Re-Designing the Nasal Cannula for Facial Surgery

The Introduction of Novel Healthcare Technologies and Methods In Least Developed Countries

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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The Introduction of Novel Healthcare Technologies and Methods In Least Developed Countries

Introduction

For my STS topic I will be exploring the introduction of medical innovation to nations defined as "least developed" as defined by the UN Committee for Development Policy(CDP)(Anon n.d.-b). These least developed nations, scattered mainly throughout sub saharan Africa and southeast Asia, otherwise known as "LDC's" account for roughly an entire 13% of the world's population, further defining the scope of a major humanitarian crisis(Anon n.d.-a). These countries are often marred by consistent conflict, corruption at the highest levels of bureaucracy, and poor infrastructure and development potential, all of which contribute to a far lower than average quality of life for the citizens. Furthermore, healthcare in these nations is no exception to these trends as such decreased quality of life, life expectancy, and epidemic are all commonplace especially compared to developed first-world nations(Deaton and Tortora 2015; Moeti 2016). This research shows the skewed nature of advances in healthcare in favor of already developed nations. Finally, I aim to identify the primary socio-economic barriers to aiding healthcare infrastructure of developing nations.

In the operating room surgeons are subject to incredibly high standards in order to ensure the safety of the patient defined as the "Standard of Care" which are imperative for the safety of the patient as well as the reputation of the physician. This Standard of Care is rooted within the hippocratic oath all physicians take at the start of their careers and as such is the incredibly important too the duty the owe their patients. However, due to the lack of any specific or absolute standards, physicians are left in the challenging position of turning to their own intuition in deciding the treatment of a patient and whether or not it adheres to the "Standard of Care" (Grady 2005). This vague position leaves open the possibility of error on the part of the

physician as well as a constant room for innovation which my group and I's technical project aims to contribute.

Our project aims to redesign the dual-channel nasal cannula, a device used to detect O_2 and CO_2 levels in patients undergoing Monitored Anesthesia Care(MAC)(Kim and Asai 2019). However, the placement of the cannula becomes contentious in facial surgeries due to obstruction of large portions of the face. This forces surgeons to either place the nasal cannula within the mouth of the patient or to apply general anesthetics, both of which raise complications that are not present in MAC, decreasing the accessibility of certain operations. General anesthesia in particular is more expensive than MAC, requires greater amounts of expertise, and carries a more extreme risk to patient health(Brooks and Hand 1999; Prathigudupu et al. 2018). Thus my team proposes an adapter which will ergonomically fit within the patient's mouth and firmly attach to the nasal cannula. By creating such a tool the range of facial surgeries operable in MAC should increase, thereby making them more accessible worldwide.

Re-Designing the Nasal Cannula for Facial Surgery

Facial plastic surgery reconstructs or reshapes structures of the face such as the nose, lips, and cheeks after an injury e.g. dog bite, skin cancer resection, or to change features present from birth. The wide range of use cases makes the surgery incredibly popular. As such, in 2021, a total of 1.4 million facial plastic surgery procedures were performed(Solutions and Reconstructiv n.d.). In order to have an unobstructed view of the face and provide the best outcome, these surgeries are often performed under monitored anesthesia care (MAC), also known as conscious sedation, rather than general anesthesia(Bitar et al. 2003; Taub, Bashey, and Hausman 2010). MAC allows for the patient to be sedated, making them unaware of their surroundings, while still breathing on their own. Using MAC avoids the risks associated with general anesthesia and endotracheal intubation such as injury to teeth, lips and gums, bleeding,

and aspiration of gastric contents leading to pneumonia(Jaisani et al. 2015; Taub et al. 2010). As such MAC is far more accessible and is preferable to general anesthesia when possible because of reduced risk of complication, especially in younger patients and those with significant comorbidities such as the elderly(Bitar et al. 2003; Prathigudupu et al. 2018). During facial plastic surgery specifically, the use of a nasal cannula unfortunately obstructs the surgical field and makes certain surgeries impossible under MAC. Thus, there is a need for a device to monitor oxygen and carbon dioxide designed specifically for facial plastic surgery.

The current solution to this, used by The UVA Department of Otolaryngology, is to place the Nasal Cannula in the mouth of the patient between their teeth in order to mitigate facial obstruction. However this solution places added unnecessary stress on both the partially awake patient and the conducting surgeon. The placement of the Nasal Cannula in the mouth is both incredibly unsafe and uncomfortable for the patient as there is risk that they swallow or spit out the nasal cannula. The constant re-adjustment of the nasal cannula adversely affects cost and safety of the surgery by prolonging the time spent under anesthesia.

Our current solution to this problem involves the repurposing of an oropharyngeal airway(OPA), used in general anesthesia cases, as an adapter for the nasal cannula being placed in the mouth rather than the nose. Through the involvement of prior art our technology is anticipated to be easily usable by surgeons as well as generally comfortable for patients. At the same time by placing the device in the mouth rather than the nose we can minimize the amount of obstruction to the face of the patient allowing for simpler surgeries. This allows for the use of MAC in a far larger range of facial surgeries in turn increasing the accessibility of those surgeries to more patients.

One of the key considerations in the development of this adapter has been accessibility too both patient and doctor. This focus on accessibility will be used to aid in the understanding of how the design process can be shifted to accommodate those with greater need such as the LDC's which make-up the subject of this paper.

The Introduction of Novel Healthcare Technologies and Methods in Least Developed Countries

Least Developed Countries otherwise known as LDC's are a a classification of the UN Committee for Development(CDP). These nations, located primarily in sub-saharan Africa and Southeast Asia, are characterized as having severe infrastructural handicaps that prevent development and growth of GDP(Anon n.d.-a). The already lacking infrastructure mean that these nations are by default far more vulnerable to major disasters that only serve to exacerbate the ongoing humanitarian crisis faced by these nations such as epidemics, natural disasters, and near constant warfare and corruption(Seyf 2001; Tchole et al. n.d.).

Healthcare in these nations is no exception to these failing trends and as such I look to identify the major barriers in the introduction of healthcare care technologies to these nations to explore how the engineers may better incorporate these ideals into the design process for the sake of accessibility.

While lack of monetary resources may stand as an obvious barrier to these nations they are not the standalone answer to these nations problems(Moeti 2016). These nations additionally face series of other setbacks that must be addressed in order to improve healthcare. One of the key issues is the lack of expertise and those with the technical knowledge to properly operate in a healthcare setting such as doctors and nurses(Ighobor 2016; Yates and Lillie n.d.). Due to the poor standard of living, those who can find work outside of their home nations are very unlikely

to stay and as such mass migrations of skillful workers, known as brain drain, contribute to the lack of skillful people. This alongside the lack of strong education means that nations are producing talent at a far slower rate than first-world nations further aggravating the lack of technical knowledge in these countries.(Salmi 1992).

Additionally these nations citizens have a tendency to stigmatize modern medicine and healthcare and who should receive it. In Ghana this can clearly be seen the fear held by women of certain abdominal procedures as well as the fear of being socially outcasted should the go through with modern procedure(Gyedu et al. 2016).

Research Question and Methods

This paper will seek to answer the following question: what are the socio-economic and political barriers that contribute to the lacking healthcare in developing nations and what steps can be taken to circumnavigate these issues in the introduction of medical innovations? I aim to answer this question through a framework of an in-depth literature review of the humanitarian aid policies and protocols carried out by organizations such as the UN and Red Cross in delivering aid to LDC's. Additionally to answer this question I will conduct an in-depth review on the culture's of the people living in these regions as well as lifestyle's as can be found in primary resources in the UVA library.

Conclusion

The humanitarian crisis in LDC's seems to be back on upward trend as relief from the covid-19 pandemic wanes, however inefficiencies in the protocol's set about to address current barriers continue to grow. As I embark on an in-depth study on the lives the people living in these nations as well as the current standards applied in aiding them, I aim to improve the

processes by which those with technical knowledge in first-world countries can introduce novel methods to these nations.

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