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Collaborative Development of Medical Devices: Qualitative Study of Communication Between Engineers and Medical Doctors

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Abstract— **Background: While research shows the importance of the interdisciplinary collaboration between medical doctors and engineers to successfully develop medical devices, there is scarce literature specifically exploring what makes these partnerships work. This paper examines the gap between engineers and medical doctors by exploring the enablers, barriers and difficulties of their collaboration and communication through the qualitative case study method.**

Methods: This pilot study explores the experiences of two surgery residents and three engineers in training who have had the collaborative work experiences in medical device design. Data sources include interviews, lab observations, and interview notebooks. The interviews were conducted with engineering students at UBC who have had work experience with clinicians/residents and surgery residents who have had work experiences with engineers.

Conclusion: While maintaining a successful collaboration is challenging, engineers and residents were both interested to continue collaboration and emphasized the importance of collaboration in designing medical devices. There is no question that there are hurdles in the communication between these two professional groups, such as knowledge deficiency, differing priorities and lack of sufficiently dedicated time; however, both groups found collaboration necessary and effective in the whole process of developing medical device technology.

Keywords— **Communication, Collaboration, Medical devices**

I. Background

To design better and safer medical devices, research shows that medical doctors and engineers need to work effectively together [1][2]. This means that rather than designing in isolation, these two professional groups should work more closely together in collaborative team environments [2]. However, research shows the collaborative practices and communication between medical doctors and engineers are difficult to achieve [1][3].

Communication, in the field of medical device development, is mainly focused on bridging the gap between engineering and medical disciplines [1][4]. However, the empirical research that focuses on this gap, by exploring the dynamic of collaboration between doctors and engineers, is very limited [3]. Findings mainly discuss the difficulties that these two professional groups often face [1][3][4][5] which are mostly around the notions of knowledge and language. Many engineers who are currently involved in designing medical devices lack knowledge of complex health care processes as they were trained in traditional engineering programs with no exposure to formal patient and clinical knowledge [3][5]. On the other hand, research shows that individuals in the health care profession find mathematical and analytical logic challenging to understand [3][6].

Effective communication is central to successful collaboration [3]. Communication can take various forms, such as verbal, nonverbal, direct or indirect, but to collaborate effectively, one has to communicate with the other and understand what the other means. According to Thayer-Bacon and Pack-Brown, sharing a common language, spending time together (though not necessarily in each other's physical presence) and conveying accurate messages to the other collaborator(s), ensuring that the messages are accurately received, appreciating each other's worldview, and working together on some common goal all contribute to effective communication [7].

In the context of doctors and engineers working together, factors that contribute to effective communication vary. Ng suggests three ways of improving the interaction between doctors and engineers: teaching engineering to doctors, teaching medicine to engineers, and increasing their interdisciplinary interactions [3]. This could be very productive as it involves the underlying educational backgrounds of the relevant students; however, this is a long term approach which is not as useful for the current doctors and engineers who are currently practicing. According to Yoda, other factors such as government funding, leadership and the personality of members, regulation of medical devices, and the involvement of

private firms influence the successful collaborations [4].

The existing research, though very scant, has mostly focused on the knowledge and educational/language aspects of the miscommunication between medical doctors and engineers. This paper is based on a pilot study the first author completed as part of her Master's degree. The pilot study guided the development of the thesis work. The aim of the study is to explore the barriers and difficulties that exist in communication between these two groups and explore potential enablers or recommendations to overcome these issues. Thus, the following are the main questions of this pilot study: 1) What are the challenges and benefits of communication between engineers and medical doctors in designing medical devices collaboratively? 2) How can we address the difficulties in their communication?

II. Methodology

This study uses a qualitative research approach, specifically the case study methodology. The goal of qualitative research is to question, explore and identify phenomena by giving detailed description of various data acquired through observation, interview, journal writing and reflection [8]. This case study, explores the perspectives and interactions of both engineers and doctors in training to develop an in-depth understanding of the communication barriers and benefits in situations where they work collaboratively on medical device design and development. This pilot study has received ethical approval (course-based project) from the Behavioral Research Ethics Board, University of British Columbia (UBC). Consent form was given in writing to the participants. Interviews were conducted after the forms were signed.

A. Research Objectives

In this pilot study, communication is taken as the interactions and teamwork collaboration between emerging professional medical doctors in training and engineers in training. This project proposed the following objectives: a) further explore the communication gap between engineers and medical doctors, b) identify the benefits and barriers in their communication, and c) explore some potential ways to address these difficulties.

B. Data Collection

Participants: This research project involved five participants from the UBC: three engineers (2 males and 1 female) and two surgery residents (both male) in training. The participants already had experience working with other clinicians and engineers in medical device technology. The engineers were two Ph.D. students (one in computer science and one in biomedical engineering) and one Masters student (in biomedical engineering). The two surgery residents were in orthopaedics. Having these professionals-in-training as participants for this pilot study was a natural place to begin exploring the questions of the larger study.

Interviews and Observation: Interviews were completed with five participants, each lasted around 30 minutes. Observations were completed in a biomedical lab at Centre for Hip Health and Mobility. Over two 3-hour sessions, the communication between engineers and a resident who worked together on a collaborative project was observed. In the first session, there were only engineers who had worked on the device; in the second observed session, the resident joined the group. The notes from this observation recorded in a field notebook. An interview notebook was used to record the interviewer's thoughts, the setting of each interview, as well as the main topics that would emerge throughout the interview. This was done before starting the interview and at the end of each interview. The notebook was more like a journal with a focus on the interviewer's assumptions, thoughts and feelings prior to and after each interview.

C. Data Analysis

Data analysis consisted of three steps. First, the recordings of 5 interviews were transcribed individually. In the second step, transcripts, interview notebooks, and lab observations were coded to identify the indicators of challenges and enablers between engineers and medical doctors in their communication. During this stage, data was classified and a clustering strategy was used to facilitate analysis [9]. In the final phase of analysis, the similarities, differences, and any repetition of challenges related to communication were explored. Coding was also used to explore the recommendations or enablers suggested by the participants.

III. Results and Discussion

Overall two main categories, each including two themes, emerged from the data. The two categories were labeled as differences and priorities, in which differences included 'using different terminologies/languages', and 'having different ways of thinking'; and priorities included 'the problem of time pressure' and 'lack of having common goals'.

To design a safe and effective medical device, it is important to take into account the perspectives of both engineers and clinicians. As one of the engineer participants explained: "*...biomedical engineering by definition is the constant communication between the engineers and clinicians. I should*

add not only clinicians but other health care providers as well. Maintaining this communication is a key to have a successful medical device but it is challenging."

The collaboration between these two groups often faces challenges including finding time to work together, or using different terminologies and academic languages. In this pilot study, one of the residents stated that he decided to take courses and learn about designing medical devices because of his own interest. Through the program, he has had the opportunity to work collaboratively with engineers and become familiar with their language and terminology. But this might not be an option for all clinicians as they may not find time after being in medical school for 8-9 years. Similarly, learning the medical terminology and becoming familiar with clinical world might take years for engineers. This can create barriers in the communication between these two disciplines.

To address this problem, these two groups need to spend more time to work together, explain their thoughts to one another in plain language, and build a shared understanding among themselves. The challenge of "speaking two different languages" was evident among all the interviewees. It was recommended that each professional group invest some time to research about the other field and be prepared for their collaboration once they have committed to work on the project collaboratively. As one of the engineers suggested, *"... I think when engineers and doctors agree to work together so they both agree to spend time in the project together, and it is necessary engineering people do research into the health part and people in health need to do research into engineering."*

During both interviews and lab observations, It was noticed that engineers and residents have their own ways of thinking and their own separate mindsets when it comes to their respective approaches of designing or utilising medical devices. This can be both hindering and facilitating. For instance, one of the participants explained this hinderance, *"[Engineers] were automatically thinking about design and mechanical aspect of device like the various stresses and forces that this device would have to incur."* While engineers may intend to incorporate the most challenging state of the art technology into the medical device design, this might not be the main interest for medical doctors, as one of the residents stated *"The first thing that may come into an engineer's mind is about the design and how to make a device more sophisticated, but the first thing in every project that come into a doctor's mind is the patient outcomes and how practical is the device for patients."*

On the other hand, having different ways of thinking could facilitate a solution. For instance, involving doctors' perspectives can change the direction of a project to a more applicable clinical need, as explained by an engineer: *"... part of my project is trying to improve the dynamic assessment of DDH screening... I was reading a lot about dynamic assessment as a technique that doctors use in patient diagnosis process. After the meeting with the clinician who has seen this issue in practice he suggested another method instead of using the dynamic assessment... If there was no clinician I would have gone to the wrong direction in my research, spent a lot of time on something that might not be as useful as something that I do now in my research... "*

Insufficient time allocation also appeared to be a barrier for collaboration. The important role of doctors in saving lives of many patients and dedicating most of their time to patients is an inevitable fact, however, incorporating doctors' knowledge, experiences and perspectives to design effective medical devices is necessary, as well. The participants in this study highlighted the importance of maintaining continuous communication throughout the collaboration. The existing literature does not suggest a facilitator to overcome the time limitation of clinicians. However, in one of the interviews, the participating engineer proposed an interesting approach to address that:*"In my other project, there is another surgeon who is very busy, too! However, he has a couple of surgery residents, so whenever he is not available he sent us his residents in the meeting [who] are much more available than himself to contact to. I think that is a very successful model that has been proven to be really effective for me."* Involving the residents in medical device projects would be beneficial not only for engineers who need the clinical advice, but also for the residents: *"More residents need to be aware of the collaboration opportunities with engineers. These opportunities are out of medical schools and need to be promoted... it might be something that they could really benefit their patients in the future... "*

Having common goals and visions in collaborative projects are central to the success of any teamwork. The participants of this study mentioned that these two groups usually have different goals and outcomes in mind, which impedes strong communication. For instance, one of the engineers indicated that sometimes the motivation of engineering professors is to 'publish papers' or to '[get] future grants', whereas the clinicians think about 'improving clinical workflow and treating patients'. Such differences in goals and interests in interdisciplinary project collaboration are obstacles in working together and producing new scientific knowledge [10]. This was explained by one of the residents: *"Helping patients and the safety of medical device are important factors for both engineers and doctors. However, it might be defined differently for these two groups. What we [medical students] are taught all the time in medical schools is 'do no harm' while helping patients. Those principles are not nec-*

essarily taught or repeated in engineering as much as we are warned in medical ethics. I guess error in design for engineers would result in a structural failure or mechanical failure. It's not something that necessarily put someone's life in risk. Having common understanding of concepts like this is important."

While barriers in collaboration between medical doctors and engineers are likely to remain for the foreseeable future, research participants nevertheless emphasized the importance of maintaining ongoing collaboration. One participant noted how collaboration, however imperfect it may be, yields a better end result: *"...there are the difficulties but at the end of the day I look at the result. It is a great successful result working collaboratively with doctors. So I don't see them as barriers stopping me to continue working with them..."*.

Having known the significance of collaboration between these two groups, it is essential to examine the barriers and facilitators within such collaboration. The emerging themes and findings derived from the interviews conducted in this pilot study have informed first author's Master's project, especially their implication in long term collaborative projects. To this end, the Master's thesis focuses on examining this collaboration in more depth by not only recruiting more participants from both engineers and medicine but also including practicing professionals to better understand the current state of these issues in practice.

IV. Conclusion

Maintaining a successful partnership between medical doctors and engineers seems to be more attainable when these groups work together for a longer period of time. The present study shows that central to their successful communication are: bridging the knowledge gap between these two groups, appreciating their diverse perspectives, having common goals and understandings, and addressing the time pressure in their collaborative projects. While the differences in terminology and ways of thinking, or the pressure of time and lack of common goals, between clinicians and engineers are shown as barriers, they do not mean to discourage their team work. In fact, they show the beauty of collaboration by bringing technology and patients safety together.

V. Limitation

The present pilot study was done with a small number of participants in training within a short period of time. Thus, the findings may not be generalized to other research projects. It is suggested that future research should be more comprehensive and in depth, and will be conducted with practicing professionals to explore whether their ability to communicate changes over a longer period of time. Moreover, having a larger number of participants (equal numbers of engineers and clinicians) can provide this opportunity to compare their collaboration experiences in designing medical devices. It would be interesting to know if future (similar) studies see whether the mentioned differences and priorities will get adjusted.

Conflict of Interest

The authors declare that they have no conflict of interest.

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