of Things (IoT) portrays the network of physical objects referred to as "things". These objects are embedded with sensors, software, and other technologies (Patel & Patel, 2016). The objective of such connectivity is to share and exchange information with different gadgets and systems over the internet protocol. IoT asset tracking devices can range from household objects to sophisticated industrial machines and tools.

Asset tracking is one of the most promising areas of IoT. The asset tracking IoT device market is anticipated to triple by 2022 with revenue growth of $7.5B (Bahrynovska & Rosil, 2021). Implementing asset tracking systems require the connection between assets and devices (sensors) that can scan/read RFID tags, barcodes, NFC tags, etc. to deliver data obtained and process it in software management systems – this is the whole essence of IoT. Therefore, healthcare industry players can get comprehensive insights into their asset's conditions. Moreover, the convenience and high usability of IoT devices in the form of smartphones make it easy-to-use for each member of the company who can get the most up-to-date information and access it with just a few clicks.

Being a major industry that benefits from the adoption of IoT asset tracking solutions, the healthcare industry has already stepped on the path of transformation of asset management globally. One of the core challenges in healthcare facilities is excessive spending on equipment and wasting nursing hours. Therefore, the critical need to efficiently manage workforce has forced healthcare institutions to adopt IoMT (Internet of Medical Things) and asset tracking solutions in medical facilities that have made a huge impact on shifts toward traditional approaches of medical asset control and utilization (Bahrynovska & Rosil, 2021).

5. CONCLUSION

An effective medical equipment management technology is important for efficient healthcare delivery in our hospitals. Tracking of biomedical equipment in the south-eastern healthcare centers using IoT embedded technologies will assist to optimize the use of the available ones. This will ensure adequate health technology management operations in our hospitals, and help in the forecast for developmental budgets of the states in the region, which will result to robust policy making and implementation in the health sector of our nation's economy.

6. RECOMMENDATION

It is recommended that that all biomedical equipment should carry a compulsory IoT technology tags. This is to put a stop to theft of hospital equipment, reduce wastage of time in locating those equipment in the hospital, optimize servicing of the equipment, which subsequently means a reduction in expenditure and to trigger a signal for decommission of the equipment when it has elapse it full life cycle. It is also recommend that all medical equipment purchases be mandated to be directly from vendors/Original Equipment Manufacturers (OEMs) and not open market. This is will ensure direct deal with manufacturers in case of repair, replacement, or purchase of spare parts.

BIBLIOGRAPHY

1. Abubakar, M., Basiru, S., Oluyemi, J., Abdulateef, R., Atolagbe, E., Adejoke, J., & Kadiri, K. (2018). *Medical Tourism In Nigeria: Challenges And Remedies To Health Care System Development.* African Journals Online, 223-238.

2. Aroomoogan, K. (2021). *How Asset Management Firms Can Use AI For Data Analytics.* New Jersey: Forbes Finance Council.

3. Bahrynovska, T., & Rosil, M. (2021, July 20). *What is Asset Tracking and How Does It Work?* Retrieved Septmeber 19, 2021, from Eueistiq: https://euristiq.com/what-is-asset-tracking-and-how-does-it-work/

4. CFI. (2021, September 19). *Vendor*. Retrieved from Corporate Finance Institute.: https://corporatefinanceinstitute.com/resources/knowledge/finance/vendor/

5. David, Y., & Jahnke, E. G. (2005). Medical Technology Management: From Planning to Application. *Conference proceedings: Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference*, (pp. 186-189).

6. Dhillon, A., & Singh, A. (2019). Machine Learning in Healthcare Data Analysis: A Survey. *Journal of Biology and Today's World, 8*(6).

7. Emmert-Streib, F., Yang, Z., Feng, H., Tripathi, S., & Dehmer, M. (2020). *An Introductory Review of Deep Learning for Prediction Models With Big Data.* Frontiers in Artificial Intelligence.

8. FDA. (2019). *Artificial Intelligence and Machine Learning in Software as a Medical Device.* Maryland: US Food and Drugs Administration.

9. Grant, M. (2021, September 19). *Vendor*. Retrieved from Investopedia: https://www.investopedia.com/terms/v/vendor.asp

10. Home, H. (2019, September 19). *The Many Types of Medical Equipment*. Retrieved from Harmony Home Medical Supply: https://harmonyhomemedical.com/blogs/news/all-types-of-medical-equipment

11. Kadir, E. A., Rahman, T. A., & Rahim, S. K. (2013, September 19). *Active RFID Technology for Asset Tracking and Management System - Scientific Figure on ResearchGate.* Available from. Retrieved from https://www.researchgate.net/figure/Basic-concept-active-RFID-for-asset-tracking_fig1_275496098

12. Lenel , A., Temple-Bird, C., Kaur, M., & Kawohl, W. (2004). *How to Organize a System of Healthcare Technology Management.* Lewes, UK: Ziken International Consultants Ltd.

13. McCarthy, J., & Minsky, M. (1956). *Artificial Intelligence.* https://www.researchgate.net/publication/43069842_Artificial_Intelligence.

14. MGM Solutions. (2018, February 13). *6000 Hours Per Month Wasted on Nurses Finding Lost Equipment*. Retrieved from Healthcare Facilities Today: https://www.healthcarefacilitiestoday.com/posts/MGM-Solutions-6000-Hours-Per-Month-Wasted-on-Nurses-Finding-Lost-Equipment--17611

15. Middleton, M. (2021, February 08). *Deep Learning vs. Machine Learning — What's the Difference?* Retrieved from Data Science - Flatiron School: https://flatironschool.com/blog/deep-learning-vs-machine-learning

16. Ministry Of Budget, Economic Planning And Statisti. (2021). *"Budget Of Wealth Creation'' Approved Year 2021 Budget.* Owerri.

17. Patel, K. K., & Patel, S. M. (2016). *Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenge.* International Journal of Engineering Science and Computing, 6122-6131.

18. Petersson, D. (2021). *What is artificial intelligence?* Retrieved from Tech Target: https://searchenterpriseai.techtarget.com/definition/AI-Artificial-Intelligence#:~:text=Artificial%20intelligence%20is%20the%20simulation,speech%20recognition%20and%20machine%20vision.

19. Saleh, N. (2021, september 19). *Medical Equipment Management*. Retrieved from Asian hospital and healthcare management: https://www.asianhhm.com/technology-equipment/medical-equipment-management

20. Schäferhoff, M., Suzuki, E., Angelides, P. K., & Hoffman, S. J. (2015). *Rethinking the Global Health System.* London: Chatham House, the Royal Institute of International Affairs.

21. Sen, A. (1998). *Mortality as an Indicator of Economic Success and Failure*. The Economic Journal*, 108*(446), 1-25.

22. WHO. (2011). *Medical Equipment Maintenance Programme Overview.* Geneva: WHO Medical Device Technical Series.

23. WHO. (2015). *Global Atlas of Medical Devices: Health Technology Management.* Geneva: World Health Organisation.

24. WHO. (2019). *Decommissioning Medical Devices: WHO Medical Device Technical Series.* Geneva: World Health Organization: CC BY-NC-SA 3.0 IGO.