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Editor's Corner

Magic and miracle might mean the same thing to some people, but there is a vast difference between the two terms. What is the difference between magic and miracle? To a large degree, the response depends on who is answering. A gambler would say perhaps it depends on the size of the booty. While a faith-based person might respond that a miracle is the extraordinary work of god or his/her disciple, while magic is the extraordinary act of a person. One would be considered a sage or miracle worker while the other would be considered a sorcerer or magician. Magic may also be used in a derogatory way, suggesting deception, particularly in discussions of spirituality and stewardship. Miracles on the other hand are used to describe things we do not understand and are related to various faith traditions as being perhaps the result of some powerful super being intervening in the world.

As someone who, over the past three decades, has helped create organizations whose purpose was to improve patient care outcomes by strengthening the communities of clinical engineers (CEs), I've pondered these very questions. Each time a new organization has been established I've wondered if I am witnessing a miracle or magic? This started over 30 years ago with the creation of the American College of Clinical Engineering (ACCE),[1] and continued with the formation of the Center for Telehealth & eHealth Law (CTeL),[2] 5 years later. This was followed about 18 years ago by the establishment of the Healthcare Technology Foundation (HTF).[3] All these organizations filled a specific gap, empowered professionalism, gave a voice, and became impactful over time as well as operationally effectively elevating the level of cooperation and knowledge sharing among peers.

In recognition of the growth in the number of aging persons around the world, the need for faster adoption of new technological tools, rising expectations of consumer's from health care programs, and the changing regulations of healthcare products, the 2019 Global CE Summit, held during the 3rd ICEHTMC[4] Congress in Rome, Italy, focused on identifying paths that CEs can take to optimally address these issues. The top-ranking action path at the Congress was a vote to "increase the CE role in decision-making processes." But, a couple of months later the world was engulfed with the devastation of the COVID-19 pandemic. The world we were living in had changed forever and we're facing a new set of challenges. This challenge involved the need to urgently improve availability and access to need healthcare technological tools. This included personal protection equipment, mechanical ventilators, oxygen supplies, and safe spaces for caring for infected patients. Just as important was the need to manage the safety and quality of inventories and disinfecting processes. As the world keeps on changing, CEs are searching for valid guidance on how to optimally manage the lifecycle and scarcity of these technological tools. These tools are not only critical for healthcare providers but the public as a whole and populations have grown to depend upon their ability to help save lives. The role of CEs has increased significantly and has become more critical than ever within just the past few months (see the *Global CE Journal* issue on COVID-19[5]). With an aging vulnerable population, the inability of the supply chain to deliver life-critical technological products and adapt to a shifting focus on safety and quality has been apparent.[6]

In an article published in this issue of our Journal *"International Survey of Clinical Engineering Professionals,"* the authors concluded that "Patient care outcomes stand to improve when healthcare technology is optimally managed. Identifying the global challenges faced by the international community of CEs is the first step towards overcoming them and the shared goal of better healthcare outcomes can then be better guided. Establishment of global collaboration and structure to achieve partnerships will help to overcome barriers, support professional development, and increase recognition, as well as addressing other challenges facing the CE profession."[7]

The combination of evolution and COVID-19 as an inflection point has magnified the dependence of the future of healthcare outcomes on access to a pool of competent practitioners in each phase of the technology lifecycle. From ideation to commissioning and integration to servicing and program managing, we have no choice but to empower all national CE groups. This can be accomplished by joining a global alliance of clinical engineering that advances the field via cooperation, collaboration, increased visibility, and unique unified relevant representation that seeks to improve the delivery of safe, effective, and high-quality care and its outcomes and thus gain a seat at the decision-making table.

There is no miracle or magic here. Rather hard work, persistence, and the commitment to act as professional members of the healthcare team is what's needed. And that is my colleagues, the purpose of the new Global Clinical Engineering Alliance (http://globalcea.org).

I am sure that you will join me in welcoming this new baby to a safer and better world (welcoming video: https://youtu.be/Hz_y5l6eZP0)

REFERENCES

1. The American College of Clinical Engineers. Homepage. Available at: https://accenet.org
2. Healthcare Technology Foundation. Homepage. Available at: http://www.thehtf.org/
3. The Center for Telehealth & e-Health Law. CTeL Digital Health Summit. Homepage. Available at: http://www.ctel.org
4. International Clinical Engineering Health Technology Medical Congress. The 3rd ICEHTMC Congress Rome, Italy, October 2019. Available at: http://www.icehtmc2019.com/index.html
5. Global Clinical Engineering Journal. Special Issue on COVID-19. Available at: https://www.globalce.org/index.php/GlobalCE/issue/view/9
6. US Food and Drug Administration. FDA Emergency Use Authorization. [Internet]. Available at: https://www.fda.gov/emergency-preparedness-and-response/mcm-legal-regulatory-and-policy-framework/emergency-use-authorization
7. David Y. et al: International Survey of Clinical Engineering Professionals. Global CE Journal 2020;3(2). https://globalce.org/index.php/GlobalCE/article/view/111

Together we are making it better!

Dr. Yadin David

CONTENTS

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International Survey of Clinical Engineering Professionals

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ABSTRACT

To determine the maturity of a profession one must have knowledge of the individual attributes of the practitioners of that profession and the universal strength of unique skills among them. We have conducted an international survey of Clinical Engineering (CE) professionals associated with the management of technological tools developed for and deployed within the healthcare delivery system. The survey targeted participants who are practicing engineering tasks related to the safe and efficient management of technology used in the delivery of healthcare services. The participants, consisted of cohort of individuals whose contact information was collected from attendees at previous clinical and biomedical engineering events including: (1) presentation at congresses/regional meetings, (2) serving on international technical committees or task forces, (3) attending virtual clinical engineering events, or (4) subscribing to the Global Clinical Engineering Journal. The purpose of the survey was to identify the state of organization of CE professionals and the potential gaps, if any exists, in meeting their professional development needs. The survey was developed and conducted using on-line internet apps and links that provided access to a questionnaire in six different languages to facilitate optimal participation and response accuracy in as many geographical regions as possible. The survey was conducted in the early part of 2020 over period of 6 weeks. The overall response rate[1] was over 5% (total of 14,400 individual contacts less estimated 1,750 contacts who did not open/bounced back). A total of 667 responses from 89 countries were received. This survey is considered an improvement, over previously reported international surveys,[2,3] with regard to response volume and rate. The strength of this survey, having larger response volume and geographical representation, when compared with previously documented CE surveys has improved even with narrower time window of data collection. The current survey consisted of twelve questions, beginning with information request about the respondent professional affiliation and moves on to request the ranking of the criticality of C.E. specific issues, while another question provided for comments in free formatting text style. The responses received were in all of the seven languages posted and included representation from all the continents. The analysis of the survey responses shows that about 60% of the responders identified themselves as clinical engineers, 16% as other type of engineers, 13% as technicians, and 12% as health professionals. Responses to particular questions demonstrate highest ratio of number of affirmative to negative responses. They were related to the perceived value responders placed on stronger international collaboration and on their willingness to engage in it. A conclusion, based on the analysis of the responses to this international survey, that the CE profession is awaiting the consolidation of the momentum generated by growing healthcare needs and present global conditions. The identified gap is lack of a dedicated international representation that is clearly identifiable within the CE field. Analysis of the survey data suggests the need of an international framework focusing on the various CE professional groups/associations and their members to face present challenges. The establishment of a global alliance to clearly identify the field of clinical engineering; to promote public awareness; to form liaison with government agencies and other healthcare decision makers, will improve global cooperation and inter CE societal relations that will serve patients as well.

Keywords – *Clinical engineering, survey, questionnaire, global, association, professional, technicians, health, international, alliance, collaboration.*

INTRODUCTION

The dependency of healthcare systems on technology for the delivery of their services is at an all-time high and projected to continuously grow.[4,5] In addition, costs associated with the provisioning of healthcare programs are showing an increasing trend to consuming a large portion of total national gross product.[6] To maximize patient care outcomes and to achieve optimal return on the investment in healthcare technology, it is important to manage the healthcare technology life cycle. This is the main area that clinical engineers, and related technologists and technicians are trained to apply their respective competencies to cost effectively manage and service healthcare technology.

To meet the need to determine how well optimal management of healthcare technology is improving the ability of care providers to practice their profession, fundamental data must be collected relating to how well the needs of the professionals who manage and service this industry are being met.[7] The authors intended to gain new knowledge about the needs of CE practitioners. Specifically, how to overcome lack of opportunities for sustaining sharing of knowledge between international clinical engineering practitioners due to limited clinical engineering professional associations knowledge sharing and exchanging.

Other researchers attempted, in previous work, to determine availability and the extent of CEs responsibilities were deployed by using survey methodology and concluded that lack of harmonization and wide variation are evident in the management of hospitals biomedical technology around the world.[8] Reported results of one of the early surveys looked at CE effectiveness at hospitals in developing countries included 163 responses from 43 countries mostly from Africa, Latin America and Asia.[9]

This survey states "This is the first study to collect and analyze data on the complexity and state of hospital equipment across the developing world; additionally, it is the first to collect significant responses from Africa. Prior to this study, only 10 developing countries had been profiled in international studies." To increase knowledge of a field of practice and to identify attributes of practitioners in that field can be accomplished through a survey. However, limited response volume and the only few published surveys recorded in the international CE field highlight the challenge that this work is addressing in an attempt to gain understanding of current state of the CE profession needs.

A survey that directly seeks answers from the involved community according to industry norms suggests that "Wherever possible, researchers should use existing data, and not bother people again with questions they have already answered in other surveys or can be found in registers."[10] The International Handbook of Survey Methodology[7] identifies a survey as "A study that collects planned information from a sample of individuals in order to estimate particular population characteristics." It further concludes that "Although sample surveys are costly and time-consuming, it may turn out that they are in many situations simply the best instrument for collecting high quality, relevant data." we designed the optimal survey format to be used. It is characterized by short content without open ended style, and yet providing for free text format area at the end of the survey to collect additional information not included within the formal set of questions.

METHODOLOGY

One specific form of data collection method was an online survey consisting of a set of structured questions that can be clearly understood by the expected respondents. The online survey delivers advantages of being easy to respond to and efficient to analyze, having a low margin of errors as respondents select buttons and can easily change or correct their choices prior to submission. Available on-line tools can be used to analyze the data in variety of determinants. In addition, the survey was offered online with applications that could be easily be read and responded to on a working station, tablet, as well as other mobile devices.

Most surveys have a goal of being able to make inferences about points of interest in the target population. In general, one is faced with the need to make assumptions that the persons in the data collection sample are similar on the characteristics of interest to persons not in the sample to be able to make inferences about the population. As such, the design of a survey is critical to its success, and therefore special attention should be given to fit the survey design and structure the questions to clearly preventing possible errors that responders may commit.

The optimal survey format to be used is based on literature of systematic survey and analysis of the use of international population surveying methods in various other fields. Our survey used a questionnaire template style following an introductory statement about its purpose and identifying its administrators and timetable for response acceptance. Clear and simple questions' language, together with a small number of questions and the use of multiple-choice questions style were all intended to help increase survey response rate.[11] Since the total size of the international community of practicing C.E. is unknown at present and the response rate of previous survey was low[9] the sampling methods for this research study was probability sampling[12] where members of the community are chosen randomly. The survey questions were translated into six different languages, in addition to English, to facilitate better response rate from the different continents and countries. The languages used included: English, Spanish, French, Arabic, Chinese, French, and Russian.

A short introductory that preceded the questionnaire explained for the community who received it the survey's purpose and the importance of completing the questionnaire. It is presented in figure 1 below.

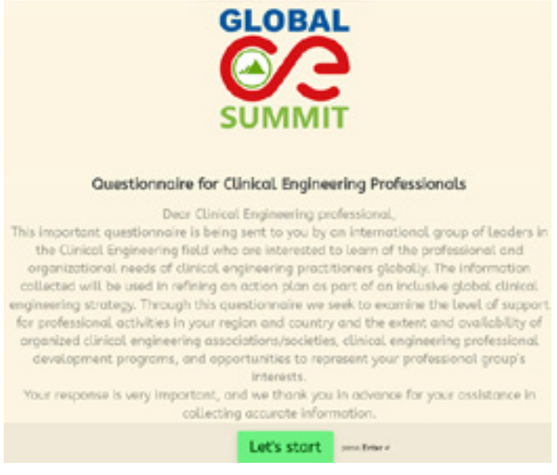

FIGURE 1. Introduction explaining the purpose of the Questionnaire.

The questionnaire consisted of twelve questions, eight of them (shown in table 1 below) having multiple choice answers, three asking for additional information and one provides space for free text format at the end of the questionnaire to collect un-prescribed comments. The last question asks the responders for ranking of professional challenges faced by the clinical engineer practitioners. The main questions are shown in the following table 1 below and the full questionnaire in its original form is found in the appendix.

TABLE 1. Questionnaire format

Question	Response
Are you a member of one of the following professional groups:	Engineer - A Clinical/biomedical Engineer
	Engineer (other)
	Clinical Engineering Technician (BMET)
	Scientist - Healthcare Scientists
	Healthcare professional
	Professional (Other)
Do you have a representative clinical engineering association/society in your country?	Yes
	No
	I do not know
Are you a member of the Association/ Society and do you participate in their meetings or programs?	Yes I am a member, and participate in its meetings/activities
	Yes I am a member, but do not participate in its meetings/activities
	Not yet, but plan to do so in the future
	No
Are there any higher education-based programs in the area of clinical engineering offered in your country?	Yes
	No
	I do not know
Would you volunteer a few hours a month to help advance clinical engineering and its application and impact locally and globally?	Yes
	No
	I am not sure
Do you see value in an international organization focusing the needs of clinical engineering?	Yes
	No
	I am not sure

TABLE 1. Questionnaire format (continue)

Question	Response
Would you participate in the activities of such an organization?	Yes
	No
	I am not sure

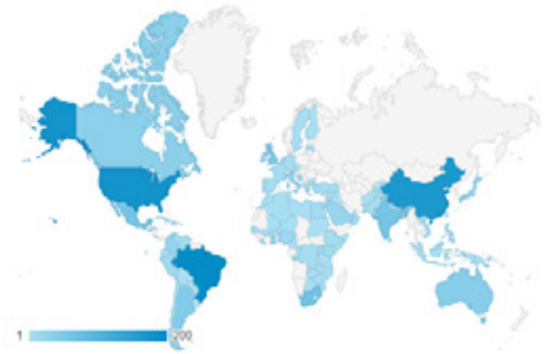

FIGURE 2. World map showing in levels of color intensity origin of the responses received.

RESULTS

The volume of responses to the survey that were collected over relatively short time (six weeks) suggests that the survey was clear to understand and that subject matter was of interest to responders. As a matter of fact, the average time to complete the survey was measured to be 11:27 minutes for desktops, over 3 minutes for tablets, and over 8 minutes for mobile devices all respectfully for users of the English language. It is also interesting that although the number of responses from English speaking countries like USA, UK, Ireland, Canada, and Australia accounted for 121 participants, the number of survey responses in the English language was 282; suggesting that individuals found the survey questions to be sufficiently clear even as a second language.

Responses were received from all the continents and are shown in figure 2 below. The blue color indicates location from where responses were received, and the color intensity indicates volume of responses with darker blue means larger volume.

The first question was about the professional standing of the respondent. Of the total of 669 responses received: 59% of the respondents identified themselves as clinical or biomedical engineer, 16% identified themselves as other type of engineer, 13% identified themselves as clinical engineering technician, healthcare scientists were checked at 5%, healthcare professional at 4%, and other professional were marked 3%. A graphical presentation of the results of question number # 1 is shown in Figure 3 below.

TABLE 2. Questionnaire participation by continent

Continent	Participation
Australia	23
Africa (Rwanda, Nigeria, Ghana, Ethiopia, Uganda, Egypt, Kenya, Bhutan, Zambia, Somalia, Zimbabwe, South Africa, Senegal, Benin, Cameroon, Niger, Tanzania, Botswana)	76
North America (USA, Canada, Mexico, El Salvador, Costa Rica)	101
South America (Brazil, Peru, Colombia, Venezuela, Argentina, Ecuador, Bolivia, Chile, Cuba, Puerto Rico, Uruguay)	200
Asia (China, India, Lebanon, Bangladesh, Bhutan, Bahrain, Japan, Jordan, Nepal, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, Turkey, United Arab Emirates, Yemen, Syria)	142
Europe (Italy, France, UK, Ireland, Spain, Portugal, Greece, Germany, Latvia, Netherlands, Sweden, Bosnia and Herzegovina, Czech Republic, Russia)	86

The second question addressed information about the prevalence of CE national societies, where 73% answered that they have such an association or society, 20% did not, and 7% were not sure.

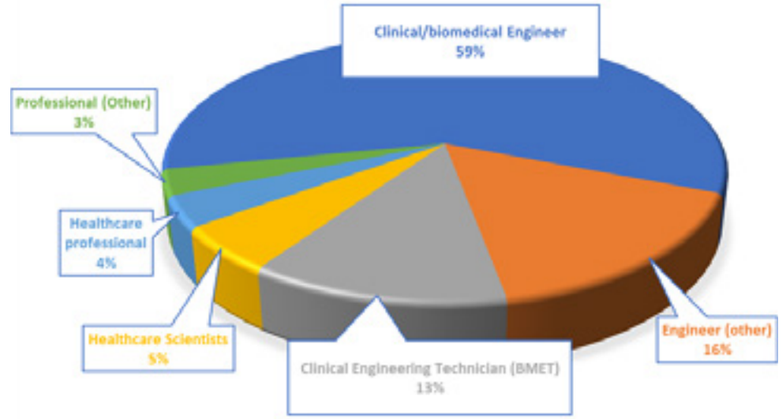

FIGURE 3. Graphical representation of the results of question #1: *Are you a member of one of the following professional groups?.*

The fourth question asked if the respondent is a member of such an organization and do you participate in its meeting or activities; 48% responded that yes, they are members and participate. While 17% wrote that they are members but do not participate, while 20% said that they are not but planned to join in the future, and 15% replied with No, as shown in figure 4 below.

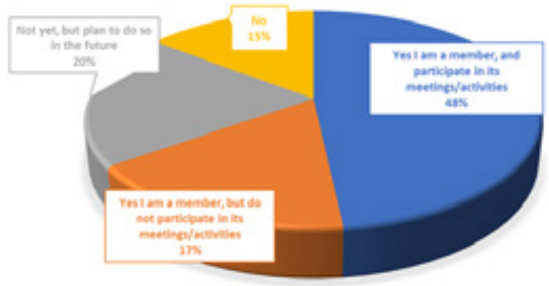

FIGURE 4. Graphical representation of the results of question #4: *Are you a member of the Association/Society and do you participate in their meetings or programs?*

The fifth question asked about higher education-based programs being offered in the field of CE in your country? Responses were 74% Yes, 17% No, 9% I am not sure. The sixth question asked: Would you volunteer a few hours a month to help advance clinical engineering and its application and impact locally and globally? the answers show distribution of 86% Yes, 4% No, and 10% Not sure. The two questions that received the highest ratio of positive to negative responses were question number 7 and question 8, shown in table 3 below. Question number 7: Do you see value in an international organization focusing the needs of clinical engineering? This question registered the highest positive responses with 93% Yes, 2% No, and 5% Not sure. Question seven is important for the understanding of the responders' level of perceived value and need for global organization to unite the CE field. To the question eight: "Would you participate in the activities of such an organization?", 84% replied with Yes, 4% with No, and 12% were not sure.

TABLE 3. Responses to survey questions # 7 & #8

Question	Response		
Do you see value in an international organization focusing the needs of clinical engineering?	Yes	612	93%
	No	13	2%
	I am not sure	32	5%
Would you participate in the activities of such an organization?	Yes	553	84%
	No	28	4%
	I am not sure	76	12%

Next, responders were asked to rank in order of importance eight topics, shown in table below. These topics were discussed at the Global CE Summits[13] that show continuous growing attendance over the last five years as during the 2019 Third International CE and HTM

Congress, Rome, Italy, having record number of accepted abstracts and of international participation.[14] The top challenges that needed to be addressed were listed. The analysis of the survey results shows the following order for the challenges as were ranked by responders:

TABLE 4. Questionnaire results show order ranking of top challenges in current CE field

Challenges in CE field	Answers
Education-Training	446
Recognition	361
Professional Standing-Credentialing	337
Engagement with leaders	270
Networking	230
Career progression	299
Publication opportunity	184
other	31

DISCUSSION AND CONCLUSIONS

Most of previously reported surveys conducted in the clinical engineering field resulted in relatively small response volume and rate. These surveys were discussed in the introduction segment of this manuscript. The present survey was distributed and available for response for shorter time duration than the previous surveys and yet the volume of the responses was higher. The results of this clinical engineering international survey provide representative data that suggest gaps in building sustainable global exchange of knowledge and professional networking between groups/associations of clinical engineering practitioners.

The survey essentially composes of two parts. The multiple-choice questionnaire (part I) and the ranking of challenges and free text (part II). The results from part I, deem to suggest that a positive change taking place in the CE field reflected by growth in the volume of the number of national CE associations around the world as reflected by the relatively high confirmation response rate to question two "do you have CE association in your country?" (73%) and to question four about participation in such association (48%). In yet another demonstration, for same phenomenon observed by the data, is the high positive response to the question about availability of higher education-based program in your area (74%).

However, this stands in contrast to the results analyzed for part II - the ranking of the top challenges the responders are facing. The data clearly reveals that the most important challenges responders face are limited availability of education and training (446 responses), follow by lack of professional recognition (361 responses), and by absence of professional credentialing programs (337 responses). All other listed challenges recorded less than 200 responses each, placing higher significant on the top three.

The data also sufficiently demonstrate a clear and overwhelming positive response for the value seen in having international organization that will focus on CE needs (612 responses) as well as for responders' intention to participate in such an organization (553 responses). It is also revealing to see that only 2% of the responders (13 responses) do not perceive of such a value. The combination of the results of (part I) of this questionnaire with the ranking of top challenges the CE field is facing (pat II), with also the growing attendance at international CE congresses, and the recent increase volume of CE publications[15] – reveals a CE field in the midst of a professional evolution in need of leadership to further facilitate its important impact on healthcare programs. The survey highlighted the state of CE associations, networking, professional challenges, and the desire for more international cooperation that leads needed professional development programs. Programs that support expansion of skills, job responsibilities and equal participation in healthcare teams. Patient care outcomes stand to improve when healthcare technology is optimally managed. Identifying the global challenges faced by international community of CEs is the first step towards overcoming them and the shared goal of better healthcare outcomes can then be better guided. Establishment of global collaboration and structure to achieve partnerships will help to overcome barriers, support professional development, and increase recognition, as well as addressing other challenges facing the CE profession.

Based on the analysis of the survey data, one such initiative can be to unify the global CE field and provide a framework for the various professional groups/associations and their members with continuous opportunity for collaborations across areas and on issues better resolved on an international level. As such, the establishment of a global structure clearly identifying unified field of clinical engineering that will: promote public awareness; form liaison with government agencies and other healthcare decision makers; and improve international cooperation and inter societies relations and will ultimately support better patients care and wellness everywhere.

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REFERENCES

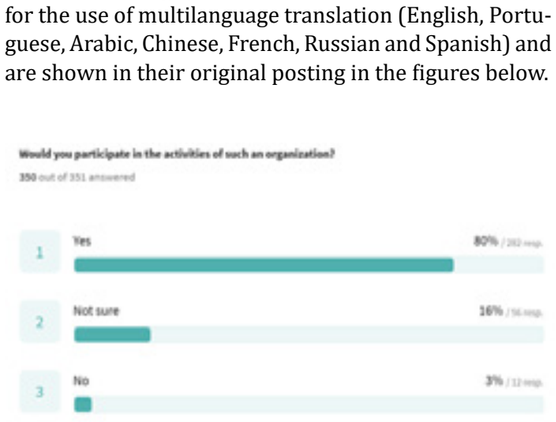
1. M. Clark, M. Rogers, A. Foster, F. Dvorchak, F. Saadeh, J. Weaver, V. Mor: *A Randomized Trial of the Impact of Survey Design Characteristics on Response Rates Among Nursing Home Providers Eval Health Prof.* 2011;34(4):464-486. doi:10.1177/0163278710397791.
2. L. Nascimento, S. Calil, T. Judd, Y. David: Analysis of IFMBE-CED 2017 Worldwide Clinical Engineering Survey, Global Clinical Engineering Journal, Vol. 2, Issue 1, December 2019 https://doi.org/10.31354/globalce.v2i1.70
3. M. Frize, X. Cao, I. Roy: Survey of Clinical Engineering in Developing Countries and Model for Technology Acquisition and Diffusion, Proceedings of IEEE, 2005 EMBS 27th annual conference, Shanghai, China, Sept. 1-4, 2005. https://ieeexplore.ieee.org/abstract/document/1616369
4. J. Dyro: Clinical Engineering: Evolution of a Discipline, Clinical Engineering Handbook, Chapter 1, Elsevier Academic Press Series in Biomedical Engineering, USA, 2004.
5. Clinical Engineering Handbook, E. Iadanza (ed.), Chapter 1, Second Edition, Academic Press, Elsevier 2020. https://www.elsevier.com/books/clinical-engineering-handbook/iadanza/978-0-12-813467-2?countrycode=US&format=print&utm_source=google_ads&utm_medium=paid_search&utm_campaign=usashopping&gclid=CjwKCAjw4rf6BRAvEiwAn2Q76u0EU1BXj0Asb7pYRSpRovmzQWMPlJH6BFXJq2k9B1xkm0RLqmbYgxoCeiYQAvD_BwE
6. American Institute for Medical and Biological Engineering, Wiley Encyclopedia of Biomedical Engineering, April 2006. https://www.wiley.com/en-us/Wiley+Encyclopedia+of+Biomedical+Engineering%2C+6+Volume+Set-p-9780471249672
7. de Leeuw, E. D., Hox, J. J., & Dillman, D. A. (Eds.). *International handbook of survey methodology.* Taylor & Francis Group/Lawrence Erlbaum Associates. (2008). https://psycnet.apa.org/record/2008-04187-000
8. M. Glouhova, N. Pallikarakis: World Clinical Engineering Survey, Clinical Engineering Handbook, Chapter 15, Elsevier Academic Press Series in Biomedical Engineering, USA, 2004.
9. S. Mullaly, M. Frize: Survey of clinical engineering effectiveness in developing world hospitals: equipment resources, procurement and donations, Conference Proceedings IEEE/EMBS 2008, doi: 10.1109/IEMBS.2008.4650212.
10. D. Korniewicz, T. Clark, Y. David: A National Online Survey on the Effectiveness of Clinical Alarms, American Journal of Critical Care 17 (1):36-41, January 2008. https://aacnjournals.org/ajcconline/article-abstract/17/1/36/643/A-National-Online-Survey-on-the-Effectiveness-of?redirectedFrom=fulltext
11. Part IV Culture, Cognition and Response in Survey Methods in Multinational, Multiregional, and Multicultural Contexts, edited by Harkness et al. 2010, John Wiley & Sons, Inc. https://www.researchgate.net/profile/Daphna_Oyserman/publication/230015384_Cognition_Communication_and_Culture_Implications_for_the_Survey_Response_Process/links/59eccf864585151983ccd415/Cognition-Communication-and-Culture-Implications-for-the-Survey-Response-Process.pdf
12. B. Schouten, F. Cobben, J. Bethlehem: Indicators for the representativeness of survey response, Survey Methodology, June 2009, Vol. 35, No. 1, pp. 101-113 Canada. https://www.researchgate.net/profile/Jelke_Bethlehem/publication/267836796_Indicators_for_the_Representativeness_of_Survey_Response/links/547458fc0cf245eb436dd8ae/

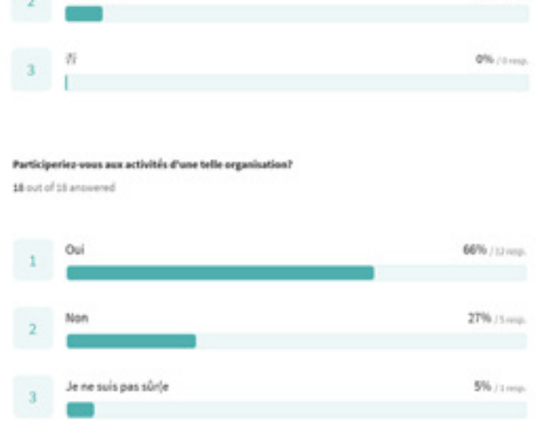
Indicators-for-the-Representativeness-of-Survey-Response.pdf

13. The Global Clinical Engineering Summit, 3rd ICEHTMC Congress, Rome, Italy, 2019. https://ced.ifmbe.org/blog/ifmbe-ced-cestatus-cesummit2019.html
14. International Clinical Engineering and Health Technology Management Congress, Rome, Italy, October 21-22, 2019. http://www.icehtmc2019.com/paper-submission.html
15. Making a Difference – Global Health Technology Success Stories: Overview of over 400 submissions from 125 Countries. Global Journal of Clinical Engineering, Vol.1, No. 1, 2018. https://www.globalce.org/index.php/GlobalCE/article/view/43

APPENDIX I

The following question was selected as an example for the use of multilanguage translation (English, Portuguese, Arabic, Chinese, French, Russian and Spanish) and are shown in their original posting in the figures below.





APPENDIX II

Full questionnaire in English.

1 * Are you a member of one of the following professional groups:

- A Engineer - A Clinical/biomedical Engineer; graduate of these engineering programs
- B Engineer (other) - graduate of engineering program other than Clinical or Biomedical engineering
- C Clinical Engineering Technician (BMET) or Engineering Technologist - technically trained to support healthcare technology/medical devices
- D Scientist - Healthcare Scientists (computing, mathematics, physics, etc.) working with healthcare technology and medical devices
- E Healthcare professional - graduate of a program in Health sciences (physician, nurse, radiographer, physiological measurement technologist, etc.) working with healthcare technology/medical devices
- F Professional (Other) - graduate of a program in an area other than engineering or health sciences (e.g. physics, chemistry, computing, informatics etc.) and managing or working with healthcare technology/medical devices

2 * Do you have a representative clinical engineering association/society in your country? *

- A Yes
- B No
- C I do not know

3 * Please provide the Association/Society's name and contact person:

Type your answer here...

4 * Are you a member of the Association/Society and do you participate in their meetings or programs?

- A Yes I am a member, and participate in its meetings/activities
- B Yes I am a member, but do not participate in its meetings/activities
- C Not yet, but plan to do so in the future
- D No

5 * Are there any higher education based programs in the area of clinical engineering offered in your country?

- A Yes
- B No
- C I do not know

6 * Would you volunteer a few hours a month to help advance clinical engineering and its application and impact locally and globally?

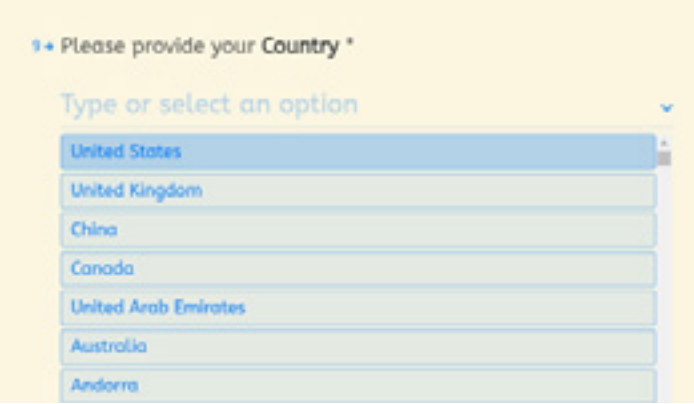
- A Yes
- B No
- C I am not sure

7 * Do you see value in an international organization focusing the needs of clinical engineering?

- A Yes
- B No
- C I am not sure

8 * Would you participate in the activities of such an organization?

- A Yes
- B No
- C Not sure


9 → Please provide your Country *
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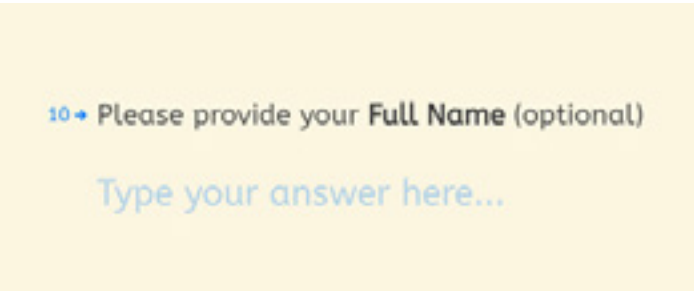
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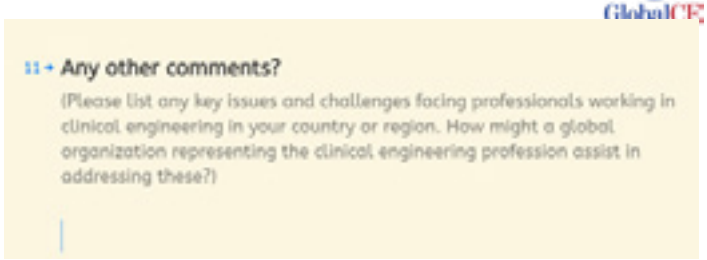
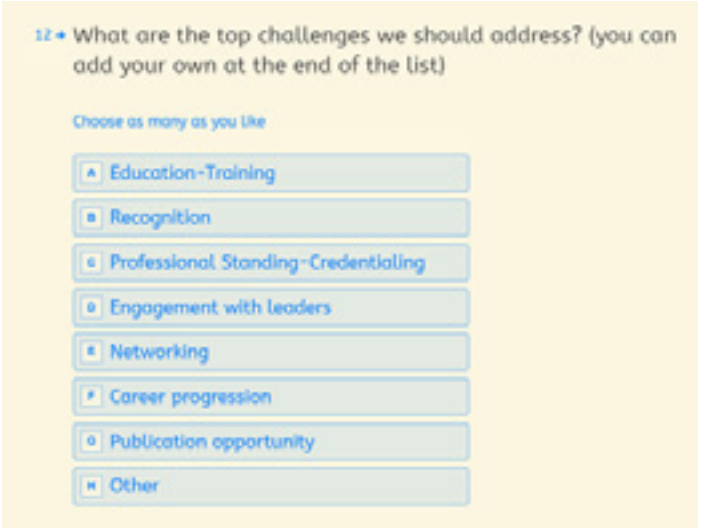

11 → Any other comments?
(Please list any key issues and challenges facing professionals working in clinical engineering in your country or region. How might a global organization representing the clinical engineering profession assist in addressing these?)


12 → What are the top challenges we should address? (you can add your own at the end of the list)
Choose as many as you like
A Education-Training
B Recognition
C Professional Standing-Credentialing
D Engagement with leaders
E Networking
F Career progression
G Publication opportunity
H Other

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Editorial: Unravelling the magic of latent safety threats

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Sterile processing errors in medical and dental offices are ranked the third highest hazard according to the annual ECRI 'Top 10 Health Technology Hazards' 2020 report.[1] Other experts have raised similar concerns with sterilisation processes. For example, the WHO and the Clinical Engineering Division of International Federation of Medical and Biological Engineering (IFMBE) have partnered to provide a series of webinars with international experts exchanging knowledge on COVID-19 related critical topics. A recent webinar addressed the critical challenge of decontamination and disinfection of COVID-19 medical equipment in low-income and middle-income countries.[2] During the webinar, participants asked about methodologies to assess whether the transmission of infection is borne by technological tools used to fight the disease. How can critical lifesaving breathing equipment be safely and quickly sterilised and moved from one patient to the next? The WHO/IFMBE webinar[2] stated that 'engineers and infection control professionals seem to be working in different silos'. Such silos must be dismantled because medical technology is indispensable in the provisioning of healthcare services. Disinfection and sterilisation of medical equipment are key concerns for healthcare organisations, and they require serious consideration of sociotechnical system interactions. The annual 'top 10 Health Technology Hazards report' is based on retrospective studies, yet management of COVID-19 safety requires capacity to process real- time data and the input of experts to predict where risks may occur and how to deploy plans to maintain a safe healthcare environment.

Alfred et al[3] in this issue of BMJ Quality & Safety describe the Sterile Processing Department (SPD) as 'an example of a socio-technical system, where people, procedure, technology, environment, and organization interact to produce a range of proximal and distal outcomes'.3 The goal of their study was to 'develop a comprehensive understanding of the SPD assembly work system by uncovering key relationships between system components, and the sources of variance that might influence reliable assembly in instrument reprocessing'. They explain their findings as a function of a variety of contributing factors including: technological, labelling and human capacity issues. The authors' analysis cogently points to interventions 'beyond the hospital's traditional focus on individual staff '. Their results show the necessity of identifying system components and the impact of their interactions, to reveal appropriate interventions to improve the quality and safety of care and to reduce delays. The emphasis on expanding beyond 'tradition' is particularly pertinent now.

SAFETY IS A DYNAMIC NON-EVENT

The rapidly evolving COVID-19 epidemic has stretched the capacity of healthcare systems worldwide; consequently shining a light on existing quality and safety processes that often go unnoticed because, as Karl Weick advanced, safety is a dynamic non-event.[4,5] Safety is dynamic because processes remain within acceptable limits due to moment-to- moment adjustments and compensations by the healthcare workers. It is a non- event because safe outcomes are taken for granted and often go unrecognised. Paradoxically, the public appreciates quality and safety more when the system is unsafe, because lack of safety is salient, whereas normalcy is not.

You do not have to look far these days to see how much more appreciation the public has for the quality and safety of healthcare. However, this level of interest—concern, really—has the risk of isolating the responsibility for healthcare safety and quality to the (relatively) small group of professionals who actually deliver healthcare. It is further presumed to be their

job to teach and apply medical, engineering and other scientific knowledge to improve the quality and safety of everything related to the healthcare services. However, we now realise that these presump tions need to be examined. Recent global conditions have demonstrated that national emergency response plans and the stocking of medical supplies fell short of expectations. Yet with the inclusion of experts specifically trained in safety and quality, these plans are already better networked with the supply chain that is being designed to be patient ready when urgently needed. Similarly, safety and clinical engineers were finally permitted to use ultraviolet radiation as sterilisation technology in patient care spaces. Ultraviolet radiation is not a new tool, but it is now applied because of expert recommendations and consequently it now plays an important role in protecting medical personnel, patients and family members.[6]

All of this begs the question: why has COVID-19 spurred recognition on the part of the public, and by medical professionals, of safety and quality controls in the delivery of healthcare? Pandemics highlight the existing people and processes that keep our systems safe and the fact that these elements of our system are not failsafe. There are threats in the system that remain latent because people are dynamically adapting in real time, but when the system is stretched too far, the threats no longer remain dormant. Deploying a predictive model of quality and safety, with professionals specifically trained in these areas, will be impactful to show in which scenarios such threats are likely to appear and can be timely mitigated.

UNDERSTANDING WHAT KEEPS OUR SYSTEMS SAFE

Without sufficient knowledge of what protects us, the ambiguous methodology for optimal provisioning of staff and patient safety was initially like performing magic. Starting with the elderly community and later with all ages, it has been like watching a Houdini act—how did that illusion which we were watching just happen? Will it happen again? As noted above, we need to re-examine the presumptions we hold about delivering safe and high-quality healthcare services. Once we understand the latent threats in the system, these can become controllable features. What appears to be magic is anything but. There are many system factors at play—people, processes and technologies— that are keeping us safe, but they require further attention if they are to remain safe under unprecedented conditions.

Neither safety nor quality seems to have kept up in the rush to find an effective response to the pandemic. Whose job is it to keep up? As pointed out by Alfred et al[3] regarding the instrument assembly process and a previous paper on the decontamination of instruments[7] if we fail to identify all the system factors and their interactions, we fail to understand what keeps our systems safe. Consequently, we make assumptions about the backbones of our system, and when the system reaches its breaking point, we jump to solutions that are not aligned with the true root cause of the problem because we do not understand the mechanisms that underlie the safe operating state.

Previous examples regarding problems with instrument reprocessing have already pointed to the lack of understanding on the systems factors at play that led to poor solutions. For instance, I participated in an investigation in 2005 following the exposure of patients during surgeries in Duke University Health System, to instruments that were processed between procedures in hydraulic fluid instead of cleaning detergent.[8] The hospitals did not detect the problem for weeks, despite complaints from staff members that the instruments felt unusually slick. The mix-up occurred when an elevator company drained hydraulic fluid into empty detergent barrels and the detergent supplier mistakenly redistributed them. The COVID-19 pandemic has emphasised the importance of decreasing instrument contamination risks[9] as well as a general sense of urgency that may impose the risk of jumping to solutions too quickly. It is important to note that these latent safety threats have been there all along, but we are just noticing them more now than before because some of them are no longer latent. It was never magic; it was always the steady and adaptive coping of system factors—mostly people in the background—that never got recognised.

People around the world are now more clearly recognising their own responsibility and the benefits of adopting a more safety-oriented culture in their personal lives as well as in the products they use. The respect of paying homage to safety reached such a high awareness that one must again wonder, why did it take a global devastating pandemic to bring us to this level? And can the same be stated about quality?

URGENT NEED TO IMPLEMENT APPROPRIATE SOLUTIONS FOR SOCIOTECHNICAL PROBLEMS

Alfred et al[3] in their analysis of sterile processing already pointed to the need 'for a wider range of interventions to enhance system performance beyond the hospital's traditional focus on individual staff behaviours and motivations'. System safety is thus dependent on the coordination of healthcare staff and management at the front line of service deliveries with the manufacturers who produce medical products, regulatory bodies and government who monitor its introduction into the market and clinical engineers who manage it over its life cycle use. This was acknowledged and highlighted by the 67th World Health Assembly when they issued a declaration in 2014 that states, in part, '[C]oncerned by the impact on patients of medical products of compromised quality, safety and efficacy, in terms of poisoning, inadequate or no treatment, contributions to drug resistance, the related economic burden, and erosion of public trust in the health system; … urgent action is needed by the international community, Member States and relevant actors in health systems… to develop appropriate norms, standards and guidelines, including taking into account national, regional and international needs and initiatives,… to prioritize support for establishing and strengthening regional and subregional networks of regulatory authorities… to promote the greater participation of Member States in existing international and regional initiatives for collaboration and cooperation… to support the building-up of effective national and regional regulatory bodies and networks… to raise awareness of the importance of effective regulatory systems within the health system context'.[10] In other words, system safety is dependent on coordination of all levels, not each level in isolation, and is a shared responsibility. Interventions to address disinfection and sterilisation risks are dependent on the coordination of all stakeholders, including the public.

As we begin to transform from fragility to vitality, this is the moment to convert the present heightened awareness into a strategy of education. Together, we should adopt guidelines for incorporating healthcare technology life cycle management beyond the focal point of products entry into the market and expand it to include consideration of the entire healthcare technology life cycles. From ideation to obsolescence, healthcare technology should be benchmarked at every stage based on indicators that every member including the public can understand, relate to and embrace as measure of minimum acceptable performance level for safety and quality. This will include the public, who for example may begin using home-based medical technology more than ever, in gaining participation to make care decisions. Every segment of care providers will now have tools to assess the whole life cycle of medical products from installation, performance assurance, upgrades, reallocation and retirement from one market to another.

Regardless of the reasons that led to relegating the quality and safety role only to those professionals who were formally tasked with it, we must embrace the strategy to expand the responsibility to the public. Instead of a single product mentality, let us challenge our ability to measure and embed predictive preventive measures of system performance. Critical characteristics of safety and quality management can be used to measure and mitigate latent risks and can be used to rank healthcare delivery and provide a 'report card' that can enhance choices the public can make. I suggest, therefore, a call for action to establish national institutions and international cooperation that will promote and harmonise safety and quality indicators relating to technological tools being deployed in our healthcare delivery systems.

No more magic show.

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REFERENCES

1. Emergency Care Research Institute (ECRI). Top 10 health technology hazards for 2020. Expert insights from health devices. Special report, 2019. Available: https://www. ecri.org/landing-2020-top-ten-health-technology-hazards [Accessed Sep 27].
2. International Federation of Medical and Biological Engineering (IFMBE). Online course 7. Decontamination-Disinfection of critical COVID-19 equipment, health workers, and patients. Available: https://ced.ifmbe.org/covid19/guruPrograms/16-covid19/16-covid19-townhalls-decontamination.html [Accessed Sep 27].
3. Alfred M, Catchpole K, Huffer E, et al. Work systems analysis of sterile processing: assembly. BMJ Qual Saf 2020:bmjqs-2019-010740.
4. Weick KE. Organizational culture as a source of high reliability. Calif Manage Rev 1987;29:112–27.
5. Reason J. Safety paradoxes and safety culture. Inj Control Saf Promot 2000;7:3–14.
6. Zhang J, Li J, Wu Z. The Chinese experience - fighting against COVID-19, Shanxi Medical engineers. Global Clinical Engineering Journal 2020;2:35–8.
7. Alfred M, Catchpole K, Huffer E, et al. Work systems analysis of sterile processing: decontamination. BMJ Qual Saf 2020;29:320–8.

8. The New York Times. Surgical Tools 'Washed' in Hydraulic Fluid. Available: https://www.nytimes.com/2005/06/13/us/ surgical-tools-washed-in-hydraulic-fluid.html
9. Aj B, Brown C, Abdelrahman T, et al. International surgical guidance for COVID-19: Validation using an international Delphi process - Cross-sectional study. Int J Surg 2020;79:309–16.
10. World Health Organisation. Regulatory system strengthening for medical products. Sixty-seventy World health assembly, 2014. Available: https://apps.who.int/gb/ebwha/pdf_files/ WHA67/A67_R20-en.pdf?ua=1 [Accessed Sep 27].

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Modeling an Integrated Network for Remote Patient Monitoring, Based on the Internet of Things for a More Preventive and Predictive Health System in West Africa

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ABSTRACT

Background: As a result of globalization it is important to examine health systems organization in Africa to highlight the failures and propose possible solutions in terms of patient care.

Objective: Modeling was based on the Internet of Things (IoT) an Integrated Network for Monitoring Patient Data in West African Health Systems.

Methodology: To achieve the objective three steps were followed. (1) Identification of the different characteristics of IoT-based health surveillance systems, Wireless Body Area Network (WBAN) systems, and the physiological parameters that are monitorable on a patient. (2) The modeling of the architecture of West African health systems in the form of a cloud of technocenters. (3) Cross analysis between different IoT technologies, characteristics, and identification of any functional requirements. All this was based on wireless medical sensor networks in the WBAN systems.

Result: This work has been used to model health systems in Africa as a remote monitoring network for patients.

Conclusion: The implementation of this model of monitoring networks will be a tool to support large-scale decision-making for health systems in Africa. It will enable an information database for the West African health system.

Keywords – *Modeling, Integrated Network, Internet of Things, health system, Technocentre.*

RÉSUMÉ

Contexte: Du fait de la globalisation des systèmes sanitaires, il est important d'examiner l'organisation des systèmes de santé en Afrique, sous l'angle de prise en charge des patients, pour mettre en évidence les défaillances et proposer des pistes de solutions.

Objectif: Modéliser à base de l'internet des objets (IoT) un Réseau Intégré de Monitoring de données des patients dans les systèmes sanitaire de l'Afrique de l'ouest.

Méthodologie: Pour y parvenir, trois étapes ont été suivies. (1) Le recensement les différents caractéristiques des systèmes de surveillance sanitaires basés sur IoT, des systèmes Wireless Body Area Network (WBAN) et les paramètres physiologiques monitorables sur un patient. (2) La modélisation de l'architecture des systèmes sanitaires ouest-africain sous forme d'un nuage de Technocentres. (3) L'analyse croisée entre les différentes technologies de l'IoT, les caractéristiques et les exigences fonctionnelles identifiées. Tout ceci en se basant sur des réseaux de capteurs sans fil médicaux dans les systèmes WBAN.

Résultat: Ce travail a modélisé les systèmes sanitaires d'Afrique comme réseau de monitoring de données des patients.

Conclusion: La mise en œuvre de ce modèle de réseaux de monitoring consistera un outil d'aide à la prise de décision de grande envergure pour un système sanitaire en Afrique. Il permettra au système sanitaire ouest africain de disposer d'une banque de données d'information.

Mots-clés – *Modélisation, Réseau Intégré, Internet des objets, Système de santé, Technocentre.*

INTRODUCTION

The current challenges and goals of information and communication technologies (ICTs) are to provide effective and efficient healthcare. One of the latest advances in ICTs is the Internet of Things (IoT) providing global connectivity and management of sensors, devices, users, and information. The IoT concept provides the ability to search for information about a tagged object or person by browsing Internet addresses or a database entry that matches a particular active Radio Frequency Identification (RFID) with a detection function. In the last decade, wireless medical sensors, smartphones, and other mobile devices have attracted growing interest as tools that can be used for personal healthcare, and monitoring activities and physical condition.

Some research has been done on the clinical applications of these technologies in remote healthcare surveillance architectures for long-term management, registration, and clinical access to patient physiological information

Based on these current technological advancements, it is easier to plan or schedule your physical examination, which is preceded by a period of a few days of continuous monitoring of your physiological state with less expensive wireless medical sensors. During this monitoring, wireless medical devices continually record signals correlating with the patient's important physiological parameters and sends them to a database of medical records. This scenario allows the medical professional (doctor and other) to have more information about the patient's state of health before the next appointment. Using this information and making it available to health professionals who also have access to a vast body of observational data for other individuals, the medical professional can make a better diagnosis and recommend appropriate treatment regarding early intervention and particularly effective lifestyle changes that can improve the patient's quality of health. These technological advances have a transformative impact on global health systems by dramatically reducing health costs and improving the speed and accuracy of diagnostics.

The vision presented previously from the technological point of view has been available for some years now in several sanitary systems around the world not within the African health systems and especially West Africa despite the technology already on hand. The West African health system presents for the most part the same configuration and structuring inherited from their time as colonies.

In this article, we are particularly interested in modeling an architecture that takes into account the current structure of West African health systems while implementing the healthcare surveillance architecture.

METHODOLOGY

It is very important to choose the appropriate techniques and methods in the literature search and data analysis. To ensure the integrity of the data, the means used to perform the analysis will depend on the information provided by the various search engines such as Google Scholar and scientific databases such as PubMed, Wiley, NCBI, IEEE Xplore, Scopus, and Web of Science. Google Scholar and IEEE Xplore are the two most used in our research.

The keywords used for data collection were: "IoT and Health Surveillance", "Internet of Things and Health System", "Remote Patient Monitoring with IoT". These three combinations of keywords were used on Google Scholar for the documentary review.

This review of the literature revealed that the challenges of health surveillance are very topical. Most of the work has not been in favor of a particular health system from a country, region, or area depending on its configuration but has shown there is an opportunity presented by technological progress to aid in monitoring several aspects of a patient's state of health including managing patient data,[1,2] WBAN networks and architecture, security in health data management systems and many other areas.[3,4] All of militated in favor of the results obtained.

RELATED WORK

A total of 128 articles between 2010 and 2019 were found, with an emphasis on research between 2014 and 2016. The 128 articles were then sorted to rank those that best met the criteria of research. In the end, 34 articles were excluded and 94 were included as the subject of our study. The results are shown in Table 1.

The IoT is of great potential interest for medical applications and healthcare. Many technologies are related to

TABLE 1.

Year	Number of articles found per year	Number of articles excluded per year
2010	3	0
2011	4	0
2012	3	1
2013	3	0
2014	27	2
2015	37	1
2016	29	18
2017	19	12
2018	2	0
2019	1	0
TOTAL	**128**	**34**

IoT. Technologies such as wireless medical body sensors, advanced healthcare systems, wearable sensors, cloud-based platform for wireless transfer, storage, and display of clinical data (see Table 2, in appendix) carry particular interest. In conclusion, we note that the challenges of any medical surveillance system lie in the proper design of the network architecture. In light of this, our work aims to model an integrated patient monitoring network (RIMP) in the West African health system, based on the IoT. This article presents the methodology adopted for the work, the results obtained, and the analysis, discussion, and perspectives envisaged.

RESULTS

Despite the specificities observed in each country, the health pyramid of West African countries generally includes first-level structures (dispensaries, health huts, etc.), so-called reference structures (general hospital), specialized structures (dedicated to a disability or illness), and university hospitals. In principle, so-called primary health care is the foundation of health systems, whose national health development programs (PNDS) stipulate that the structures responsible for it must cover n thousands of inhabitants in a given geographical area [Org]. Such a health pyramid has enormous advantages for mastering health data from scratch when it comes to diagnosis and care, so it has a modern remote monitoring architecture. For better monitoring of patients in African health systems, we propose an architecture integrating the different levels of each health system facilitated by a cloud of technocentres from remote monitoring networks. This would include surveillance centers allowing centralized accessible health information.

IoT Architecture of an Integrated Patient Monitoring Network

Several physiological parameters can be monitored Sixteen different groups of physiological parameters can be monitored using IoT sensors placed at 17 different locations on the patient's body.5 Figure 1 shows an outline of some of the physiological parameters ([A] blood pressure, [B] electrocardiogram, [C] pulse oximeter, [D] electromyogram, [E] inertia).

The IoT architecture of the Integrated Patient Monitoring Network shows the interaction of the different IoT components of our system and its network and computer technologies. The different IoTs in this architecture include intelligent medical sensors of different sizes and types that monitor patient health parameters and also process and record the raw data from the sensors. The transceiver modules of the medical sensors communicate with the base stations via a wireless interface. The most powerful base stations will act as data aggregators, well nodes, or gateways to servers. The different IoT Gateways

work with the different types of devices and associated network protocols to provide overall connectivity.

The integrated IoT patient monitoring architecture

FIGURE 1. IoT architecture of an integrated patient monitoring network.

is made up of several levels. The first level is the IoT sensor level, which fits the patient with several sensors to measure the desired physiological parameters (EMG, ECG, blood pressure, heart rate...). The second level of the architecture shows the connectivity elements. This level shows the symbols of the different communication networks used to route the data collected by the sensors to the treatment centers. Depending on the application, wifi, Bluetooth, or zigBee can be used to route measured physiological data to the sensor nodes and then to the treatment centers called here technocenters. Technocenters are data processing centers available at all levels of the health system including those in village health centers, district health centers, communal health centers, departments, and zones at the national level. These technocentres are interconnected through a network. To allow different requests from users of the network including healthcare providers, the healthcare administrator and the patients, we are implementing a DNS service so the users can successfully request the data from the closest server with a different zone access from the internal and external users of the network. The patient's personal digital devices (PDAs) will allow healthcare providers to capitalize on the capabilities in smartphones that patients already carry. Since these smartphones can be connected to the Internet through their GSM network, it would be enough to install eHealth applications allowing the patient's phones to receive and send the necessary information to and from the treatment center. Recommendations could easily be made for these smartphones regarding their specific characteristics as needed.

Functional Architecture of the Hospital Platform

We propose the functional architecture of the hospital's platform detailed in Figure 2 to enable the West African health system to monitor patients effectively.

The functional architecture of the hospital platform that we propose takes into account several aspects for the monitoring and the traceability of the patient inside and

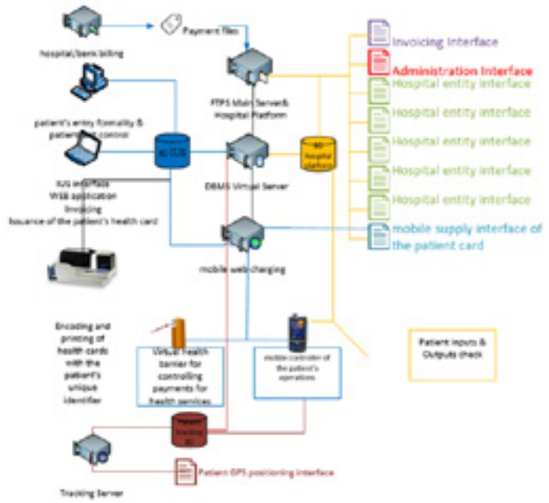

FIGURE 2. Functional architecture of the hospital platform.

outside the hospital. We propose the use of the Country Unique Patient Health Identification (CIUS-P) for patients in the West African health system. This will allow a patient in Benin or any other African country to have a unique identity card from his country of origin. This new health card will make it possible for any hospital in the African health system to have access to the patient file and will make it possible to know any health antecedent of a patient wherever they are. This multifunctional health card will also allow the payment of the patient's health services since it integrates a virtual account. The patient's localization feature will be integrated with the patient's CISU-P card to find it through GPS on an integrated platform. This feature will allow a patient's hospitalization to be known in real time. More interesting in this architecture is that the position of the patient is known even outside of the hospital in real time as long as they have the health card on them. The architecture of the platform integrates all the entities (surgery, medicine, emergency, laboratory ...) of the hospital so that the patient record can be seen by all (except for any access restrictions added as required).

DISCUSSION

Faced with the challenges of the West African health systems and in particular, the Beninese health system, which are (i) to provide quality health care to a growing population, (ii) to optimize the availability of health care personnel, and (iii) to utilize patient health data in a more predictive health system; we proposed in this work an integrated IoT architecture for patient monitoring and the functional architecture of the hospital platform whose implementation could revolutionize the West African health systems in general and Benin in particular. The implementation of this solution would go through several stages: first, choosing a health zone in Benin that has village, district, and communal health centers, departmental hospitals, and university hospitals. Once the expected positive results in this first zone were confirmed we would consider the extension of the architecture to other health zones.

Constraints of WBAN networks (i.e., scalability, quality of service [QoS], energy consumption, wireless technology) will have to be taken into account.[6,7] There is a large amount of work in the literature that deals with the application of WBANs in a healthcare setting.[8,9] This research outlines the characteristics and requirements of the medical application of WBANs as well as the characteristics and design factors.

Another consideration in the design of WBAN networks involves security requirements (WBAN and traditional networks have the same security requirements).[10,11] However, this does not present a functional issue for the architecture of the hospital platform, which is the focus of our work. Moreover, we can see that the multitude of work in the literature does not consider a global architecture of a health system but often speaks of service architecture, while at the security level the security of patient and billing data will be considered when implementing the proposed solutions. Security threats or attacks, such as modifying and eavesdropping on medical data, detecting and locating activities, and hacking into security systems and alarms, can occur and must be taken into account.[10,11] Also, data flow and network capacity are also among the parameters that have an impact on system performance. In this scenario, the choice of high-speed wireless technology offers advantages to meet the scalability of the network and increase the number of people being monitored. On the other hand, other technologies allow for lower power consumption, but have higher delays (production) and/or lower transfer rates. The technology chosen will therefore be a compromise between throughput and energy consumption. As several technologies are used in patient monitoring architectures to provide multiple services[9,12] we started to identify all technologies used within the different services. On this basis, our work extends this knowledge by proposing the essential characteristics of any monitoring system adapted to the Beninese health system as well as the different possible positions where the sensors could be placed on a patient's body as mentioned in our previous work.[5,13]

CONCLUSION

In this work, we modeled West African health systems by proposing an IoT architecture for patient monitoring and the functional architecture of the hospital platform. This model incorporates the CIUS-P which allows the patient information to be available in all areas across the West African health system. This architecture will allow the West African health system to respond to health challenges and provide data for better health forecasting. Future work will allow this architecture to be implemented in Benin to analyze its effect and any limitations. The implementation will occur through the choice of a health zone in Benin and take advantage of the unique identification database of the population set up, the project to interconnect all the health systems in Benin, the national data center, and the availability of the GPRS network of GSM networks in the various health zones in Benin.

REFERENCES

1. Kodali RK, Swamy G, and Lakshmi B. An implementation of IoT for healthcare in 2015 IEEE Recent Advances in Intelligent Computational Systems (RAICS), Trivandrum, Kerala, India; 2015. doi: 10.1109/RAICS.2015.7488451.
2. Naqishbandi T. Big data, CEP and IoT: Redefining holistic healthcare information systems and analytics. Int J Engineer Res 2015;4(1):6.
3. Sood SK and Mahajan I. Wearable IoT sensor based healthcare system for identifying and controlling chikungunya virus. Computers Industry 2017;91:33–44. doi: 10.1016/j.compind.2017.05.006.
4. Firouzi F, et al. Internet-of-Things and big data for smarter healthcare: From device to architecture, applications and analytics. Future Gen Computer Sys 2018;78:583–86, janv. doi: 10.1016/j.future.2017.09.016.
5. Medenou D, Ahouandjinou MH, Piaggio D, et al. New intelligent network approach for monitoring physiological parameters: the case of Benin. Health Technol 2020. doi: 10.1007/s12553-020-00418-5.
6. Charlton S, et al. Architecture for field upgrade of a health monitoring system. US8978026B2; 2015.
7. Akyildiz IF, Melodia T, and Chowdhury KR. A survey on wireless multimedia sensor networks. Comp Network 2007;51(4)921–60. doi: 10.1016/j.comnet.2006.10.002.
8. Gogate U and Bakal JW. Smart healthcare monitoring system based on wireless sensor networks in 2016 International Conference on Computing, Analytics and Security Trends (CAST), Pune, India; 2016. doi: 10.1109/CAST.2016.7915037.
9. Goyal A, et al. Smart home health monitoring system for predicting type 2 diabetes and hypertension. J King Saud University Comput Info Sci 2020; doi: 10.1016/j.jksuci.2020.01.010.
10. Sathya D. Secured remote health monitoring system. Healthc Technol Lett 2020;4(6):228–32. 10.1049/htl.2017.0033. Available at: https://sci-hub.tw/10.1049/htl.2017.0033.
11. Mshali H, Lemlouma T, Moloney, M, and Magoni D. A survey on health monitoring systems for health smart homes. Internat J Industr Ergonom 2018;66:26–56. doi: 10.1016/j.ergon.2018.02.002.
12. Bourennane W. Étude et conception d'un système de télésurveillance et de détection de situations critiques par suivi actimétrique des personnes à risques en milieu indoor et outdoor », phdthesis, Université Toulouse le Mirail - Toulouse II; 2013.
13. Medenou D, Ahouandjinou MH, and Pecchia L. National Integrated Network For Remote Monitoring Of Patients In Benin. CEUR Workshop Proceedings 2544, CEUR-WS.org; 2020.
14. Jara AJ, Alcolea AF, Zamora MA, et al. Drugs interaction checker based on IoT. In 2010 Internet of Things (IOT), Tokyo, Japan; 2010. doi: 10.1109/IOT.2010.5678458.
15. Bui N and Zorzi M. Health care applications: a solution based on the internet of things. In Proceedings of the 4th International Symposium on Applied Sciences in Biomedical and Communication Technologies - ISABEL '11, Barcelona, Spain; 2011. doi: 10.1145/2093698.2093829.
16. Rohokale VM, Prasad NR, and Prasad N. A cooperative Internet of Things (IoT) for rural healthcare monitoring and control. In 2011 2nd International Conference on Wireless Communication, Vehicular Technology, Information Theory and Aerospace & Electronic Systems Technology (Wireless VITAE), Chennai, India; 2011. doi: 10.1109/WIRELESSVITAE.2011.5940920.
17. Zhao W, Wang C, and Nakahira Y. Medical application on Internet of Things. In IET International Conference on Communication Technology and Application (ICCTA 2011), Beijing, China; 2011. doi: 10.1049/cp.2011.0751.
18. Chen Y-K. Challenges and opportunities of internet of things. In 17th Asia and South Pacific Design Automation Conference, Sydney, Australia; 2012. doi: 10.1109/ASPDAC.2012.6164978.
19. Doukas C, Maglogiannis I, Koufi V, et al. Enabling data protection through PKI encryption in IoT m-Health devices. In 2012 IEEE 12th International Conference on Bioinformatics & Bioengineering (BIBE), Larnaca, Cyprus; 2012. doi: 10.1109/BIBE.2012.6399701.
20. Tarouco LMR, et al. Internet of Things in healthcare: Interoperatibility and security issues. In 2012 IEEE International Conference on Communications (ICC), Ottawa, ON, Canada; 2012. doi: 10.1109/ICC.2012.6364830.
21. Gubbi J, Buyya R, Marusic S, Palaniswami M. Internet of Things (IoT): A vision, architectural elements, and future directions. Future Gen Comput Syst 2013;29(7)1645–60. doi: 10.1016/j.future.2013.01.010.
22. Turcu CE, and Turcu CO. Internet of Things as Key Enabler for Sustainable Healthcare Delivery. Procedia Soc Behav Sci 2013;73:251–56. doi: 10.1016/j.sbspro.2013.02.049.
23. Fan YJ, Yin YH, Xu LD, et al. IoT-Based Smart Rehabilitation System. IEEE Transact Indust Infor 2014;10(2):1568–77. doi: 10.1109/TII.2014.2302583.
24. Yang G, et al. A Health-IoT Platform Based on the Integration of Intelligent Packaging, Unobtrusive Bio-Sensor, and Intelligent Medicine Box. IEEE Transact Indust Inform 2014;10(4):2180–91. doi: 10.1109/TII.2014.2307795.
25. Yang L, Ge Y, Li W, et al. A home mobile healthcare system for wheelchair users. (:unav); 2014. doi: 10.1109/cscwd.2014.6846914.
26. Xu LD, He W, Li S. Internet of Things in Industries: A Survey. IEEE Transact Indust Informat 2014;10(4):2233–43. doi: 10.1109/tii.2014.2300753.
27. Suresh P Daniel JV, Parthasarathy V, and Aswathy RH. A state of the art review on the Internet of Things (IoT) history, technology and fields of deployment. (:unav); 2014. doi: 10.1109/icsemr.2014.7043637.
28. Singh D, Tripathi G, and Jara AJ. A survey of Internet-of-Things: Future vision, architecture, challenges and services. (:unav); 2014. doi: 10.1109/wf-iot.2014.6803174.
29. Ray PP. Home Health Hub Internet of Things (H3IoT): An architectural framework for monitoring health of elderly people. (:unav); 2014. doi: 10.1109/icsemr.2014.7043542.
30. Rasid MFA, et al. Embedded gateway services for Internet of Things applications in ubiquitous healthcare. (:unav); 2014. doi: 10.1109/icoict.2014.6914055.
31. Li S, Xu LD, and Zhao S. The internet of things: a survey. Information Systems Frontiers 2015;17(2):243–59 avr. doi: 10.1007/s10796-014-9492-7.
32. Lee BM and Ouyang J. Intelligent Healthcare Service by using Collaborations between IoT Personal Health Devices. Internat J Bio-Sci Bio-Technol 2014;6(1)155–64. doi: 10.14257/ijbsbt.2014.6.1.17.
33. Kupwade H, and Patil R. Big Data Security and Privacy Issues in Healthcare. (:unav); doi: 10.1109/bigdata.congress.2014.112.
34. Kulkarni A and Sathe S. Healthcare applications of the Internet of Things: A Review 2014;5(4):2014.
35. Hiremath S, Yang G, and Mankodiya K. Wearable Internet of Things: Concept, Architectural Components and Promises for Person-Centered Healthcare. At the 4th International Conference on Wireless Mobile Communication and Healthcare. Transforming healthcare through innovations in mobile and wireless technologies. Athens, Greece; 2014. doi: 10.4108/icst.mobihealth.2014.257440.
36. Granados J, Rahmani A-M, Nikander P, et al. Towards Energy-Efficient HealthCare: an Internet-of-Things Architecture Using Intelligent Gateways. At the 4th International Conference on Wireless Mobile Communication and Healthcare. Transforming healthcare through innovations in mobile and wireless technologies. Athens, Greece, 2014, doi: 10.4108/icst.mobihealth.2014.257394.
37. Gia TN, Thanigaivelan NK, Rahmani A.-M, et al. Customizing 6LoWPAN networks towards Internet-of-Things based ubiquitous healthcare systems. In NORCHIP, Tampere; 2014. doi: 10.1109/NORCHIP.2014.7004716.
38. Zhou W and Piramuthu S. Security/privacy of wearable fitness tracking IoT devices. 2014 9th Iberian Conference on Information Systems and Technologies (CISTI), Barcelona, Spain; 2014. doi: 10.1109/CISTI.2014.6877073.
39. Fernandez F and Pallis G. Opportunities and challenges of the Internet of Things for healthcare. The 4th International Conference on Wireless Mobile Communication and Healthcare. Transforming healthcare through innovations in mobile and wireless

technologies. Athens, Greece; 2014. doi: 10.4108/icst.mobihealth.2014.257276.

40. Chiuchisan I, Costin H-N, and Geman O. Adopting the Internet of Things technologies in health care systems. (:unav); 2014. doi: 10.1109/icepe.2014.6969965.
41. Amendola S, Lodato R, Manzari S, et al. RFID Technology for IoT-Based Personal Healthcare in Smart Spaces. IEEE Internet of Things Journal 2014;1(2):144–52. doi: 10.1109/JIOT.2014.2313981.
42. Elhoseny M, Ramirez-Gonzalez G, Abu-Elnasr OM, et al. Secure Medical Data Transmission Model for IoT-Based Healthcare Systems. IEEE Access 2018;6:20596–608. doi: 10.1109/ACCESS.2018.2817615.
43. Firouzi F et al. Internet-of-Things and big data for smarter healthcare: From device to architecture, applications and analytics. Future Gen Comput Syst 2018;78:83–586. doi: 10.1016/j.future.2017.09.016.
44. Rahmani AN, et al. Exploiting smart e-Health gateways at the edge of healthcare Internet-of-Things: A fog computing approach. Future Gen Comput Syst 2018;78:641–58. doi: 10.1016/j.future.2017.02.014.
45. Ullah F, Habib MA, Farhan M, et al. Semantic interoperability for big-data in heterogeneous IoT infrastructure for healthcare. Sustainable Cities Soc 2017;34:90–96. doi: 10.1016/j.scs.2017.06.010.
46. Sood SK and Mahajan I. Wearable IoT sensor based healthcare system for identifying and controlling chikungunya virus. Comput Industry 2017;9:33–44. doi: 10.1016/j.compind.2017.05.006.
47. Woo MW, Lee J, and Park K. A reliable IoT system for Personal Healthcare Devices. Future Gen Comput Syst 2018;78:626–40. doi: 10.1016/j.future.2017.04.004.
48. Verma P, Sood SK, and Kalra S. Cloud-centric IoT based student healthcare monitoring framework. J Ambient Intell Human Comput 2018;9(5):1293–309. doi: 10.1007/s12652-017-0520-6.
49. Wu T, Wu F, Redoute JM, and Yuce MR. An Autonomous Wireless Body Area Network Implementation Towards IoT Connected Healthcare Applications. IEEE Access 2017;5:11413–22. doi: 10.1109/ACCESS.2017.2716344.
50. Kaur MJ and Maheshwari P. Building smart cities applications using IoT and cloud-based architectures. 2016 International Conference on Industrial Informatics and Computer Systems (CIICS), Sharjah, Dubai, United Arab Emirates; 2016. doi: 10.1109/ICCSII.2016.7462433.
51. Moosavi SR, et al. End-to-end security scheme for mobility enabled healthcare Internet of Things. Future Gen Comput Syst 2016;64:108–24, nov. 2016, doi: 10.1016/j.future.2016.02.020.
52. Kang H-W, Kim D-M, and Koh S-J. ISO/IEEE 11073-Based Healthcare Services over IoT Platform Using 6LoWPAN and BLE: Architecture and Experimentation. (:unav); 2016. doi: 10.1109/nana.2016.26.
53. Iqbal MA and Bayoumi M. Secure End-to-End key establishment protocol for resource-constrained healthcare sensors in the context of IoT. (:unav); 2016. doi: 10.1109/hpcsim.2016.7568379.
54. Hossain MS. and Muhammad G. Cloud-assisted Industrial Internet of Things (IIoT) – Enabled framework for health monitoring. Comput Network 2016;101:192–202. doi: 10.1016/j.comnet.2016.01.009.
55. Hashemi SH, Faghri F, Rausch P, et al. World of Empowered IoT Users. (:unav); 2016. doi: 10.1109/iotdi.2015.39.
56. Gope P and Hwang T. BSN-Care: A Secure IoT-Based Modern Healthcare System Using Body Sensor Network. IEEE Sensors J 2016;16(5):1368–76. doi: 10.1109/JSEN.2015.2502401.
57. Corno F, De Russis L, and Roffarello AM. A Healthcare Support System for Assisted Living Facilities: An IoT Solution. (:unav); 2016. doi: 10.1109/compsac.2016.29.
58. Basanta H, Huang YP, et Lee T-T. Intuitive IoT-based H2U healthcare system for elderly people. 2016 IEEE 13th International Conference on Networking, Sensing, and Control (ICNSC), Mexico City, Mexico; 2016. doi: 10.1109/ICNSC.2016.7479018.
59. Azimi I, Anzanpour A, Rahmani AM, et al. Self-aware Early Warning Score System for IoT-Based Personalized Healthcare. eHealth 360° 2017;181:49–55.
60. Darshan KR and Anandakumar KR. A comprehensive review on usage of Internet of Things (IoT) in healthcare system. 2015 International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT), Mandya, India; 2015. doi: 10.1109/ERECT.2015.7499001.
61. Datta SK, Bonnet C, and Gyrard RP, et al. Applying Internet of Things for personalized healthcare in smart homes. (:unav); 2015. doi: 10.1109/wocc.2015.7346198.
62. Deng Z, Yang P, Zhao Y, et al. Life-Logging Data Aggregation Solution for Interdisciplinary Healthcare Research and Collaboration. (:unav); 2015. doi: 10.1109/cit/iucc/dasc/picom.2015.342.
63. Gia TN, Jiang M, Rahmani A-M, et al. Fog Computing in Healthcare Internet of Things: A Case Study on ECG Feature Extraction. (:unav); 2015. doi: 10.1109/cit/iucc/dasc/picom.2015.51.
64. Gong T, Huang H, Li P, et al. A Medical Healthcare System for Privacy Protection Based on IoT. 2015 Seventh International Symposium on Parallel Architectures, Algorithms and Programming (PAAP), Nanjing, China; 2015. doi: 10.1109/PAAP.2015.48.
65. Gupta MSD, Patchava V, and Menezes V. Healthcare based on IoT using Raspberry Pi. p. 4, 2015.
66. Hassanalieragh M, et al. Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-Based Processing: Opportunities and Challenges. (:unav); 2015. doi: 10.1109/scc.2015.47.
67. He D and Zeadally S. An Analysis of RFID Authentication Schemes for Internet of Things in Healthcare Environment Using Elliptic Curve Cryptography. IEEE Internet Things J 2015;2(1):72–83. doi: 10.1109/jiot.2014.2360121.
68. Hou J-L and Yeh K-H. Novel Authentication Schemes for IoT Based Healthcare Systems. Internat J Distrib Sensor Network 2015;11. doi: 10.1155/2015/183659.
69. Kodali RK, Swamy G. An implementation of IoT for healthcare », in 2015 IEEE Recent Advances in Intelligent Computational Systems (RAICS), Trivandrum, Kerala, India; 2015. doi: 10.1109/RAICS.2015.7488451.
70. Laplante PA and Laplante NL. A Structured approach for describing healthcare applications for the Internet of Things. (:unav); 2015. doi: 10.1109/wf-iot.2015.7389125.
71. Giorgos KEIB, Antonis B. Internet of Things For an Age-Friendly Healthcare. Studies Health Technol Informat 2015;587–91. doi: 10.3233/978-1-61499-512-8-587.
72. Lee BM. Personalized Service Model for Sharing Medical Devices in IoT Health-Platform 2015;180–82. doi: 10.14257/astl.2015.99.44.
73. Maksimovic M, Vujovic V, and Perisic B. A custom Internet of Things healthcare system. (:unav); 2015. doi: 10.1109/cisti.2015.7170415.
74. Moosavi SR, et al. SEA: A Secure and Efficient Authentication and Authorization Architecture for IoT-Based Healthcare Using Smart Gateways. Procedia Comput Sci 2015;52:452–59. doi: 10.1016/j.procs.2015.05.013.
75. Naqishbandi T. Big Data, CEP and IoT: Redefining Holistic Healthcare Information Systems and Analytics. Internat J Engineer Res 2015;4(01):7.
76. Khoi NM, Saguna S, Mitra K, and Ahlund C. IReHMo: An efficient IoT-based remote health monitoring system for smart regions. (:unav);2015. doi: 10.1109/healthcom.2015.7454565.
77. Rahmani A-M, et al. Smart e-Health Gateway: Bringing intelligence to Internet-of-Things based ubiquitous healthcare systems. 12th Annual IEEE Consumer Communications and Networking Conference (CCNC), Las Vegas, NV, USA; 2015. doi: 10.1109/CCNC.2015.7158084.
78. Riazul Islam SM, Kwak D, Humaun M, et al. The Internet of Things for Health Care: A Comprehensive Survey. IEEE Access 2015;3: 678–708. doi: 10.1109/ACCESS.2015.2437951.
79. Shi Y, Ding G, Wang H, et al. The fog computing service for healthcare. 2015 2nd International Symposium on Future Information and Communication Technologies for Ubiquitous HealthCare (Ubi-HealthTech), Beijing, China; 2015. doi: 10.1109/Ubi-HealthTech.2015.7203325.
80. Ugrenovic D and Gardasevic G. CoAP protocol for Web-based monitoring in IoT healthcare applications. 2015 23rd Telecommunications Forum Telfor (TELFOR), Belgrade, Serbia; 2015:79–82. doi: 10.1109/TELFOR.2015.7377418.

APPENDIX

TABLE 2.

N°	Ref.	Aspect covered
1	[14]	Put in place a solution to address drug issues based on IoT technologies like smartphones and the Web to support ubiquitous access, 6LoWPAN technology for ubiquitous patient data collection, sensors and hospitals, RFID / NFC (Near Field Communication) and barcode identification technologies.
2	[15]	Propose IoT Communication Framework as Primary Tool for Healthcare Applications Spread Around the World. They presented the IoT protocol stack and the benefits it brings to health care scenarios.
3	[16]	Proposed a cooperative approach of IoT to improve the monitoring and control the health of rural and poor human health parameters.
4	[17]	Analyze the possibility and related issues of providing advanced services for human health management in the real world of medical technology on IoT.
5	[18]	Shows an overview of the challenges and opportunities of IoT.
6	[19]	Present a prototype of a cloud-based system, compliant with the IoT concept. Including those related to the authentication of entities and data confidentiality. The proposed system manages the data collected by the portable sensors and transmitted them to a gateway using cloud infrastructure techniques.
7	[20]	Worked on interoperability and security issues related to the limitations of devices used in the IoT, preventing their proper use in health systems.
8	[21]	Presents with a cloud-centric vision for the global implementation of the IoT. The authors' work allowed to make a cloud implementation using Aneka, based on the interaction of private and public Clouds
9	[22]	Showed how RFID, multi-agent technologies and the IoT can be used to allow people access to affordable and quality health services. The authors show that using the IoT and multi-agent technologies can reduce medical errors, improve patient safety, and optimize healthcare processes.
10	[23]	Presents an ontology-based design methodology for intelligent reeducation systems in IoT.
11	[24]	Worked on home health services based on the IoT. They proposed a smart home platform, named iHome Health-IoT.
12	[25]	Presented a mobile home health system (mHealth) for wheelchair users, based on emerging technologies of the IoT. The authors focused on the proposed system architecture and the design of Wireless Body Sensor Networks (WBSN).
13	[26]	Review the current research on the IoT, generic key technologies, key IoT applications in industries, and identify trends and challenges in research.
14	[27]	Structured in this work a review of the state of the art on IoT by bringing out its history, the different technologies of IoT and its different applications.
15	[28]	Present a novel architecture model for IoT with the help of Semantic Fusion Model (SFM).
16	[29]	Present H3IoT, a new architectural framework for a home health center based on the Internet of Things, which aims to monitor the health of elderly people at home.
17		
	[30]	Present the integrated services that are part of a ubiquitous health system that enables automated and intelligent monitoring and utilizing IP and Internet connectivity for end-to-end communication.
18	[31]	Present the definitions, architecture, fundamental technologies, and applications of IoT. Various definitions of IoT are introduced, emerging techniques for the implementation of IoT are discussed.
19	[32]	Worked on self-care through IoT through personal health devices. By introducing the collaborative protocol that transfers risk factors between IoT personal health devices.

N°	Ref.	Aspect covered
20	[33]	Worked on data security and confidentiality in the healthcare sector given the increasing data growth in this sector.
21	[34]	Examined the applications of IoT in personalized health care to obtain excellent health care at affordable costs through detection and wireless techniques.
22	[35]	Worked on the concept, the architectural components of the wearable IoT because of their detection and communication capabilities.
23	[36]	Worked on the energy efficiency in the architectures of the IoT in exploiting the advantages related to the standard POE (Power over Ethernet).
24	[37]	Worked on an IoT architecture and system implementation for health applications to offer a simple and economical way to analyze and monitor health data in real time.
25	[38]	Worked on the security and confidentiality of tracking physical conditions through portable connected objects.
26	[39]	Have worked on the different opportunities and challenges of IoT.
27	[40]	Worked on the development of a general architecture for IoT-based health care systems to ensure and increase patient safety, quality of life, and other health care activities.
28	[41]	Worked on the use of RFID for personal health care based on the IoT.
29	[42]	Secure medical data transmission model in health systems based on IoT.
30	[43]	IoT and Big Data for intelligent healthcare, individualized telehealth to enable healthier lifestyles.
31	[44]	Operation of the gateway between the network of medical sensors and the Internet in a health care surveillance system to offer several services.
32	[45]	A semantic interoperability model for Big Data in the IoT.
33	[46]	IoT architecture to identify and control the Chikungunya virus.
34	[47]	a reliable IoT architecture based on oneM2M for personal healthcare devices
35	[48]	IoT-based healthcare surveillance architecture to move to proactive and preventive healthcare.
36	[49]	WBAN sanl fil <Au: Please clarify sanl fil> network based on IoT for healthcare.
37	[50]	Smart city cloud platform with IoT
38	[51]	Three-level IoT architecture composed of the device layer, the fog layer, and the cloud layer.
39	[52]	A new architecture for health services based on ISO / IEEE 11073 on the IoT platform. The proposed architecture meets oneM2M and ISO / IEEE 11073. Standards with a stack of protocols for constrained healthcare devices on the BLE network.
40	[53]	A cooperative key establishment protocol to create a secure end-to-end connection for resource-limited sensor nodes with any remote server or entity. Security analysis and performance appraisals prove to be a considerable improvement in security as well as protocol resilience against known attacks and security breaches.
441	[54]	A cloud-integrated Health IoT monitoring framework, where health data is watermarked before being sent to the cloud for secure, high-quality, health monitoring.
42	[55]	A new user-oriented world of IoT. In this world, users are empowered by their ability to control access to the data that has been knowingly or unknowingly generated and belongs to them. This data can be requested by other users and organizations to be analyzed collectively and potentially bring value to society.

N°	Ref.	Aspect covered
43	[56]	security and confidentiality issues in health applications using the body sensor network (BSN). They proposed an IoT-based secure health system using BSN, called BSN-Care, which can effectively meet various security requirements of the BSN-based health system.
44	[57]	An IoT system capable of improving assistance requests and the detection of anomalies in an ALF <AU: Please expand ALF> using portable devices. With this healthcare support system, caregivers can be automatically alerted to potentially dangerous situations that occur to residents while they are out of sight. The system design focused mainly on portability and ubiquity.
45	[58]	An IoT H2U predictive health care system to provide early treatment and detect danger signs early enough to avoid the need for hospitalization. Hospital stay is minimized and doctors and nurses can be connected and monitor patients based on the report generated by the sensors in real time and daily clinical updates by the patient on the base server of data. Interaction via this IoT system is quite profitable and guarantees a higher level of security in terms of communication.
46	[59]	Exploited the concept of self-awareness to create a personalized EWS Alert Score System<AU: Please expand EWS> based on the IoT. The system is designed to be adaptive in various situations and to be able to be automatically personalized according to the needs of the patient.
47	[60]	The use of the Internet of Things for the efficiency of the health system by exploring the challenges of these systems. Their work provided an architecture / methodology for extracting information from health care data.
48	[61]	The use of the Internet of Things for the efficiency of the health system by exploring the challenges of these systems. Their work provided an architecture / methodology for extracting information from healthcare data.
49	[62]	Implementation of a data aggregation solution for interdisciplinary healthcare research after comparing the different existing IoT applications which focus mostly on the physical condition of people. They proposed the architecture for monitoring healthcare with multiple functions for the acquisition of bio-signals (EEG, EMG, ECG)
50	[63]	Computer haze in the IoT in health surveillance systems by exploiting the concept of calculating fog with intelligent gateways applied to ECG signals.
51	[64]	The security of private information in a health care information system using the Internet of Things. The authors have implemented an algorithm to secure health data. a prototype based on both software and hardware has also been implemented.
52	[65]	Implementing a system for continuous monitoring of the EEG and other vital parameters using algorithms based on Raspberry pi. The Raspberry Pi is a small computer with an integrated microprocessor card.
53	[66]	The different opportunities and benefits of using the IoT in remote health monitoring. the use of portable sensors is necessary to record data in various environments for health surveillance.
54	[67]	The security requirements of RFID authentication schemes for Internet of Things-based healthcare surveillance systems. The authors presented the overall architecture of the RFID-based authentication system and their requirements
55	[68]	The security of IoT-based health systems. They proposed a communication architecture based on sensors in health service systems integrating a secure authentication scheme and a protocol for the coexistence of multiple health systems operating under the technology of the IoT.
56	[69]	implementation of the IoT in a hospital system using ZigBee which is a mesh protocol.
57	[70]	The classification and structuring of IoT applications in healthcare. The results of the authors' work show that applications in the health of the IoT can be classified into three categories of systems.
58	[71]	A new approach to the IoT with devices compatible with IoT thanks to the XMPP protocol.

N°	Ref.	Aspect covered
59	[72]	Share the use of medical equipment used in a health service or office through the IoT. They proposed a personalized health service model that can be used in family or public offices.
60	[73]	Health self-management systems for support. They proposed the establishment of a personal health monitoring system adapted to the needs of the user (Do-It-Yourself).
61	[74]	Medical data capture and confidentiality architectures. The work allowed the authors to develop an architecture of authentication and authorization that is secure and efficient for healthcare based on IoT while taking into account the constraints of the resources of medical sensors.
62	[75]	Big Data technologies, IoT and complex event processing (CEP) and their importance in the healthcare system revolution.
63	[76]	A remote health monitoring system based on IoT, after identifying the main network requirements and studying the CoAP, MQTT and HTTP protocols.
64	[77]	Smart gateways in e-health which is a transition point between the sensor and Internet networks. They proposed an intelligent e-health gateway between the sensor and the Internet for remote monitoring of health care.
65	[78]	An intelligent collaborative security model to minimize security risks; and propose how different innovations such as big data, ambient intelligence and portable devices can be used in healthcare establishments.
66	[79]	IT fog which is a new architecture for migrating certain tasks from the data center to the periphery of the server. The authors present the characteristics of fog computing and the services it can provide in the health system by ensuring low latency of applications in health services.
67	[80]	The IoT remote healthcare monitoring system that provides patient status via a web browser using OS Contiki with the 6LoWPAN protocol.

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Discarding Flow Proposition for Hospital Electric and Electronic Equipment

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ABSTRACT

This work proposes a project establishing a staged workflow to ensure any electric or electronic equipment used in a hospital environment that is being discarded would be subject to all possible reuse of its equipment and components through to the manufacturing of new equipment. The workflow would apply to all the electronic equipment used in the hospital (i.e., biomedical, electro-mechanical, computer, refrigeration, air conditioning). This appropriate discarding workflow would address socio-environmental as well as economic/financial concerns.

Keywords – *Discarding, Electronic Equipment, Hospital, Socio-environmental.*

INTRODUCTION

Technological progress has brought benefits to society but has also resulted in increasing levels of waste which has worried organizations and environmentalists. The environmental damage involved in the disposal of electronic waste is very relevant. The production process to make these components involves the expenditure of natural resources, burning of fossil fuels and increased solid, liquid, and gas pollution emission (including Greenhouse Gas Emissions – GEE).[1]

In the assembly of electronic equipment various component are used that have other constituent heavy metals, such as mercury (used in thermostats, sensors, relays, and switches); lead (used in printed circuit board welding); cadmium (used in printed circuit boards, SMD resistor chips, semi-conductors, and infra-red detectors), and PVC stabilizers (such as the silicon used in the manufacturing of microprocessors and halogenated substances like polyvinyl chloride [PVC] etc.).[2] Other materials often used are iron and steel, used in cabinets and frames; glass, used in screens and counters; plastics, used in cabinets, cable coatings, and printed circuit as well as rubber. These substances when disposed of inadequately can cause ground, water, and air contamination in addition to having an accumulative effect in all trophic levels that can bring harm to human health.[1] Research shows that the residue from electronics manufacturing has a direct relation to 22 types of diseases. Physical and chemical effects observed include headache, nausea, impaired vision, respiratory and pulmonary problems, hearing loss, nervous tension, and hypertension. Chronic conditions as allergies, bronchitis, teratogenic effects, cancers, organ damage, central nervous system issues are affected by heavy metal exposure and have cumulative effects.[2] Table 1 outlines some relevant toxic substances and notes their uses in electric and electronic equipment (EEE) and their effects on health.[3]

TABLE 1. Relevant Toxic Substances, Its Uses in Electric and Electronic Equipment and Its Effects in Health

Substance	Uses	Health Effects
Arsenic	Semi-conductors, alloys, and transistors	Carcinogenic and gene-altering
Beryllium	Copper alloys, mechanical arts, connectors and springs	Skin sensitization, emphysema and fibrosis in the lungs, carcinogenic
Cadmium	Printed circuit boards, chip resistors, semi-conductors and infra-red detectors, batteries, switches, fluorescent materials	Damage to kidneys, liver, pancreas, increased blood pressure, carcinogenic and gene-altering
Lead	Printed circuit boards welding, glass, cathode ray tubes, welding, and lamp glass	Damage to the nervous, endocrine, circulatory, urinary, digestive and skeletal systems (it is the most toxic of the elements)
Copper	Present in several components	Liver damage
Hexavalent Chromium and Chromium VI	Decorative surfaces, pigments and covers, stainless steel	Irritations in the nose, throat, lungs (cancer), muscles, eye, skin, and liver damage
Mercury	Thermostats, switch sensors, data transmission systems, telecommunications, cellphones, flourescent lamps and batteries	Damage to the brain, central nervous system and kidneys, reproductive problems
PBB and PBDE	Printed circuit boards, components like connectors, plastic covers and TV cables and home appliances	Damage to the endocrine system
Aluminum	Computer structures and connections	One of the factors for Alzheimer's disease
Nickel	Computer docking structures	Genetic mutation

PBB = POLYBROMINATED BIPHENYL; PBDE = POLYBROMINATED DIPHENYL ETHER

The residue from the disposal of EEE becomes a technological, social, and environmental problem and its proportions are growing larger. That is why it is necessary to develop environmental management planning to reduce their negative effects. Only in 2010, was a law approved regulating the Solid Residue National Policy (law 12.305) defining, among other issues, reverse logistics and the manufacturer's responsibilities for the lifecycle of products. Still, in said law, there was, for the first time, the incentive to develop recycling sectors, the select and providing technical training to staff that work in recycling, as well as encouraging environmental and business management systems including programs like the 3Rs (reduce, reuse, and recycle), aimed at the improvement of productive processes, a reduction in residue exploitation, and recovery and energy reuse.[1]

The Federal Law n. 12.305 of 02/08/2010, establishing the Solid Residue National Policy defined in article 33 that:

> "Are required to structure and implement reverse logistics systems, by returning products after use by the consumer, independently of the public service of urban cleaning and solid waste management, manufacturers, importers, distributors and traders of: ... VI - electro-electronic products and their components."[4]
>
> "The electro-electronic equipment is small and large and includes all the computing, sound, video, telephony, ventilators, exhaust fans, and other devices equipped, in general, with electronic controls or using electric activation."[4]

For the residue from EEE (REEE) it can be considered the is an annual generation rate of 2.6 kg per capita, based on academic works and trace estimates.[1,4] REEE comes from outdated electric and electronic equipment that is selected for disposal, including all the consumable components,

subcategories and materials needed to function. In general terms, the composition of the present materials in REEEs is characterized by the high presence of metal (ferrous and non-ferrous), glass, and plastic. Televisions, computers, and monitors present, on average, 49% in metal weight, 33% in plastic weight, 12% in cathode ray tubes, and 6% other material. In studies performed it was found that printed circuit boards – PCI must be considered as dangerous residue and be disposed of in appropriate places mainly due to the presence of lead and cadmium. Therefore, recycling those materials present in the REEE through the shared socio-environmental responsibility in which manufacturers, importers, public power, and consumers are responsible can aid in environmental protection and demonstrate to present and future generations that is the most viable option. EEE is made of a variety of high commercial value material that can be recycled.[5] With the right action on the appropriate environmental management of this residue, value can be added to what, until then, was considered "waste."

To attenuate this issue there are several residue disposal avenues such as landfills and incineration although recycling is the best and most efficient. As the toxic substances can be found in bigger concentration than they were in nature, the recycling of this residue provides the recovery of toxic substances as well as reducing the exploitation of natural resources. The environmental management of solid waste is a set of activities aiming to reduce or eliminate the damage that these can cause in the environment. Also, as well as being a source of material for other technology manufacturing and generating jobs, material recycling offers great savings to organizations and shows a positive corporate image to the consumer market (an example of "Green Marketing"). The separation and destination of unwanted electronics promote residue reduction, the reuse and recycling of raw material, generate income, and promote social inclusion and the reduction of waste in landfills and helps mitigate environmental degradation from incorrect disposal.[1]

For EEE, the suggested control approaches are: general data and description, generation, collection and transport, destination and final disposal, costs, competence, and responsibilities, needs and deficiencies, relevant initiatives, applicable legislation and applicable standards. There is also the suggestion about the unity of residue processing, such as guidelines, the strategies, the quantitative goals and the programs and actions.[4] Table 2 highlights the categories of the REEEs, by the European Parliament, through the directive 2002/96/CE.[6]

TABLE 2. Categories of Electric and Electronic Equipment Residue

Category	Examples
1. Large home Appliances	Refrigerators, washing machines, dishwashers, stoves, microwaves, vacuums
2. Small house home appliances	Toasters, electric knives, hairdryers
3. Computing and telecommunications equipment	Desktop computer, laptop computer, printer
4. Consumer equipment	Cellphone and telephone, Television equipment, DVD devices
5. Lighting equipment	Fluorescent lamps
6. Electronic Tools (except consumer equipment)	Saws, sewing machines, lawnmowers
7. Toys, sports and leisure equipment	Video games, slot machines, sports equipment
8. Medical equipment (except the implanted and infected products)	Nuclear medicine equipment, radiology, cardiology, dialysis
9. Control and monitoring instruments	Thermostats, smoke detectors
10. Automatic distributors	Dispensers of money, beverages, and solid products

Considering that the Resolution, RCD 16, in 2013, *Manufacturing Good Practices,* defines the responsibilities of the manufacturer to installation stages, according to the item 6.4.1: "Each manufacturer must establish and maintain procedures to the components identification, manufacturing material, intermediate products and finished products during all the storage, production, distribution and installation stages to avoid confusion and to guarantee the correct order fulfilments,"[7] considering that the draft CONAMA Resolution, which regulates the management of waste electrical and electronic equipment in Brazil, suggests "the need to discipline correct environmental management and disposal of electrical and

electronic equipment residue, concerning the collection, reuse, recycling, treatment or final disposal."[8] This work proposes a project establishing a staged workflow that would make sure any electric/electronic equipment used in a hospital environment that is being discarded would be subject to any and all possible reuse of its equipment and components through to the manufacturing of new equipment.

METHOD

With the reference to the proposition of the disposal flow of hospital EEEs were used the researched references, according to what is described below.

Art. 7 of the Resolution, RCD 16, of 2013, about *Manufacturing Good Practices* states:

> "Are obligations: I – From the manufacturers and importers of EEE and its components: (a) adopt technologies or processes of acquisition that take into consideration the "ecodesign," that allows reducing, reusing or recycling the REEE; (b) the REEE management (collect, transport, handling, storage, processing and environmentally appropriate disposal). The manufacturers and importers should be able to choose to fulfil this management either individually, adhering to a collective regime or through a third part; (c) collect the REEE, creating accredited collection points and/or in articulation with its commercialization network, technical assistance and with the public power as the implementation of the necessary structure to guarantee the reverse logistics of this waste and to give them environmentally appropriate destination; (d) to recover, when possible, the REEE in form of new raw material or new products, in its cycle or in other productive cycles; (e) the management of REEE applies to current products and historical passages; (f) to establish collection points for the REEE that are accessible to consumers / users and to provide environmentally adequate disposal for tailings; (g) to articulate the reverse logistics of REEE with its commercialization network and technical assistance; (h) to disclose information on the location and operation of REEE collection points and to promote environmental awareness campaigns to combat inadequate disposal; (i) to ensure that the products and electric and electronic components commercialized in Brazil indicate with emphasis, the following to the consumer, at least in the equipment manual and in the producer's official site or importer on the internet."[8]

And item III of the same draft suggests:

> "III – Of consumers: (a) to adopt practices that make it possible the reduction of its generation; (b) after the use of the product, condition adequately and to deliver of REEE to the dealers/distributors or to destine them to the collection points, according to the information provided by the producer/importer."[8]

The recycling stages of REEEs are similar for and include the steps outlined below.

Disassembly

Done at a sorting center, this stage involves the removal of parts that contain dangerous substances (chlorofluorocarbons, mercury, polychlorinated biphenyl, etc.), parts that contain valuable substances (copper cables, steel, iron, and precious metals). The environmental risk in this stage is from ground contamination by improper storage of REEEs or oil or CFCs leaking from removed parts.

Separation of Ferrous and Non-ferrous Metals, and Plastics

This step is normally performed manually in a sorting center.

Recycling/Recovery of Valuable Material

Items containing ferrous and non-ferrous metals, plastics, and precious metals are sent to specific recycling companies for recovery.

Processing/Disposal of Dangerous Material and Residue

Any remaining non-recovered/recycled material is sent to landfills or industrial landfills for further disposal following the appropriate legislation.[5]

Figure 1 illustrates the sorting scheme for materials present in EEE.[4]

Also described are possible process indicators:

- The number of producers, importers, and dealers for used EEE.
- The number of establishments receiving REEEs.
- The number of agents involved in the waste collection program.
- The percentage of employment and income generated.

- The quantity of generated residue and the estimate of the amount of waste that is no longer being sent to landfills.[5]

The implementation of a plan for the disposal of EEE

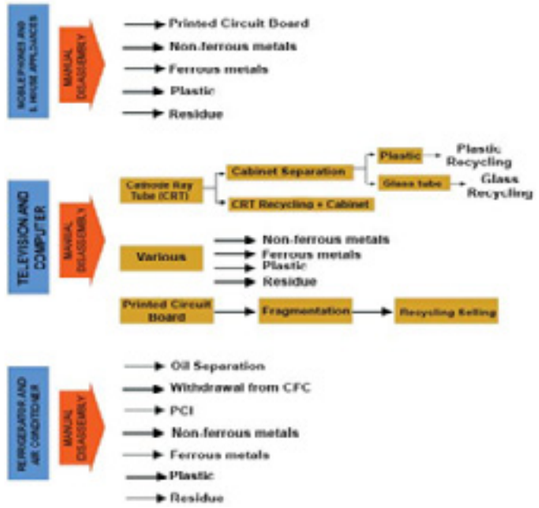

FIGURE 1. Sorting scheme for material present in electric and electronic equipment.

makes it possible to improve environmental conditions, encourages future generations to continue the process of environmental education, and generates the potential for increased employment and income. Establishing an evaluation and monitoring program is of great importance to help identify the stages that need correction and to continuously improve the process. The monitoring must evaluate all the stages from environmental education to final disposal. The results found by monitoring must be available to those involved in the work. The implementation of monitoring activities also needs a preestablished selection of indicators to simply illustrate the functioning of the plan.[5]

RESULTS

Based on our results and shown in Figure 2 we have a proposed flow for discarding hospital EEE.

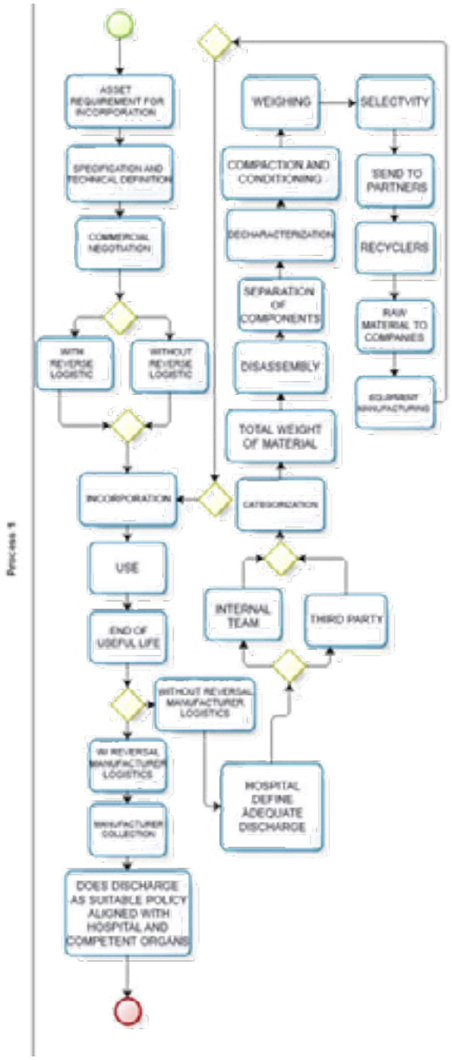

FIGURE 2. Proposed flow for discarding hospital electric and electronic equipment. Adapted from Meta-recycling.[1]

DISCUSSION

There are some points worth taking into consideration to clarify the process of defining and executing the management plan for disposal of hospital EEEs:

- Local issues
- Use of dedicated personnel (own or outsourced)
- Partners to conduct the external stages
- Internal policies as well as any relevant municipal, state, or federal guidelines

This project should be continuously evolving in the hospital and include the involvement of various departments such as environmental management, patrimony management, and accounting in addition to hospital and clinical engineering. This is important so that after well-defined and detailed stages are in place the results can be taken to the hospital's directors for analysis and validation.

CONCLUSION

The reality demonstrates the need for definition by standardization, detailing, and validation of the EEEs flow disposal. The proper disposal management of the components of EEEs can eliminate potential environmental damage and be a source of material for other applications. There is also the possibility to generate new jobs and create potential saving for health organizations. Hospitals can contribute considerably in this issue by instituting the right processes in handling and disposal of EEEs.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

1. Del Grossi AC. II Brazilian Congress of Environmental Management. Unopar. Disposal of Waste Electrical and Electronic Equipment (REEE). Londrina; 2011.
2. Pallone S. Electronic waste: reduction, reuse, recycling and recovery. Available at: http://www.comciencia.br/comciencia/handler.php?section=8&edicao=32&id=379. Accessed: 26 April 2017.
3. Del Grosi A. Electronic Waste Task Force. Back of Flyer. Londrina, Paraná, Brasil; 2010.
4. Federal Government Ministry of the Environment. Local governments for sustainability. ICLEI. Solid Waste Management Plans: Guidance Manual Supporting the Implementation of the National Solid Waste Policy: From National To Local. Brasília – DF, Brasil; 2012.
5. Belo Horizonte: State Environment Foundation: Foundation Israel Pinheiro Integrated Management Plan For Waste Electrical And Electronic Equipment-PGIREEE / Eualdo Lima Pinheiro; 2009.
6. EUROPEAN PARLIAMENT Directive 2002/96 / EC of the European Parliament and of the Council of 27 January 2003. Concerning Waste Electrical and Electronic Equipment – REEEs. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32002L0096
7. ANVISA. Good Manufacturing Practices RDC 16, 2013.
8. CONAMA Resolution Draft. Regulates the Management of Waste Electrical and Electronic Equipment in Brazil. Access in: 28 April 2017.

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Commentary/Letter to the Editor of the Global CE Journal

By B. M. Gamble[1], Francoise Mailhot[2], R. Rivas[3], S. Rabbani[4], M. Secca[5], M. Cheng[6]

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Dear Editor,

It is clear that potential COVID pandemics will be recurring events and the use of PPE is basic and vital. *Everyone* will need such simple devices to protect themselves and others. The consequence of no PPE protection could be disastrous for global health!

Stockpiling PPE is not for everyone. Healthcare facilities in low-resources countries have limited PPE supplies. Furthermore, transportation and distribution across the country can be problematic in rural areas. Home-made PPE is the most practical solution but this needs effective global efforts to educate and guide global populations.

In the past 3 months, the IFMBE/CED, in collaboration with WHO and other professionals, has conducted an excellent series of webinars to inform the world about medical devices in combating the COVID-19 pandemic bringing invaluable information for global healthcare. We wonder if IFMBE/CED would pioneer another important initiative with WHO to advocate and co-ordinate the resources from different organizations and individual professionals to create a manual on home-made PPEs and basic knowledge on cleaning and sterilization so that laypersons can make PPE to protect themselves and others. A highly successful public health education publication *Where There Is No Doctors*[1] is an example.

Preventing SARS and other related diseases are a global problem that currently relies mainly on isolated and scattered national solutions. It is urgent that international organizations such as IFMBE and WHO provide *trusted advice* to countries worldwide to create a *global protection-sensitive culture* against pandemics.

REFERENCE

1. Burma/Myanmar Library. Where There Is No Doctor. Author: 2011. Available at: https://www.burmalibrary.org/docs12/Where_there_is_no_doctor-2011(en)-red.pdf

This Letter is dedicated to Brian Gamble, deceased on July 31st at the age of 88. Brian was a most well informed and open-minded internationalist I have known. Michael Cheng

Editor's answer:

Dear Dr. Cheng,

Thank you for deciding to address your concerns and the proposed initiative to the *Global Clinical Engineering Journal*. Although it does not comply the typical material that we have published, after reviewing your letter to the editor carefully, we have decided to publish it due to its international scope and the offering of potential involvement for clinical engineers from around the world.

While you are making specific conclusions (i.e., pandemic will be recurring events, PPE in limited supply, the success of public health education via a book) no support has been offered to substantiate these. Nevertheless, we would like to encourage you to further explore the optimal route to assemble expert authors and to write your proposed manual. We see value in such collaboration especially if it will be sensitive to local availability of resources and in a format that accommodates worldwide access such as through Internet tools.

We encourage you to pursue this idea.

Respectfully,
Dr. Yadin David