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A Healthier Future: Replacing Plastics in Healthcare

Executive Summary

Our planet is awash in plastic pollution. We see it every day on the news, in social media, and everywhere around us. And with less than 10% of all the plastic made since 1950 ever having been recycled – the problem is only getting worse (Ritchie, 2018).

Chemicals released by plastic waste can interfere with normal hormone function, raising the risks of cancers and birth defects (Royte, 2018). An estimated twenty-five percent of the annual six million tons of U.S. hospital waste is plastics - creating a paradox whereby the very work of healing people also contributes to increased health risks (hprc.org/hospitals).

This project addresses the problem by exploring how replacing plastics can help ensure healthcare is delivered without causing increased harm. The project examines the scope and impacts of plastic pollution generated in healthcare and reframes this problem as an opportunity to act and drive positive change. The case for action is supported with findings acquired through discussions with international materials experts and alternative materials research conducted via one of the world's leading materials databases. The case is advanced through examples of success obtained in interviews with senior executives of organizations that have succeeded in replacing plastics for a wide range of products.

The final product provides a framework that others can utilize in any industry. For those seeking to replace plastics, the project answers questions like - where to begin, what evidence is available, and is there proof of success? Most importantly it provides evidence that replacing plastics can drive change to create a healthier future.

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Abstract

This paper recounts a project journey that was taken to explore how replacing plastics with less harmful materials can drive positive environmental impact. The project examined the scope and impacts of plastic pollution attributable to healthcare delivery and the adverse impacts it has on population health. Identifying potential options to replace plastics was accomplished by obtaining access to one of the world's leading materials databases. This access enabled identification of several alternative materials with documented uses as plastic replacements. Evidence of successes that have been achieved in replacing plastics with less harmful materials was gathered by conducting interviews with international materials experts and senior executives from several different industries. These examples are combined with the research findings on alternative materials to construct a case that taking action can yield financial benefits while doing less harm to people and the planet. The completed project presents a framework that can be followed in future efforts to replace plastics. While the scope of the project focused on the plastic pollution problem from a healthcare perspective, the framework that was created is portable and can be adapted for use in any organization or industry seeking to replace plastics and drive change to create a healthier future.

A Healthier Future: Replacing Plastics in Healthcare

Introduction and Background

Project Concept

The concept for *A Healthier Future: Replacing Plastics in Healthcare,* involves building a case for healthcare leaders to take action toward combating the growing problem of plastic pollution by replacing plastics currently being used in their industry.

The project first details the scope and impacts of plastic pollution generated through healthcare delivery, and then provides current examples demonstrating solutions that have been implemented in other industries. The data and information to inform the case was obtained through research of materials libraries and conducting interviews with international materials experts and senior leaders representing various industries.

Having made the case to address this problem, the project puts forth a call to action for healthcare leaders. The call is designed as an appeal to demonstrate their commitment to ensuring the health of patients, and as a challenge to for them to seize the opportunity of leading change that will create a healthier future for all people and the planet.

Vision

The vision statement for the project was designed to influence healthcare leaders on two distinct levels, the first being a sense of responsibility for doing what is in the best interest of their patients and the second being a challenge to them, to reach for the audacious goal of creating a better future. The following is the vision statement that was put forth:

To create a healthier future in which we heal people without harming the planet

- *Replacing plastics used in healthcare with less harmful materials will:*
    - *Establish a commitment to a cleaner, healthier planet*
    - *Demonstrate to the public how the industry cares about their health*
    - *Be an impactful action to combat one of the world's most pressing environmental problems*
    - *Serve as an example that inspires others to act*

Motivation and Goals

The primary motivation behind selection of the project concept was to create a challenging opportunity for learning and growth by addressing a critical environmental issue. The challenge would also present opportunities to acquire new knowledge outside of my current field or previous experiences, and to build an expanded professional network beyond healthcare.

A secondary motivation that existed was to design the project in such a way that the final product would be portable and not have its value tied to a specific organization or industry. This principle of portability would ensure that both the execution of the project and the final product created would be free from the influence or direction of any particular organization.

Identification of an environmental issue that aligned with the project concept did not require an extensive search. Being a firsthand witness to the levels of plastic pollution generated through healthcare delivery presented a case that fulfilled the primary motive behind the project. This case also provided the means to meet the project goals of building new knowledge and an expanded professional network through working exclusively with external stakeholders that included international materials experts and senior leaders outside the healthcare industry.

Project Overview

Problem and Opportunity

The initial phase of the project consisted of identifying the problem to be addressed and the subsequent reframing of that problem as both a challenge to - and an opportunity for - healthcare executives to take leadership in the resolution of an urgent environmental issue.

The problem was identified through firsthand observation combined and research on waste being generated by the healthcare industry which revealed significant findings. These findings were used to establish the scope of the problem by detailing the extent and impacts of waste generated by healthcare delivery, much of it being single use plastics.

The research showed that in the U.S. alone, hospitals generate over six-million tons of waste annually, a quarter of that being plastics (Bryant, 2017). In taking a systems-level view of this problem to identify the broader impacts, further research revealed that some of the chemicals associated with plastic pollution contribute to adverse impacts on population health in the form of

endocrine disruption that can lead to cancers, learning difficulties, diabetes and toxicity to human reproductive systems (Neslen, A. 2017).

The opportunity revealed by these research findings is for healthcare leaders to help create a healthier future by reducing the amount of plastic waste generated in their industry. It is an opportunity to take action that will lead to a healthier environment, and in turn contribute to improved population health through reductions in exposure to toxins associated with plastic pollution (www.epa.gov). It is also an opportunity for healthcare leaders to be recognized for their success at both an organizational and industry level (www.hpoe.org).

SWOT Analysis (Strengths/Weaknesses/Opportunities/Threats)

To ensure viability of the project concept, the design included completion of a SWOT Analysis (figure 1) through which critical success factors were considered and planned for to limit the risk of disruption in project execution. The project benefitted from several areas of strength that proved to be important factors in successful execution. These strengths acted as effective offsets to identified weaknesses, were valuable in establishing timelines and deliverables, and were key to formulating risk mitigation strategies for the identified threats.

Strengths	**Weaknesses**
• Significant project leadership experience • Project designed to be portable, not dependent on resources from a specific organization or industry • Existing relationships with healthcare leaders	• Lack of materials expertise • Lack of established contacts in materials field
Opportunities	**Threats**
• Significant generation of plastic healthcare waste afforded wide range of potential solutions • Alternative materials suited for healthcare have potential for use in other industries • New relationships with materials experts and senior industry leaders presents new opportunities	• Ongoing disruption in healthcare limits opportunities to engage stakeholders • Economic pressures in healthcare limits resource availability

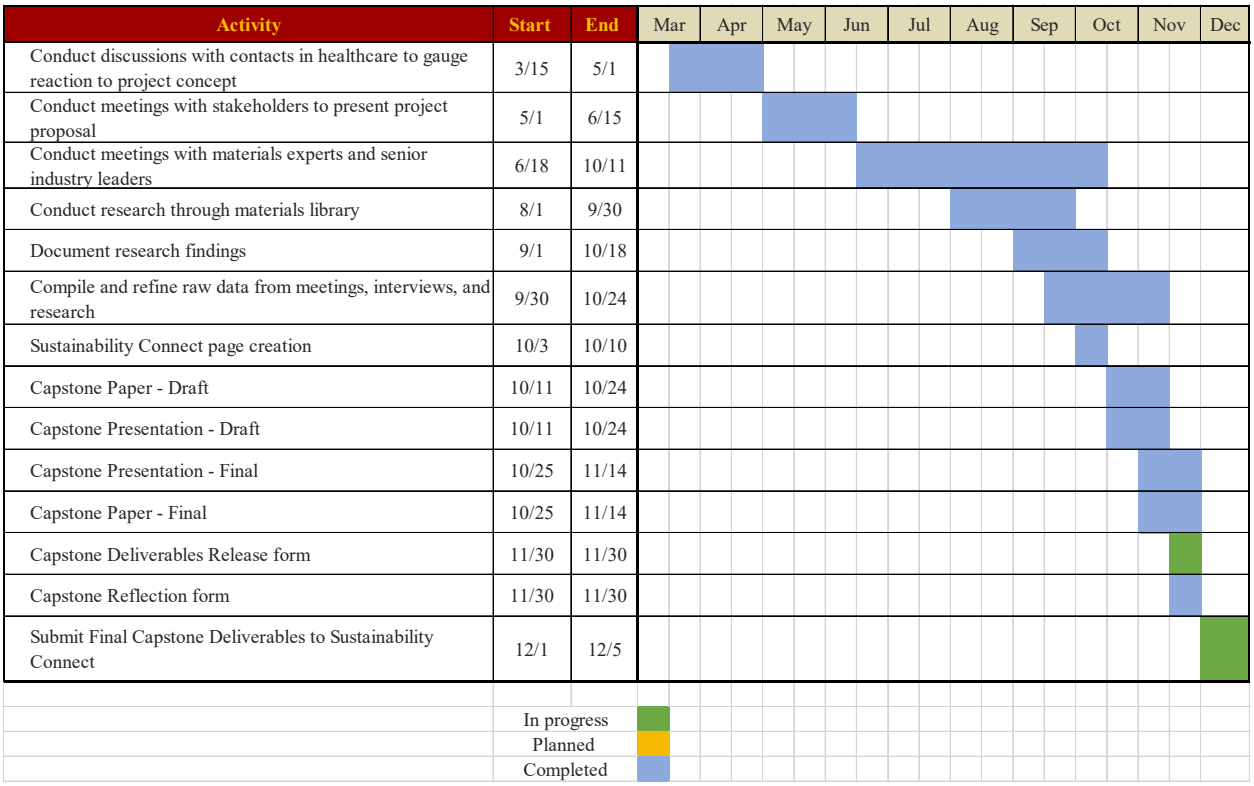
(figure 1, SOWT Analysis)

Project Execution

Project Management Plan

The project execution consistently kept pace with the established schedule and no significant delays or changes in scope were encountered. The greatest challenges occurred during the stakeholder engagement phase and involved gaining access to, and scheduling and meetings with senior level executives. This challenge had been anticipated from the start and was therefore allotted the longest duration in the project schedule as shown in the Gantt chart below (figure 2) and in Appendix 1.

The overall success achieved in execution of the project is viewed in part as the result of having a substantial body of project leadership experience to draw upon. This proved to be a valuable resource in designing the project and establishment of a plan with both realistic timelines and clearly stated deliverables. It was also beneficial in identification of risks and development of effective mitigation strategies. The full project plan is provided in Appendix 2.



(figure 2, Gantt chart)

Research Findings

The initial phase of project execution focused on completing research in two areas that were foundational to framing the problem and opportunity messaging. The first area of research documented the scope and impacts of the plastic pollution problem in healthcare. The key data points selected to present as evidence of this problem included the following:

- Of the 8.3 billion tons of plastic ever produced, 6.3 billion tons, or approximately seventy-six percent, has ended up as waste (Parker, 2018)
- Healthcare facilities in the U.S. generate approximately 14,000 tons of waste per day with an estimated 20 to 25 percent of that being plastics (hprc.org/hospitals)
- Of all plastics produced since 1950 only 9% has been recycled (Ritchie, 2018)
- For 2018, the plastic recycling rate in the U.S. declined to only 4.4% (Dell, 2019)
- A growing body of scientific evidence shows that chemicals released from plastic pollution are having adverse impacts on population health (www.who.int)
- Several chemicals released from plastic waste are known endocrine disruptors that interfere with normal hormone function and are known to cause cancers and birth defects (Royte, 2018)

Reframing of the problem as an opportunity relied in part on research that identified examples of alternative materials that are less harmful than plastics. The source chosen for this area of research was one of the world's leading materials libraries, the Material Connexion. Operating offices in the U.S., Europe, and Asia, Material Connexion houses data and samples for over 6,500 materials. Each material in the database has been extensively researched and tested. The database houses details on the material properties, potential uses, and includes information on the creators and manufacturers of each material (FINSA, 2018). Gaining access to the Material Connexion database afforded a view of both the depth and breadth of the many materials that have already been introduced to replace plastics. The research examined and documented a dozen alternative materials that are suitable for a wide range of uses in the replacement of traditional plastics. A sample list of the materials included in the research is presented below (figure 3). The complete listing of the materials researched in the Material Connexion database is presented in Appendix 3.

Material	Description	Potential Uses
BiologiQ resin	Thermoplastic starch (TPS) resin made from renewable agricultural resources such as corn, potatoes and cassava. It offers competitive cost comparable to polyethylene (PE), which is lower than similar bio-plastics on the market. The material is highly compostable and biodegradable when in contact with soil or water.	It may be processed using conventional injection molding and extrusion machines into forks, knives, spoons, plates, bags and bottles.
actiVLayr™	A new, clinically proven delivery platform for natural nutrients and treatments using nanofibers made from marine collagen, providing optimal skin care benefits. It is a patch on which a proprietary blend of fruit (kiwifruit, grape seeds) extracts and marine collagen has been immobilized in a dry, stable format with no additives, preservatives, or fragrances.	The use of bio-origin nanofibers act as a delivery platform for topical skin applications, as well as for wound dressings, drug delivery, and other healthcare applications, such as acne treatment and burn treatment.
EcoPrime™	FDA-compliant post-consumer recycled HDPE for food, beverage, drug, and medical packaging. It meets strict purity standards through a unique, patented cleaning process for the recycled material, which eliminates all contaminants without exposing the resin to any chemical treatments or processes or tough sustainability standards certain producers require to meet regulatory compliance.	Applications are for packaging of vitamins, supplements and herbal medicines, prescription pills, personal care products, frozen foods, milk, and juice. The material offers good flex modulus, impact resistance, and can be used in flexible packaging for any direct food contact application where virgin HDPE resin is currently used.

figure 3

Stakeholder Engagement

To meet one of the primary goals of making the final product portable across multiple organizations and industries, the project design focused on working exclusively with external stakeholders. Successful execution of the project was heavily dependent on engaging two

stakeholder groups and, by design, engaging them in a specific sequence. In both instances, the target audience consisted of senior level leaders because of the critical role they play in connecting others to a vision and driving change to meet audacious goals (Kouzes and Posner, 2017, p.14).

The first stakeholder group to be engaged was comprised of international materials experts who provided expertise on alternative materials and information on how to gain access to the most respected sources of data. The second group to be engaged were senior leaders from organizations that had already been successful in replacing plastics with less harmful materials. This work represented the most critical stage of the project as the knowledge and information gathered from these two groups formed the foundation of the call to action that was made in the final presentation to healthcare leaders. The work with these groups provided validation of the project concept and established credibility with healthcare leaders who respected the evidence of what had been achieved by their counterparts in other industries.

Having no existing relationships with resources in these groups required setting a bold vision and then taking the steps to realize it. These steps involved outreach efforts that included "cold calling" to establish connections with materials experts and senior leaders from organizations and industries where none had previously existed. This approach was undertaken with very real expectations around the odds of success or failure. Given the significant time demands on those in senior leadership positions, a request for their time, from an unknown graduate student, had long odds of being granted. Despite this challenge, previous experience had shown that crafting the right message would capture the interest of this audience and pay dividends, even if only a few of them were to lend their support.

The results achieved with this approach demonstrated strong leadership skills in communications, influencing, and relationship building. The key steps to success in this critical project phase entailed building an effective communications plan consisting of multiple channels including email, phone, social media, and making a significant commitment of time and resources to attend the GreenBiz 2019 conference for face-to-face networking.

Models of Success

While many recent success stories had been gathered through researching scientific and industry sources, a decision was made that the final stakeholder presentation would prominently

feature three specific examples of organizations that have successfully replaced plastics. These examples were chosen because of how they illustrated the power of innovation and taking action. These characteristics are embodied by each example in that they come from organizations that have driven meaningful impact by making changes to products that may seem insignificant. The results they have achieved and the diversity and uniqueness of their products also stimulates curiosity around what is possible. The first two examples, Kwik Lok and Yulex, were also selected as they represent the most successful stakeholder engagement outcomes that were achieved which resulted in gaining direct access to senior executives of these organizations. Another factor in choosing these examples is that the reductions in use of fossil fuels achieved by Kwik Lok and LEGO demonstrate the potential for cost savings.

Kwik Lok

Attendance at the GreenBiz 2019 conference resulted in connections being established with the incoming Chief Executive Officer of Kwik Lok, Don Carrell, and their Director of Marketing and Communications, Karen Reed. Headquartered in Yakima, Washington, Kwik Lok is the global leader in production of bag closure systems. With billions of units produced at six factories around the world, the largest volume product manufactured by Kwik Lok is one that many of us encounter nearly each day - the hard-plastic tabs used to close bags for bread and other food products. In discussions with Mr. Carrell and Ms. Reed, they expressed interest in this project and shared that their organization was in the process of exploring ways to reduce their use of plastics (Carrell, D. and Reed, K. 2019). A few months following the GreenBiz 2019 conference, under Mr. Carrell's leadership, Kwik Lok successfully replaced their largest volume product, the traditional plastic tab bag closure, with a new bio-plastic version, Eco Lok™, which is made with potato and corn starch (Reed, 2019). The organization's motivation to make this change is in keeping with their commitment that "as a company with a global footprint, we have both a responsibility to minimize our impact and an opportunity to drive meaningful change (www.kwiklok.com). In shifting to this new material Kwik Lok has already been able to reduce their fossil fuel consumption by 20% (www.kwiklok.com). The change also meant that a plastic product which took decades to biodegrade was replaced with a new material that biodegrades in only a few years.

While at first glance Kwik Lok's experience would appear to be of little importance to the healthcare industry, it was featured prominently in the final presentation to healthcare leaders as an outstanding example of what can be achieved through elimination of plastics, even those found in simple items that we come in contact with daily. The results achieved by Kwik Lok's introduction of the new Eco Lok™ were included in the presentation as they demonstrated how replacing even a small product can have a powerful impact.

Yulex

Contacting Yulex was a true "cold call" and therefore a risk to the project but one that was determined to be worth taking for the potential to gain valuable insights into their unique and innovative work. Yulex has been widely recognized for their creation of new plant-based materials to replace those created with fossil fuels and other chemicals that carry health risks and are harmful to the environment. Interest in meeting with senior leadership from Yulex to discuss their Yulex Pure™ product was directly related to its unique property of being non-allergenic and therefore of particular value in medical applications. The product is made using rubber from the indigenous Guayule plant found in the desert southwest of the U.S. and northern Mexico (www.yulex.com). This product has been proven to meet critical performance standards for many medical, industrial and consumer uses (www.yulex.com). Through a partnership with outdoor clothing and equipment manufacturer Patagonia, the product that has garnered the greatest attention has been Patagonia's new wetsuits made from Yulex Pure™ as a replacement for traditional fossil-fuel based neoprene wetsuits (Larson, 2014). The following quote from Jason McCaffrey the Director of Patagonia's Surf Division, illustrates the importance placed on this collaboration:

> "I knew that if we could somehow change this process, change the way that this material gets made, we could take the biggest step forward environmentally for the wet suit industry. But we have to prove it" (Cardwell, 2014).

In discussions with Jeff Martin, founder and Chief Executive Officer of Yulex, he noted that through their work "we have reached a tipping point where more companies are ramping up efforts to replace fossil fuel-based materials" (Martin, 2019). Mr. Martin went on to note that the motivations behind this shift have been a combination of;

recognizing the need to do the right thing, reaction to consumer pressure, and cost and performance improvements that have put plant-based materials on equal footing with many fossil fuel-based products (Martin, 2019). The Yulex example was chosen as it showed the importance of collaboration in driving innovation to replace commonly used materials but also because it provided valuable insights directly from a materials manufacturer on the current direction of the plant-based materials market.

LEGO

The privately held LEGO group headquartered in Billund, Denmark is globally recognized for their building "bricks" toys that have historically been made using hard plastics. In 2015 LEGO announced a major investment of 1 billion Danish Krone ($150 million US), to create the LEGO Sustainable Materials Center which would search to find sustainable alternatives to the plastic used in their toys and packaging (Stott, 2015). Their commitment and investment began to pay dividends in 2018 when LEGO began replacing traditional plastics in their products with a sugar cane based material (www.LEGO.com). This innovation is consistent with one of LEGO's core values to "help all of us imagine and create a better, brighter world for children to inherit" and is a major step toward their goal of making their toys out of things that "can be grown again or are recycled by 2030" (Prisco, 2018). The LEGO example illustrates not only success in replacing plastics but also the importance of a bold vision and the leadership, vision, and commitment needed to make it happen (www.LEGO.com).

Call to Action

The final phase of project execution presented the case in support of the call to action. Building this case relied upon two key elements, the first being the research findings on how plastic pollution adversely impacts population health, and the second element being the success stories from other industries that served as evidence of what has been, and can be achieved.

Understanding the motivations, or the "why" of the target audience of healthcare leaders was critical to crafting a message that would influence them to act (Estrada, 2019). This understanding came through development of an "Audience Persona" which generated key learnings that underpinned the themes of the call to action for this group (de Mesa, 2019). Prior

experience in working directly with senior healthcare leaders and consultation with a former hospital CEO revealed that their key motives included a strong sense of "doing what is best for the patient" and a desire to be recognized as leaders, both within their profession and in the eyes of the public. The connections between these motives and the project goals gave rise to the final messaging that became the project vision statement

"To create a healthier future in which we heal people without harming the planet"

This statement embodies the deep sense of responsibility for doing what is best for the patient, captures the desire to pursue new opportunities, and sets a challenging vision for the future, a future in which healthcare leaders are recognized for being at the forefront of solving a critical environmental problem. (Kotter, 2019).

Project Outcomes

The primary outcome that had been envisioned for the project is contained within this paper. As had been envisioned, the final product that has been created is a foundational white-paper on how-to drive positive environmental change by replacing plastics.

Often times the biggest hurdle in making a significant change is simply identifying where to start and answering questions like – how do we do this, what has already been done that can be leveraged, who are the experts, and why is this work important? In recounting the project journey and addressing these questions, this paper has established a starting point for the future efforts of those seeking to reduce plastic waste from any industry, not just healthcare.

Others who use this work to push further and pursue reducing the use of plastics will ultimately have to judge the value of this product. Should they find that this work falls short of answering their questions and giving them a starting point, one can still view the project as a success based on the other valuable outcomes that were achieved as detailed below.

Results Achieved

The stakeholder engagement strategy to "swing for the fences" by connecting with senior level executives carried substantial risk. While it did not pay off all cases, in some instances it

produced very valuable results, most notably the Kwik Lok and Yulex examples which were crucial to crafting the call to action and an effective presentation.

One instance where this approach did not pay off involved the attempt to secure a meeting with executives from LEGO's Corporate Responsibility team. As was the case with Yulex (detailed earlier) reaching out to LEGO was completely a "cold call" but viewed as a worthwhile effort because of the potential value it could produce. There was significant interest in meeting with this group because of how the LEGO organization has made noteworthy progress to reduce adverse environmental impacts by replacing plastics used in their products. Although attempts to coordinate a meeting eventually proved unsuccessful, a LinkedIn connection has been established with Tim Brooks, Vice President of Corporate Responsibility for LEGO.

New knowledge in an unfamiliar field was built through in-depth research that resulted in gaining access to one of the world's leading materials libraries. This research identified a dozen materials that have potential uses as plastic replacements, which represents only a very small sampling of such materials that are already available.

Substantial expansion of my professional network outside of my current field and industry was accomplished through working exclusively with external stakeholders. Networking with international materials experts and senior leaders resulted in new professional relationships including twenty-six contacts via the LinkedIn platform. Among the contacts established are several C-Suite leaders and founders of three different organizations. These new connections provide opportunities to realize a professional goal of taking a new career direction to make an impact as a sustainability leader.

While the project focused on the healthcare industry by meeting the design goals, the final product is portable and can be utilized to drive change in other industries.

Lessons Learned

Given the valuable results generated by the stakeholder engagement approach, one of the most valuable lessons learned is the importance of exploring all avenues and thinking BIG. Making significant and impactful changes doesn't happen by playing it safe and thinking small, it requires bold ideas and bold action to bring them to life!

The overall success of the project truly rested on the stakeholder engagement approach. Absent a strong plan for engagement of international materials experts and senior executives, and without effective execution of that plan, credibility of the final product would have been significantly weakened. Both the scope and quality of content would have been far more limited and thus the door opened (fairly) to scrutiny regarding the level of rigor behind the project output.

The most important lesson learned is that when pursuing this type of project, one must fully invest themselves in the work. You are not simply writing a paper – you are driving change - and success or failure will depend on what you as the owner and champion put into it.

The Next Journey

Near the conclusion of my project a newly published article caught my attention and provided confirmation that I had been traveling the right route on this journey. In one section of the article, *Can Medical Care Exist Without Plastic Waste,* the author details the "recycling nightmare" related to plastic medical waste (Gibbens, 2019). Statistics that I have cited in this paper note that less than 10% of all plastics ever produced have been recycled (Ritchie, 2018). These dismal recycling results are part of what prompted Cyrill Gutsch, founder of Parley for the Oceans, to note that "plastic pollution is a design failure" (www.parley.tv). Clearly solutions other than recycling are needed. As Yulex CEO Jeff Martin, noted in my interview with him "the tide is turning" and as presented in this paper, a wide range of new materials are already available for replacing plastics (Martin, 2019).

Having reached the completion of this journey, I find myself considering what other paths beyond the scope of this project that are yet to be explored? Paths like - partnering with designers and manufacturers to create prototype products for testing in healthcare, working with materials experts to promote alternative materials, and examining opportunities to reduce plastic pollution in other industries. The completed project has set the stage for carrying the work forward to organizations seeking to do less harm but unsure of how to begin. The examples of Kwik Lok, Yulex, and LEGO cited in this paper demonstrate how meaningful change can be driven through seemingly insignificant products like bread-bag tabs, wetsuits, and children's toys. The factors noted in the preceding paragraph indicate that *now* is the opportune time to embark on the next journey – who's ready to come along?

Conclusion

In conclusion, the case has been made that a significant opportunity exists for leaders in healthcare, and other industries as well, to reduce their environmental impact by replacing traditional plastics with less harmful materials. Given the examples detailed in this paper, one would recommend that leaders consult with their counterparts in other organizations and across industries to learn from the successes and failures and to explore potential partnerships that can benefit not only their organizations but all of humankind. Taking such action has the potential to yield not only financial benefits but can also improve the health of the planet by ensuring that fewer toxic chemicals are released into the environment. Or in other words – the project has successfully created a path that can be followed by others in pursuit of the triple bottom line - People, Planet, and Profit.

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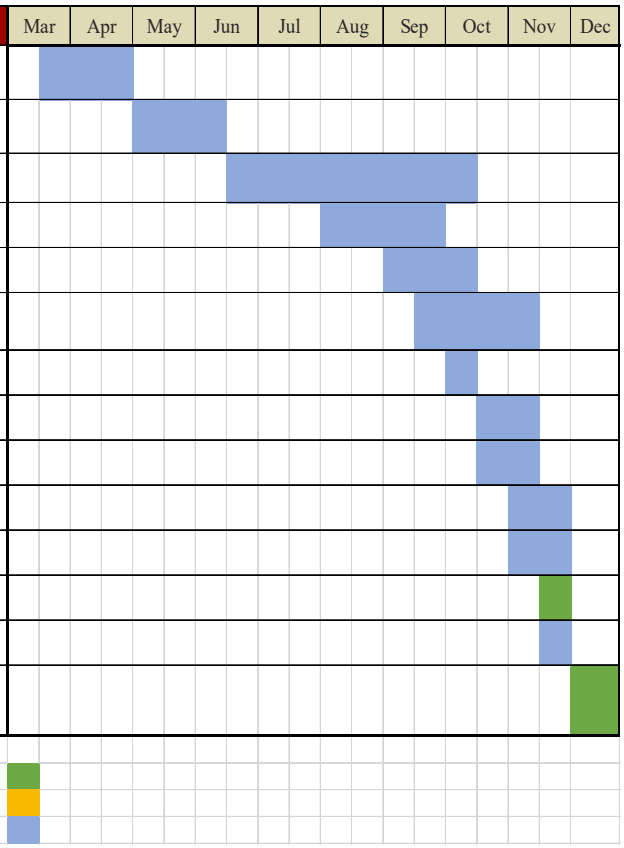
Appendices

Appendix – 1: Gantt Chart

Activity	Start	End
Conduct discussions with contacts in healthcare to gauge reaction to project concept	3/15	5/1
Conduct meetings with stakeholders to present project proposal	5/1	6/15
Conduct meetings with materials experts and senior industry leaders	6/18	10/11
Conduct research through materials library	8/1	9/30
Document research findings	9/1	10/18
Compile and refine raw data from meetings, interviews, and research	9/30	10/24
Sustainability Connect page creation	10/3	10/10
Capstone Paper - Draft	10/11	10/24
Capstone Presentation - Draft	10/11	10/24
Capstone Presentation - Final	10/25	11/14
Capstone Paper - Final	10/25	11/14
Capstone Deliverables Release form	11/30	11/30
Capstone Reflection form	11/30	11/30
Submit Final Capstone Deliverables to Sustainability Connect	12/1	12/5



Appendix – 2: Project Plan

A Healthier Future: Replacing Plastics In Healthcare				updated	18-Nov-19
#	Activity	Start	End	Status	Comments
100	**Project Feasibility**				
101	Conduct discussions with contacts in healthcare to gauge reaction to project concept	3/15	5/1	Complete	
102	Conduct meetings with stakeholders to deliver project presentation	5/1	6/15	Complete	
200	**Materials Research**				
201	Conduct meetings with materials experts (Kelly Wilcox, ASU and Reebok)	7/10	7/10	Complete	
202	Conduct meetings with materials experts (Fiona Anitas, Hyloh)	6/18	6/18	Complete	
203	Conduct meetings with materials experts (Joseph Pugar, Aruga Technologies)	6/26	6/26	Complete	
204	Conduct meetings with materials experts (Catherine Sheehy, UL Environment)	7/11	7/11	Complete	
205	Meet with materials experts to conduct research	8/26	9/30	Complete	
206	Conduct meetings with materials experts (J. Martin, Yulex)	8/22	10/18	Complete	9/17 - Conducted call with J. Martin on 9/17, have been working to find time for follow-up
207	Conduct meetings with materials experts (B. Gherasim, and T. Brooks, LEGO)	8/27	10/18	Complete	9/27 - After initial email exchange, have been unable to secure time for meeting/call
208	Conduct follow-up meeting with materials experts (K. Wilcox, Reebok)	8/27	10/18	Complete	10/24 - Face-face meeting w/K. Wilcox
209	Conduct meetings with materials experts (K. Reed, Kwik Lok)	9/20	10/11	Complete	10/24 - Conducted phone meeting w/Karen Reed, Marketing and Communications Director at Kwik-Lok
210	Communicate with materials library experts (Materials Connexion) and gain access to library/database	9/9	9/12	Complete	
211	Utilize access to Material Connexion library/database to investigate new materials	9/13	10/18	Complete	
212	Follow-up meetings with materials experts and initial meetings with any new leads generated	9/13	10/18	Complete	
300	**Document Research Findings**				
301	Document findings - compile and refine raw data from meetings, interviews, and research	9/1	10/20	Complete	
302	Conduct coaching call with Dr. Behravesh	9/30	9/30	Complete	
400	**Capstone Deliverables - Draft**				
401	Sustainability Connect page creation	10/3	10/10	Complete	
402	Capstone Paper - Draft	10/11	10/24	Complete	
403	Capstone Presentation Outline - Draft	10/11	10/24	Complete	
500	**Capstone Deliverables - Final**				
501	Capstone Presentation - Final	10/25	11/14	Complete	
502	Capstone Presentation - Final	10/25	11/14	Complete	
503	Capstone Deliverables Release form	11/21	11/28	In progress	
504	Capstone Reflection form	11/21	11/28	Complete	
505	Submit Capstone Deliverables to Sustainability Connect	11/28	12/4	In progress	
		In progress			
		At Risk			
		Past Due			
		Completed			

Appendix – 3: Alternative Materials Listing

Source: Material Connexion, (www.connectionsbyfinsa.com)

Material Name	Description	Potential Uses
Bio-Granulate	A patent-pending bio-resin developed as an alternative for conventional petroleum-based resins. With a bio-sourced content of over 95%, the biopolyester resin is based on starch. What makes this resin different from other bio-based resins is the strength properties achieved in the final product. The final product is 100% certified biodegradable if exposed to certain bacteria strains found in nature.	Used as a suitable alternative to traditional crude-oil resins, the material can be applied to furniture and the plastic packaging industry.
BiologiQ resin	Thermoplastic starch (TPS) resin made from renewable agricultural resources such as corn, potatoes and cassava. It offers competitive cost comparable to polyethylene (PE), which is lower than similar bio-plastics on the market. Material is highly compostable and biodegradable when in contact with soil or water.	It may be processed using conventional injection molding and extrusion machines into forks, knives, spoons, plates, bags and bottles.
Eastman TREVA™ Engineering Bioplastic	A new, cellulose-based engineering bioplastic with up to 45% renewable carbon that offers both high performance and reduced environmental impact for demanding applications with high-sustainability requirements. It is made of cellulose derived from trees from sustainably managed forests. The material has USDA Bio-Preferred status while offering a cost-competitive alternative to non-bio-based engineering thermoplastics that chemically outperforms traditional polymers, including PC, ABS, and PC/ABS blends.	It can sustain some of the harshest chemicals, including skin oils, sunscreens, and household cleaners, and offers ease of decoration and secondary processing, making it suitable for applications that require durability and come in direct contact with skin. Applications include complex and intricate parts, eyeglass frames, wearable devices and headphones, cosmetics, display components (lenses and covers), and electronic housings and cases.
EcoPrime™	FDA-compliant post-consumer recycled HDPE for food, beverage, drug, and medical packaging. Meets strict purity standards through unique patented cleaning process for recycled material which eliminates all contaminants without exposing resin to any chemical treatments, processes, sustainability standards certain producers require or regulatory compliance.	Applications are for packaging of vitamins, supplements and herbal medicines, prescription pills, personal care products, frozen foods, milk, and juice. The material offers good flex modulus, impact resistance, and can be used in flexible packaging for any direct food contact application where virgin HDPE resin is currently used.
Lolistraw	World's first edible, 'hypercompostable' straw that offers sustainable alternative to never-recycled plastic straws. Made from patent-pending, seaweed-based edible bioplastic technology is 100% marine-degradable, non-gmo, and plastic-free. Goal is to replace the 500M plastic straws used and discarded every day in US. Unlike corn-based bioplastics such as PLA, which actually contribute to the ocean pollution crisis and are often considered "contaminants" in composting facilities.	Looks and functions just like plastic straw but designed to biodegrade at same rate as food waste (60 days or less). Can also be infused with flavor or nutritional benefit. Applications are coffee shops, fast casual restaurants, theme parks, stadiums, other high-waste venues.
Mater-Bi	Range of biodegradable and compostable bioplastics made from renewable resources which provide low environmental impact solution and solve specific environmental problems in different sectors such as catering packaging and separate organic waste collection. Made from renewable resources such as cornstarch and vegetable oils from oil crops. Plant components are various kinds (cellulose, glycerin, oils, natural fillers and non-genetically-modified starch obtained from various crops) all extracted from crops that do not exploit virgin or deforested land.	These bio-plastics can be processed for film and sheet extrusion, injection molding, foaming, thermoforming, paper lamination, and packaging in different sectors, such as catering, packaging and separate organic waste collection.
NeCycle	A moldable bio-based plastic resin that uses cellulose as a main component and can produce high perceived-quality surfaces.	Applications include parts for automotive, communication, fashion, furniture, industrial/product design, interior products, jewelry/art, packaging, and stationery.
Nuatan	A compostable bioplastic made of corn starch, sugar, and used cooking oil that is ready for mass consumption. Can withstand temperatures of over 212 °F (100 °C) without losing integrity and has a lifespan of up to 15 years.	Can replace all single-use plastic products such as water bottles, carrier bags, and drinking straws. When no longer in use and discarded into compost, would decompose in 90 days. Can be applied to products in larger dimensions such as tables and chairs. Applications include anything made of plastic except for those with most demanding requirements such as exterior parts of cars.
PLA	Bio-polymer resin from corn that offers improved performance compared to standard PLA resins. PLA is a widely used bio-based injection molding and extrusion-grade polymer that is available in either D or L types, dependent upon how it is manufactured. This producer is currently the only supplier of pure D-PLA.	They can be pigmented any color but cannot be produced in clear versions. Applications are for disposable food packaging (Nespresso capsules), fracking aids and other industrial uses.
PLA (polylactide) bottles	Bottle made entirely from industrial compostable polylactide (PLA) with bio-polyethylene (PE) top. The PLA material is made from 100% natural resources including plant and lactic acid. Offers suitable alternative to avoid using oil- and plastic-derived materials. Bottle is 10x cheaper and 20x lighter than glass and impact resistant. Bottle looks like standard PET bottle and can be manufactured in different shapes and sizes. Life of bottle is also same as standard PET bottle, as long as it does not come into contact with microorganisms that would degrade it. After approximately 9 days in a composting facility, the bottle starts to break down.	Common applications include beverage bottles for fresh fruit juice, smoothies, and dairy products.
reCUP™ with EarthCoating®	Highly-mineralized resin barrier coating engineered to address sustainability challenges in packaging. Unlike traditional paper cups produced from polyethylene-coated paper cup stock that is difficult for recyclers to process, the paper uses EarthCoating® barrier technology to permit processing through existing paper recycling streams without need for special handling or additional equipment. Affordable solution that performs as well as a traditional paper cup and can be manufactured with same processes and equipment as traditional cups.	Applications include recyclable to-go cups for coffee found in cafes and on airlines.
actiVLayr™	A new, clinically proven delivery platform for natural nutrients and treatments using nanofibers made from marine collagen, providing optimal skin care benefits. It is a patch on which a proprietary blend of fruit (kiwifruit, grape seeds) extracts and marine collagen has been immobilized in a dry, stable format with no additives, preservatives, or fragrances.	The use of bio-origin nanofibers act as a delivery platform for topical skin applications, as well as for wound dressings, drug delivery, and other healthcare applications, such as acne treatment and burn treatment.