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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.

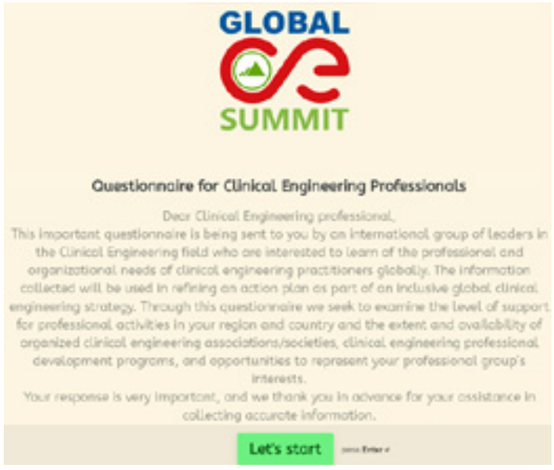

FIGURE 1. Introduction explaining the purpose of the Questionnaire.

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
What are the top challenges we should address? (you can add your own at the end of the list)	Education-Training
	Recognition
	Professional Standing-Credentialing
	Engagement with leaders
	Networking
	Career progression
	Publication opportunity
	other

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

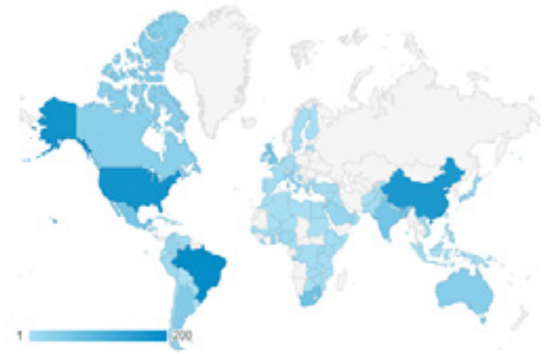

FIGURE 2. World map showing in levels of color intensity origin of the responses received.

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

of the results of question number # 1 is shown in Figure 3 below.

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.

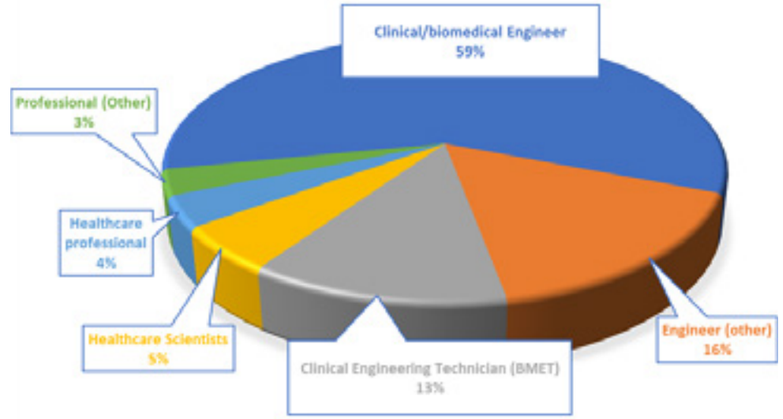

FIGURE 3. Graphical representation of the results of question #1: *Are you a member of one of the following professional groups?.*

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.

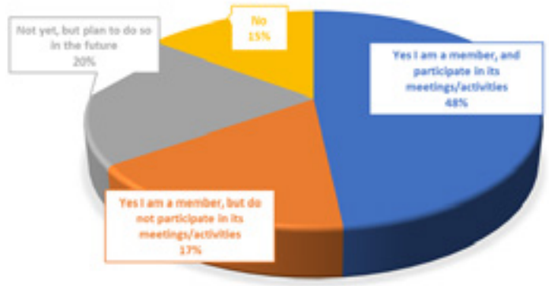

FIGURE 4. Graphical representation of the results of question #4: *Are you a member of the Association/Society and do you participate in their meetings or programs?*

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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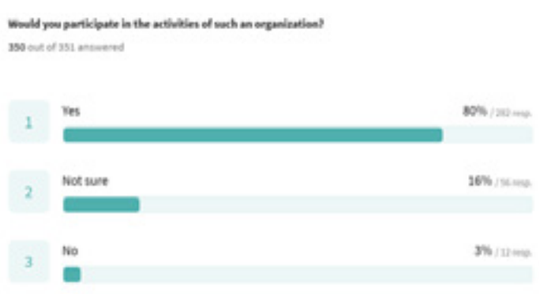
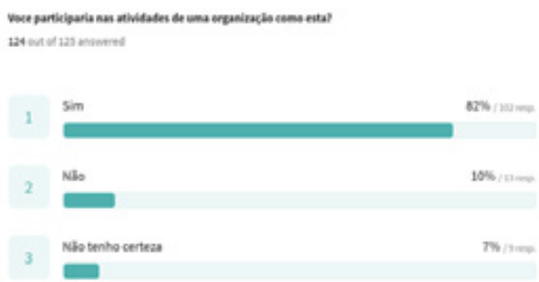
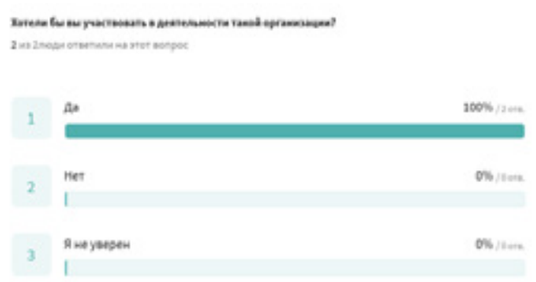
APPENDIX I

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?

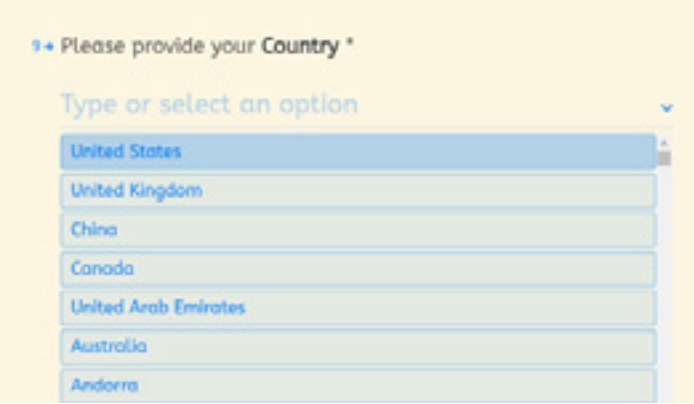
- A Yes
- B No
- C I am not sure

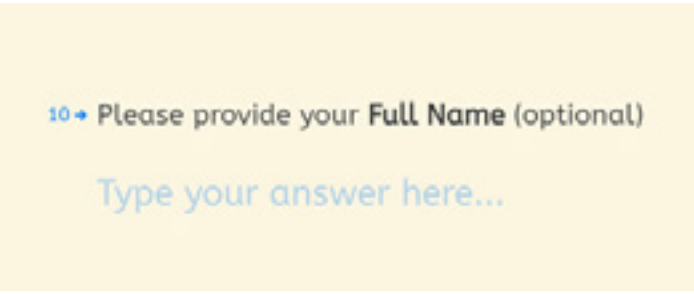
7 → Do you see value in an international organization focusing the needs of clinical engineering?

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

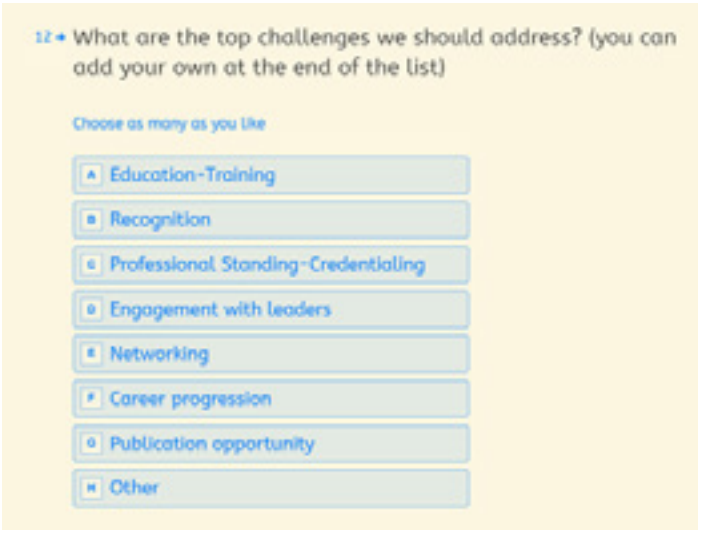
8 → Would you participate in the activities of such an organization?

- A Yes
- B No
- C Not sure


9 → Please provide your Country *
Type or select an option
United States
United Kingdom
China
Canada
United Arab Emirates
Australia
Andorra


10 → Please provide your Full Name (optional)
Type your answer here...


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