GC Project Proposal

Smartbeat

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Problem Statement

Problem

At the beginning of this semester, our team decided to shift focus from pacemakers and the cardiovascular realm to hematology and access to medical care. Our current statement is "How might we reduce the transmission of Hepatitis C (HCV) through blood transfusions in low resource settings?"* The bloodborne disease Hepatitis C is prevalent in areas without access to adequate medical care, which are mainly developing nations (World Health Organization, 2016). Many assume that drug users are the most at risk for contracting a bloodborne disease, however, in developing nations, those who seek out medical care face the biggest risk of contracting such diseases through transfusions and unsafe medical procedures due to insufficient resources in medical settings (World Health Organization, 2009). This issue creates risks in the blood donation supply chain, where blood borne diseases can be introduced when donating blood and receiving transfusions, contaminating the blood supply. This results in a risk of transmission to donors as well as patients in need of a transfusion.

*Since there are other bloodborne diseases also highly prevalent in low resource settings, such as HIV, we included information in this report related to other blood borne diseases, because we may change our disease focus next Fall.

Significance

The World Health Organization (WHO) lists "bloodborne diseases", including HIV and HCV, as one of the top ten leading causes of death in low-income countries (World Health Organization, n.d.). When a patient contracts a bloodborne disease through blood transfusions, this creates a significant financial burden in the national's overall healthcare spending, as more resources are required to treat these fatal and preventable illnesses. For HIV/AIDS alone, federal spending increased 20 percent, or 5.7 billion dollars from FY11 to FY17 (The Henry J. Kaiser Family Foundation, 2016). Life threatening illnesses as these can also create emotional stress on the infected individuals, their families and their friends and these individuals may even be ostracized from their community. In addition, PLWHA (People living with HIV/AIDS) are more likely to suffer from financial strains and avoid seeking medical treatment (Zhang, 2016). In turn, this stigma reduces the likelihood of infected individuals to disclose their HIV status and puts non-infected individuals at risk of contracting the disease.The possibility of contracting these

deadly illnesses through blood transfusions, a common procedure which involves transfer of blood between individuals, increases distrust in medical professionals and prevents people from seeking medical care. Fear or distrust of doctors removes a valuable resource from society.

There are several causes of the transmission of bloodborne diseases through contaminated transfusions, which vary in different socioeconomic regions. The heart of this issue lies in the blood donation and blood screening process, when the bloodborne disease is introduced into the general blood supply. In Sub-Saharan Africa, a primary source of blood is from family and paid donors, who are considered at high risk for transmitting HIV, Hepatitis B or Hepatitis C. As of now, only 12 sub-Saharan countries have achieved 100 percent voluntary unpaid blood donation, which has the lowest risk of disease transmittance. Because the blood supply is low in many low-resource regions, there is a large demand for blood, which is primarily obtained through unsafe donors or channels. Among this population, there are individuals who are not aware they are HIV positive due to the window period, when symptoms are not visible but the patient has been infected. Patients aware of their HIV infection may still choose to donate blood due to other incentives, such as monetary compensation or promises of receiving blood in the future (WHO, 2009). As part of its strategy to ensure a safe blood supply, the World Health Organization (2016) recommends the establishment of a well-organized blood transfusion service at the national level, but this structure is often lacking or nonexistent. Even for countries that have regulations, they may not be implemented due to flaws in the health system. This can include an unreliable supply of disease test kits, shortages of trained staff, lack of monetary resources and/or negligence. More directly, many hospitals do not have the adequate technology to safely detect diseases in blood. Of the 2.7 million units of blood collected in 40 sub-Saharan countries in 2004, 88.5% were not tested for HIV in a quality-assured manner **(**WHO, 2009). From the team's interview with Dr. Rudolf Gleason, a Georgia Tech professor involved with global health engineering, the lack of supplies is a widespread problem in such areas and influences the spread and lack of treatment of diseases. The underdeveloped management of this supply chain creates risk for acquiring bloodborne diseases through blood transfusions.

President Obama's Fiscal Year (FY) 2017 federal budget request, released on February 9, 2016, includes an estimated $34.0 billion for combined domestic and global HIV efforts, a 5.2% increase from the 2016 fiscal year spending. 6.6 billion dollars are allocated to the global HIV budget, which has increased significantly in the past decade (The Henry J. Kaiser Family Foundation, 2016). U.S. healthcare spending grew 5.8% in 2015, accounting for 17.8% of the nation's GDP. By addressing the issue of TTI from HIV, the spending of individual households on HIV treatment would be reduced, which would decrease the nation's overall spending on HIV disease treatment (The Henry J. Kaiser Family Foundation, 2016). A similar pattern is true for Hepatitis B and Hepatitis C. Around the world, HIV produces a significant economic burden. In Jakarta, (Riyarto, 2010) Indonesia, PLHIV on ART spent 96% of their monthly expenditure on

HIV-related healthcare, obtaining funds from family donations, selling assets and personal income. In addition, most residents in this city do not have insurance. In another city, Merauke, very few people pay out-of-pocket because the government covers medical costs and health insurance for the poor. Regardless of who pays, HIV produces a significant financial burden on a society. A goal of our project is to reduce the transmission of bloodborne diseases, which would reduce the associated costs of treatment for this disease.

Stakeholders

The significance of this issue is that it does not necessarily stem from ignorance, but the fact that medical professionals in low resource settings lack both proper training and materials to prevent the spread of bloodborne diseases. While individuals and medical professionals understand the gravity of these illnesses, the government does not pay enough attention to the issue. According to Europe PMC, "Lack of commitment by national governments and international aid organizations to this fundamental element of HIV prevention has resulted in a shortage of basic equipment, supplies, and trained personnel for blood screening" (Lackritz, 1998).

In this case, the primary stakeholders, those who are directly affected by this issue, are the patients who directly receive blood transfusions from medical professionals in low resource settings. For example, according to BMC Public Health, "blood transfusion still accounts for 5 to 10% of HIV infection in Sub-Saharan Africa", and "5% to 12% of patients who received blood transfusion developed hepatitis" (Mavenyengwa, 2014). Therefore, patients who are harmed, whether intentional or not, by professionals who they trust with their lives, will raise concerns with this issue.

The secondary stakeholders are the medical professionals who treat and deliver blood in low-resource settings as well as the organizations that govern such operations. A major reason the transmission of bloodborne diseases is so prevalent in medical care is that medical professionals who treat patients either lack the proper tools necessary to treat such illnesses or the proper training. For example, due to the reuse of intravenous needles by medical practitioners in Egypt, close to 15% of the nation's population had HCV in 2008. (Elgharably, 2016). From an occupational standpoint, medical malpractice could pose financial burdens on practitioners who improperly treat patients, as their sustenance relies on the delivery of adequate medical care.. Furthermore, complications in the blood donation process would strain the reputations of organizations that overlook them, especially organizations such as the Red Cross that operate globally. For these reasons, the spread of bloodborne diseases not only affect the patients receiving blood, but also indirect participants, including medical personnel.

Context and Existing Solutions

While current solutions have already been developed for this problem, there are many associated flaws that prevent them from being feasible for developing nations. For example, a single-use syringe has been developed that prevents the plunger from being retracted after use, thus preventing its reuse upon treating another patient (Gallagher, 2011). While this does incredible bounds in preventing the transmission of bloodborne diseases through needles, the costs required to manufacture them poses a barrier to the medical practitioners that may seek to use them in low-income settings. As stated in a BBC article, "Standard syringes cost between two cents (1.3p) and four cents. The smart syringes cost between four and six cents...However, the tiny difference in the price of one needle becomes huge when it is scaled up to 16 billion injections" (Gallagher, 2011).

Another solution that is rising in popularity is the point of care device, otherwise known as a rapid diagnostic test. These devices are used to diagnose bloodborne diseases in close proximity to the patient, providing quick feedback and avoiding the time and costs associated with testing blood in a lab (Labcompare, n.d.). While most point of care devices are still only prevalent in developed nations, rapid diagnostic tests under one dollar have been created for utilization in developing nations (Wu & Muhammad, 2012). Unfortunately, with the reduction of cost for these devices also comes a drastic reduction accuracy in testing for bloodborne diseases. In a test done in the Rakai district in Southwestern Uganda, a region where HIV transmission is incredibly high, it was found that 129 of the 259 individuals who tested HIV positive using a rapid diagnostic test were HIV negative (Unite For Sight, 2016).

Lastly, predonation screening procedures for donors in countries such as the U.S. have been developed to ensure a pool of uncontaminated donors (Shittu, 2014). Unfortunately, these procedures cannot be implemented in developing nations, as they may often be even more expensive than post screening procedures. This is because such tests must be conducted on all donors, regardless whether they are actually infected or not (Shittu, 2014). Thus, current solutions are either too expensive or not yet fully efficient for use in developing nations.

Why is this still a problem?

Bloodborne diseases are still prevalent in low-resource settings because the characteristics of existing solutions to reduce disease prevalence make them feasible for developed nations, but difficult to implement in low-resource settings. A fundamental issue is that low-income regions have limited to no access to diagnostic tests, so many individuals are unaware of their infections and subsequently contaminate the blood supply with their donations. Currently, low-resource settings lack access to viral load quantification, the process that detects whether surface antigens

correspond to chronic or inactive carriers of the hepatitis virus, and antiviral treatment for HBV and HCV. There are existing serological and virological tests, but they have shortcomings. Rapid diagnostic tests are unreliable, as their accuracy varies widely. Very cheap RDTs, those likely to be used to low-resource settings, usually have poor sensitivity. Dried blood samples (DBS) are easy to store, circumventing some infrastructure obstacles, but their lack of precision due to a lower range of viral loads make them suitable only for detecting HCV, and not HBV. Modern diagnostic devices do not balance affordability for global scaling with sensitivity, in order to avoid false positives in unaffected individuals.

In addition, since bloodborne diseases are often acquired through medical procedures, there have been innovations developed to address this issue. The auto-disable syringe was developed to prevent drug users from using used syringes discarded by hospitals, but it costs far more than the traditional syringe. The auto-disable syringe costs 0.085 USD as opposed to the traditional syringe, priced at 0.04 USD (Miller, 1999). Additionally, there are few solutions focused on the blood donation process, while the problem space of syringe reuse is inundated with solutions. One article did a case study in the Democratic Republic of Congo and found that an estimated 25% of pediatric HIV infections and 40% of infections among children over the age of one year were due to transfusions (Lackritz, 1998).

Another issue lies in the lack of trained staff and knowledge available at these low-resource settings. Importing technologically advanced tools do not always match the capabilities of clinical professionals, given that advanced supplies often arrive but are unused. There are not enough field tests conducted to ensure that a device that is functional in scientifically advanced nations where they are built can thrive in low-resources settings such as those of Sub-Saharan Africa.

For POC diagnostic devices, most funding and investments are toward HIV/AIDS combat, while Hepatitis is often overlooked. The inadequate financial support contributes to a lack of improvement in low-resource settings' Hepatitis rates.

The lack of access to effective diagnostic tools poses a risk in introducing hepatitis into the blood donation supply. Since detection typically occurs at a later stage of the blood supply chain, developing a POC device to implement at an earlier stage would prevent disease from entering the blood supply, leading to safer donated blood.

Proposed Work

Goal

Our goal is to reduce the transmission of bloodborne diseases in low resource settings—in particular, transmission through blood transfusions. This may involve creating a device that affordably screens blood donations for a particular disease such as HIV or Hepatitis C, or any other small scale solution to an issue in the blood donation process that allows the transmittance of bloodborne diseases. While our concept of a screening device may not be as accurate as a full lab test, our group is focusing on ridding bloodborne diseases from the blood supply as soon as possible. We hope to create a product that can be directly implemented in a wide range of situations, even if it means sacrificing perfect accuracy for a low cost. If our solution is successful, we may be able to drastically reduce the transmission rate of bloodborne diseases and eventually eradicate contaminated blood from the blood supply.

Objectives

Since our group does not yet have a definite solution direction, an objective of ours is to develop a specific solution to our problem space. At our current stage in the ideation process, we have a few potential solution ideas, but our team believes that we need more knowledge of the specific blood chain in developing nations to create an effective solution. Therefore, we intend to research case studies of both effective and ineffective blood supply chains over the summer. This may help narrow our solution space to a specific country or group of countries, since each national blood system is unique. We must then go through a second iteration of insight combination to make sure we consider all solutions before selecting one to progress with. Our group hopes to have a solution chosen at the latest by August 1st. After this goal, we plan to research the feasibility of such a solution and consider how this may impact the initial idea. The biggest barrier in reaching this solution is communication over the summer. We aim to communicate weekly and conduct research between meetings, yet it is a possibility that people will be unable to meet certain weeks due to summer plans. However, this likely should not set our group back, provided we stick to a weekly meeting schedule.

After the previous objective is achieved, our team hopes to implement our solution. This is important because the purpose of Grand Challenges is not only to develop solutions to large global issues, but also to benefit society, to actually create an impact with our solution. This can not be effectively accomplished without attempting to make our solution a reality, to use our connections at Georgia Tech and in the medical field to actual manufacture our product and distribute it to an area in need. Accomplishing this goal would also expose our group to the process of creating a product and implementing it, allowing us to be exposed to this process and become better informed engineers in the future.

There are multiple steps to achieve this objective. First we have to achieve the first objective of creating a solution. The substeps for this are delineated above. After creating our idea for a

solution, we will have to create a prototype. If our solution is a device, this would involve familiarizing ourselves with design programs and 3D printing, as well as chemical and medical equipment we would need to purchase and use. If it is a website or non-physical solution, the approach to creating a prototype would be more unique and specified at the time. After creating a prototype, we would have to conduct an experiment to determine if our solution is successful. For a device, success would be defined by a product that achieves the goals it hopes to make, such as a diagnostic device accurately diagnosing blood samples with particular blood borne diseases. Success would also involve rhetorical awareness (if the results of the experiment reflects successful application in the country or environment we are targeting). For example, if a diagnostic device requires additional professional and expensive equipment to successfully function, its application as a low-cost solution for developing nations would not be successful. If the experiment is unsuccessful, we will return to improving or developing our solution, or we will redefine success for our experiment or develop a new experiment.

After a successful experiment, there are a few different steps we could take. We could first try to enter a product competition, such as the Inventure Prize, in order to fund our project. We could also connect with labs on campus that may be interested in funding our product. For example, Dr. Wilbur Lam's lab currently is developing and funding an anemic point of care device (McGann, 2015). We could also try to connect with one of our global medical connections, such as a Brazilian cardiologist and the Brazilian research institution Fundação Oswaldo Cruz. Success for this step of process would involving winning or gaining connections through one of these competitions or networks in order to gain funding for our solution.

With any of these paths, we would then need to research FDA and other regulatory agencies in order to make sure our product is within allowable limits of the law. This may involve proposing our solution to the FDA for approval in clinical or field settings, but this would be a very long process and therefore may not be as feasible for our time as undergraduates.. However, if one of our teammates stays for their graduate degree, they may possibly continue with this part of the project. These regulations would be a problem nonetheless in the implementation of our product due to restrictions not only in the US, but also in the developing nation we target. We may also encounter problems finding funding or connections, however based on our team's current connections, this as a major problem.

Project Team

Our group will continue to work on this project, with all six members returning next fall! One of our members will be co-oping and not present in class, however, this member will still communicate with the group and contribute to the project.

This semester, we began with shifting weekly leaders, but it ended up being very complicated. However, as the year progressed, we began to shift towards a group organizer that sort of filled the role as group leader. Next semester we will need an individual who is actively involved in the class and group to be an official leader and firmly take on those responsibilities. The group leader will be responsible for leading discussions and directing group efforts, as well as representing the group if needed. We will also have a networker who will continually search for contacts in our field and keeps contact with previous contacts and a trip organizer who will organize field trips and sign up for conferences, as well as group bonding events. There will also be a treasurer, who keeps track of all the costs and finances of the group, and coordinates reimbursements with Grand Challenges. We will additionally have a research coordinator who will organize research efforts. The secretary will keep track of assignment due dates, as well as organize documents and turn in and briefly edit for overall quality of assignments.

For next semester, we have a few individuals who may be able to help us next semester. First we will have Dr. Rudolf Gleason, a mechanical engineering professor involved with global health. We interviewed him as an expert, and he was really interested in our group and our project. Our second individual is Dr. Wilbur Lam, a physician and engineer at a joint Emory - Georgia Tech Biomedical Engineering lab who works with pediatric hematology and diseases. He is currently Julia's Lab Coordinator and would most likely to gladly help our group. Our third advisor would be Newton, our current facilitator, due to his wisdom and knowledge in group dynamics. We will also be talking to Pinar Keskinocak, who is involved with infectious disease modeling, disease screening, and health care delivery.

Timeline

As mentioned in our objectives section, we plan to complete research over the summer and have a definite solution direction by August 1, 2017. In addition to the solution direction, we will update our proposal to include a specified budget, timeline for the Fall semester and other resources required. During this time, we will also establish a strengthened network of professionals, from blood bank nurses to professors with connections in the researched low resource regions, so that our team can begin implementing an action plan to realize our proposed solution. We plan to have a prototype or model of our solution created by the end of the first semester. This may not be a completely functioning prototype if our solution is very complex. For example, if we continue with creating our own diagnostic device, the chemical and medical complexity of the device would take more time than 6 months to develop, possibly taking our entire second year. With this timing in mind, we would then hope to conduct an extensive experiment with our product, most likely at the end of our second year or the beginning of our third year. Once this experiment is successful, we would then search for funding and connections to implement our solution, most likely in the Spring semester of our third year. This could then

lead to a trip of actual implementation of our solution in a developing nation the summer after our third year, or possibly visiting our target developing nation if regulations still need to be considered.

Budget

Without a definite direction for our solution, we are refraining from providing a detailed budget for our future plans. Once we develop a plan and gain clarity into our problem space, we will be able to more accurately create a budget. As of now, we intend to attend a conference this summer to further our knowledge in the field of bloodborne diseases and current innovations. If we attend one conference with approximately half of our team members, we would most likely need about $400 for flight and other trip fees. We hope to have most of our product cost funded through our lab connections. In the next year, we plan to purchase some products to test our ideas and assumptions, such as a pre-existing point of care products for Hepatitis C. An estimate price for these devices would probably be around $200 total.

Expected Outcomes and Future Directions

In order to expand our understanding of our problem space and refine our solutions, we plan on conducting more research in the field by reading published articles, conducting interviews with experts, and expanding our connections to experts in relevant fields. If we continue our pursuit of creating an affordable, easily operable detection device, then we will need to focus part of our research on current diagnostic devices in use, and learn how these can be applied to various diseases and resource settings. At our current stage in this project, it is important to keep our view of the problem space wide and to refrain from hastily narrowing the focus of our problem.

References

Centers for Medicare and Medicaid Services. (2016, December 6). Historical. Retrieved 30 March 2017 from https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nationalhealthaccountshistorical.html

Dhingra, Neelam. (2006, June 27). Making Safe Blood Available in Africa. Committee on International Relations Subcommittee on Africa, Global Human Rights and International Operations U.S. House of Representatives. Retrieved 31 March 2017 from http://www.who.int/bloodsafety/makingsafebloodavailableinafricastatement.pdf

Gallagher, J. (2015, February 23). WHO urges shift to single-use smart syringes. Retrieved March 27, 2017, from http://www.bbc.com/news/health-31550817

Labcompare. (n.d.). Point of Care Devices (POC Diagnostic Devices). Retrieved March 15, 2017, from http://www.labcompare.com/Clinical-Diagnostics/5096-POC-Diagnostic-Devices/

Lackritz, E. M. (1998). Prevention of HIV transmission by blood transfusion in the developing world: achievements and continuing challenges. . *AIDS*. Retrieved March 30, 2017, from http://europepmc.org/abstract/med/9632988

Mavenyengwa, R. T., Mukesi, M., Chipare, I., & Shoombe, E. (2014). Prevalence of human immunodeficiency virus, syphilis, hepatitis B and C in blood donations in Namibia. *BMC Public Health,14*(1). doi:10.1186/1471-2458-14-424

McGann, P. T., Tyburski, E. A., De Oliviera, V., Santos, B., Ware, R. E., & Lam, W. A. (2015, December). An accurate and inexpensive color-based assay for detecting severe anemia in a limited-resource setting. Retrieved April 20, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/26317494

Miller, M. A., & Pisani, E. (1999). The cost of unsafe injections. *World Health Organization,* 808-811. Retrieved March 30, 2017 from http://www.who.int/injection_safety/toolbox/Miller.pdf

National Institute of Biomedical Imaging and Bioengineering. (n.d.). Point-of-Care Diagnostic Testing. Retrieved March 20, 2017, from https://report.nih.gov/NIHfactsheets/ViewFactSheet.aspx?csid=112

Riyarto, S., Hidayat, B., Johns, B., Probandari, A., Mahendradhata, Y., Utarini, A., Flessenkaemper, S. (2010, February 15). The financial burden of HIV care, including antiretroviral therapy, on patients in three sites in Indonesia. Retrieved April 20, 2017, from https://academic.oup.com/heapol/article/25/4/272/559003/The-financial-burden-of-HIV-care-including

Shittu, A., Olawumi, H., & Adewuyi, J. (2014). Pre-Donation Screening of Blood for Transfusion Transmissible Infections: The Gains and the Pains - Experience at a Resource Limited Blood Bank. *Ghana Medical Journal*, *48*(3), 158–162.

Sigit Riyarto, Budi Hidayat, Benjamin Johns, Ari Probandari, Yodi Mahendradhata, Adi Utarini, Laksono Trisnantoro, Sabine Flessenkaemper; The financial burden of HIV care, including antiretroviral therapy, on patients in three sites in Indonesia. *Health Policy Plan* 2010; 25 (4): 272-282. doi: 10.1093/heapol/czq004. Retrieved 30 March 2017 from https://academic.oup.com/heapol/article/25/4/272/559003/The-financial-burden-of-HIV-care-including.

The Henry J. Kaiser Family Foundation. (2016, June 10). U.S. Federal Funding for HIV/AIDS: Trends Over Time. Retrieved 30 March 2017 from http://kff.org/global-health-policy/fact-sheet/u-s-federal-funding-for-hivaids-trends-over-time/.

Unite for Sight. (n.d.). Challenges and Failures of HIV Screening With Rapid Tests. Retrieved March 28, 2017, from http://www.uniteforsight.org/health-screenings/hiv

World Health Organization. (2009). Screening Donated Blood for Transfusion-Transmissible Infections. Retrieved 31 March 2017 from http://www.who.int/bloodsafety/publications/bts_screendondbloodtransf/en/.

World Health Organization. (2016, July). Blood safety and availability. Retrieved April 21, 2017, from http://www.who.int/mediacentre/factsheets/fs279/en/

World Health Organization. (n.d.). Rapid diagnostic tests. Retrieved March 27, 2017, from http://www.who.int/malaria/areas/diagnosis/rapid_diagnostic_tests/en/

World Health Organization. (n.d.) The top 10 causes of death. Retrieved March 31, 2017, from http://www.who.int/mediacentre/factsheets/fs310/en/index1.html

Wu, G., Muhammad, Z.H., (2012) Low-cost tools for diagnosing and monitoring HIV infection in low-resource settings. *Bulletin of the World Health Organization* 2012;90:914-920. doi: 10.2471/BLT.12.102780. Retrieved April 1, 2017 from http://www.who.int/bulletin/volumes/90/12/12-102780/en/

Zhang, C., Li, X., Liu, Y., Qiao, S., Zhang, L., Zhou, Y., … Tang, Z. (2016). Emotional, physical and financial burdens of stigma against people living with HIV/AIDS in China. *AIDS Care*, *28*(sup1), 124–131. http://doi.org/10.1080/09540121.2016.1146206