Applications of E-waste in First Aid Services in Ghana

Christopher Harvill, Gabrielle Paquette, Catherine Stevenson, Christina Tsillas
Interactive Qualifying Project, Worcester Polytechnic Institute
Advisors: Robert Krueger, Fofana Mustapha, Hermine Vedogbeton

Introduction

After an accident in the global north, patients are given the option to go to the hospital in an ambulance or through their own means of transportation. In cases of serious injury, ambulance transport is often preferred as trained medical professionals can provide stabilizing pre-hospital care and quick transport to the nearest hospital. In many parts of the world, emergency and ambulance services are taken for granted because people have the comfort of knowing that trained professionals will always be able to provide medical service to them and have the means to call for it when it is needed. Despite these resources, according to the World Health Organization, road traffic accidents are the 8th leading cause of death globally, which highlights the need for strong emergency medical services (World Bank, 2021).

In other parts of the world, emergency medical services are not the quickest and most accessible option. Specifically, Sub-Saharan Africa (SSA) is home to nearly 20% of the world's population, yet only a small percentage of this group has access to EMS response, resulting in road traffic accidents being the 10th leading cause of death in SSA. Furthermore, Africa is the continent with the highest rate of road traffic deaths, resulting in 26.6 deaths per 100,000 people (World Bank, 2021). These shocking statistics were born from a multitude of issues that have affected emergency services in Africa for years. Firstly, rapid development in cities led to the building of numerous informal settlements–unauthorized, illegal, or non-compliant areas which resulted in undeclared address systems with homes that people didn't know how to find. Secondly, poor traffic conditions, such as congested and dangerous areas, in many major African cities make it nearly impossible for ambulances and other emergency vehicles to navigate through the seas of taxis and people that populate these areas. As a result, the World Health Organization lays out five areas in which serious acknowledgments and changes are needed. These areas are safer and more mobile roads, the management of said roads, safer vehicles, safer users of these vehicles, and post-crash responses (World Bank, 2021). However, previous efforts that have been made have fallen short in addressing these issues, perpetuating the enormity of road traffic deaths in Sub-Saharan Africa.

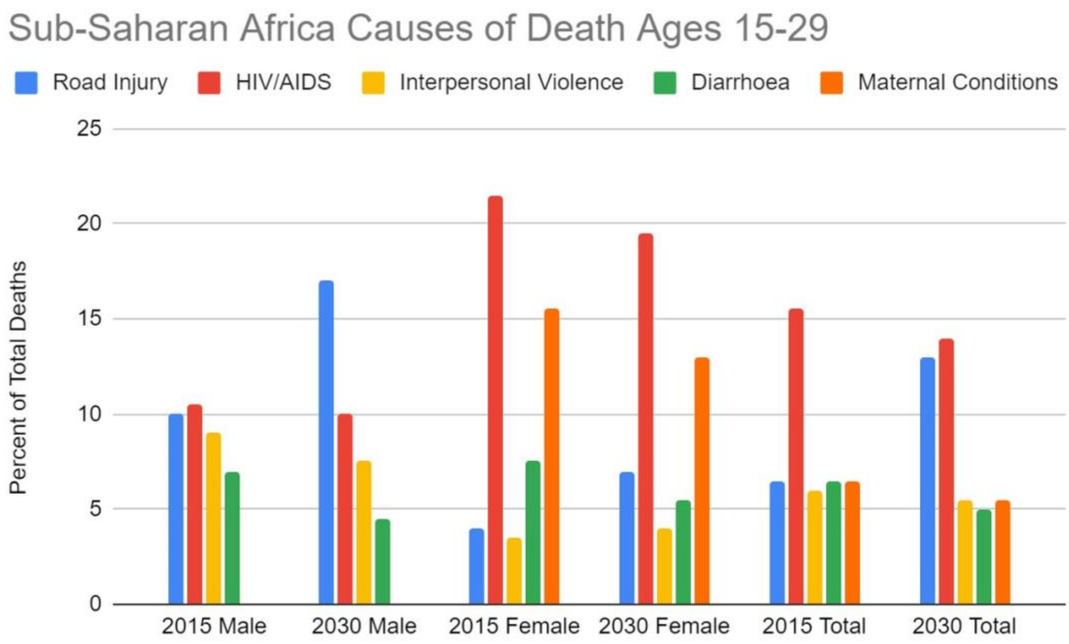

Figure 1. Causes of death in Sub-Saharan Africa (World Bank, 2021).
Figure 1 outlines the leading causes of death in Sub-Saharan Africa, with road traffic injuries being displayed in blue.

In Ghana specifically, these issues regarding road traffic deaths persist, mostly due to internal problems with the National Ambulance Service (NAS). The NAS responds to the access number 112 when called in by citizens. However, in 2014, less than 50% of the population knew that a public access number existed (National Ambulance Service, 2020). When callers do use the public access number, they risk facing being turned away due to an ambulance and staff shortage. 62.9% of respondents in a 468-participant survey felt the number of ambulances in Accra, Ghana, specifically, was insufficient. As of 2013, each of the 10 regional cities in Ghana had 1 active ambulance station and several ambulances with trained staff. Accra, the capital of Ghana, had 8 ambulances and 100 EMTs for a population of 2 million (Barriers to Accessing Emergency Medical Services in Accra, Ghana, 2015). Another limitation to NAS usage is that within the population that is aware of EMS options, 78% of people believed in Accra, a taxi was a faster means of hospital transportation. In 2013, the average response time for an ambulance was 17 minutes, which is over double the internationally accepted response time of 8 minutes (Emergency Response Time and Pre-Hospital Trauma Survival Rate of the National Ambulance Service, of the Greater Accra, 2019). Ambulances must navigate unmarked streets, poor directions to scenes, inaccessible roads, and heavy traffic congestions where there is public disrespect for ambulance sirens. Thus, Ghanaians must choose between access to fast transport and potentially life-saving pre-hospital care. This project supports the belief that if patients in Ghana had access to both quick transport and basic life support (BLS), patients with trauma-induced mechanisms of injury (MOI) would be faced with better patient outcomes late on.

These factors converge to force people in need of medical attention to find ambulance alternatives. One example is the taxi. According to medical professional respondents in a study completed by Robert Krueger and Julian Bennett, 90% of all people who came into their hospitals took a taxi or Tro Tro, not an ambulance (Development of a Barometer for Measuring Perceptions of Public Safety in sub-Saharan Africa: A feasibility study from Ghana, 2021). Taxis are frequent in Ghana and can navigate poor road conditions easily and without the need for detailed instructions. This project operates on the premise that if taxi drivers could provide BLS interventions to patients, patients would not have to sacrifice pre-hospital care for timely transport. With both medical support and a quick response time, patient outcomes are believed to improve.

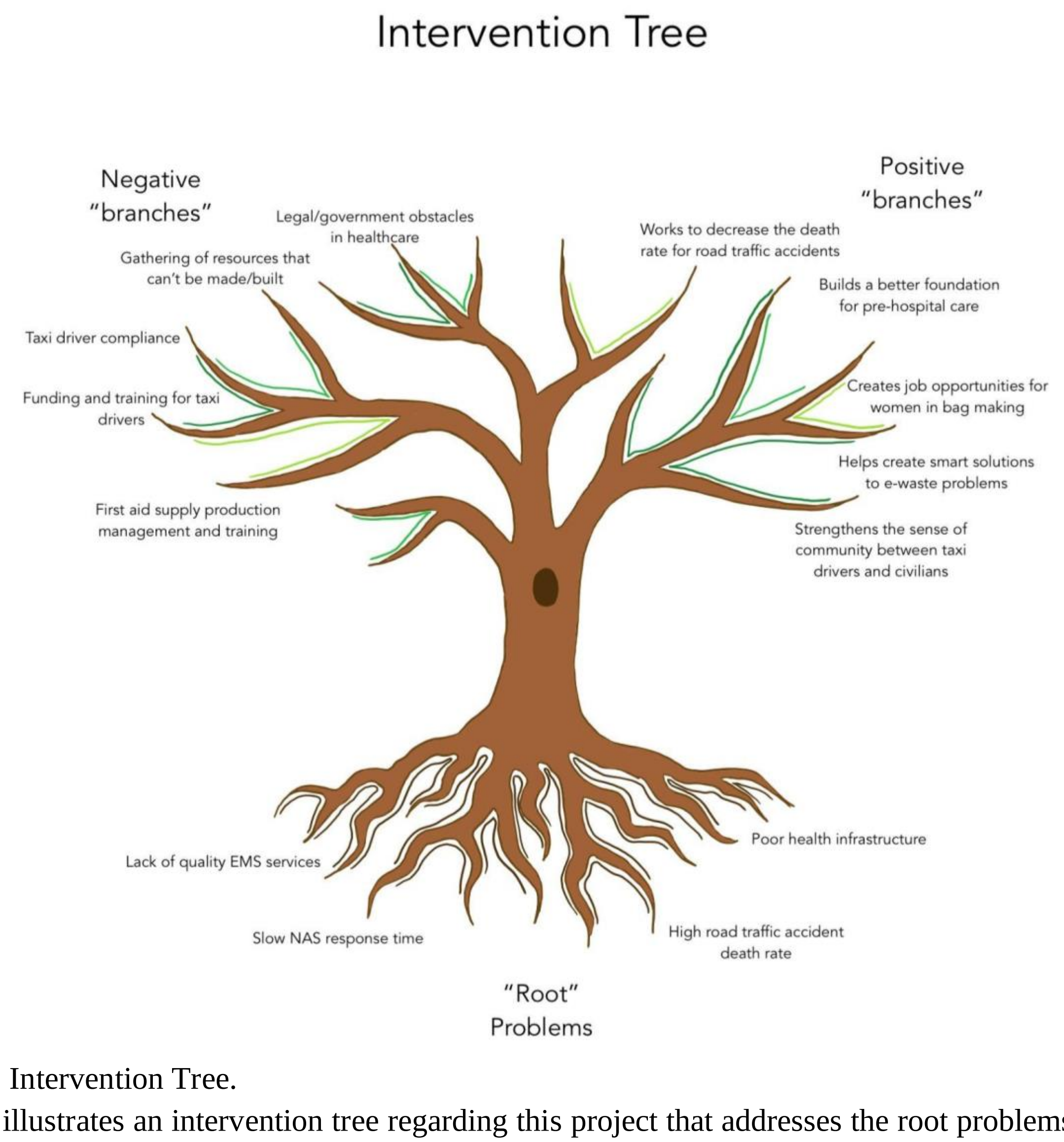

Figure 2. Intervention Tree.

Figure 2 illustrates an intervention tree regarding this project that addresses the root problems and reasons behind it, as well as the positive and negative factors to consider during the co-design process.

This project proposes the co-designing of a jump bag out of E-waste materials, and the informational resources needed to reproduce said bag that could be implemented in taxis in Ghana and used as a first-aid resource to assist with pre-hospital care. Examples of basic life-support interventions that could be present in the jump bag include - though are not limited to - splinting, bandaging, and non-invasive airway management. In addition to the physical prototype jump bag, a step-by-step explanation with photos was created on how to recreate each tool that was present in the bag along with specific information about the tools and materials used to produce them. Not only is the goal of this project to create the jump bag, but also to meet people where they are, and empower taxi drivers to become triage providers. Thus, the best way to accomplish this and assist the Ghanaian taxi drivers is to offer basic, potentially lifesaving, medical devices, and instructions on how to create them out of E-waste. This project focuses on the former—co-designing the kit and developing instructions for scaling up the manufacture of these kits.

During the proposed co-design process, it was essential to include end-users in the design of this first aid product to avoid unintended misuse and abuse of the designed product once it is produced. For this product to be of use, taxi drivers must be willing and able to provide pre-hospital care before transport to ensure that it is being used to its full potential. The potential interventions described in any training manual also must concur with all health protocols that exist locally or nationally in Ghana (Metamotivational knowledge of the role of high-level and low-level construal in goal-relevant task performance, 2019). However, since private ambulance sectors are unregulated, these legal issues might not come into play, and the co-designed product could be used privately.

This chapter continues to describe how information was gathered from literature and internet resources, medical/government officials in Ghana as well as in the United States and used in preparation for the co-design process with students from Academic City University College in Haatso, Ghana. The chapter also outlines the medical sector issues that this project targets, how and why the jump bag was designed and what materials it encompasses, and how future implementations can help continue the development of Ghanaian pre-hospital care and a generatively just smart village.

Background/Literature Review

In Ghana, the EMS system is rather different than it is experienced in the global North. Known as NAS, or the National Ambulance Service, is one of the best public EMS operations in Ghana used for prehospital care, transport, and large event detailing that is funded by the government. However, it falls behind the national standards of many countries in the global North when it comes to the services it provides and the time it takes to provide them. With this service in Ghana being so expensive, it is hard to provide access to medical and human resources, which results in response to only about 10,000 national calls annually, while some EMS companies in the United States respond to over 6,000 monthly. Once a call is received, teams in Ghana had a response time of about 20 minutes in 2009, and 17 minutes in 2013, as compared to the United States international response time average of 8 minutes, and an average of 6 minutes in Worcester, Massachusetts specifically (Emergency Response Time and Pre-Hospital Trauma Survival Rate of the National Ambulance Service, of the Greater Accra, 2019). These lengthy response times are generally due to treacherous travel conditions where only 13% of roads in Ghana are paved, along with congested urban roads, bad directions, inaccessible sites, and overall disrespect for the sound of emergency sirens. Because of this, the Ghanaian government often suggests finding a backup plan in case of emergency due to the probability that help won't make it to the scene. Furthermore, in a study conducted by Professor Robert Krueger and Julian Bennett for measuring perceptions of public safety in sub-Saharan Africa, Ghanaian medical professionals in their research observed that the majority, about 90% of people in their experience, arrived at the emergency room via taxi, or taxi-vans, known as Tro Tros (Development of a Barometer for Measuring Perceptions of Public Safety in sub-Saharan Africa: A feasibility study from Ghana, 2021). Officials in their study also noted that many of the deaths caused by the traffic accidents seen in Ghana could be prevented with simple yet life-saving interventions, which paves the way for the first aid jump bag proposed in this project.

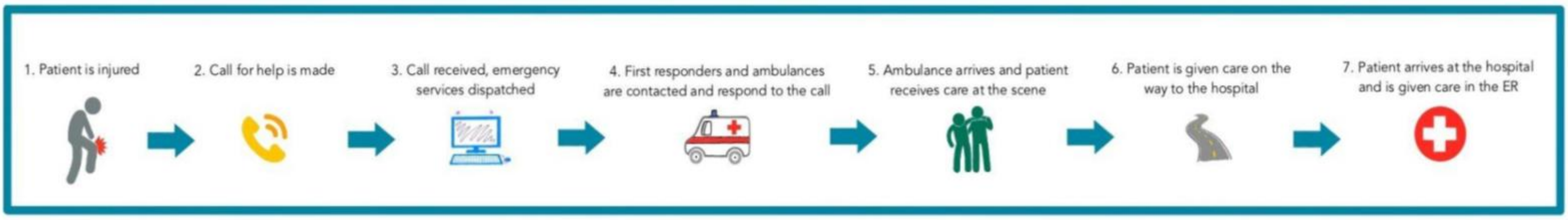

Figure 3. The 7 Steps to Pre-Hospital and Emergency Care.
Figure 3 illustrates the seven elements of emergency care and the order in which they occur. This project specifically targets steps 4-6 with the proposed taxi first aid service and jump bag.

When traffic accidents occur, they can result in many injuries that are life-threatening to the drivers and passengers of the cars, as well as pedestrians in the streets. Road traffic accidents are the 8th leading cause of death globally (World Bank, 2021). The most common trauma-related injuries are lacerations, broken bones, head, and spinal fractures, internal bleeding, and deglovement (Community Causes of Death in the Central Region of Ghana, the Missing Piece in Mortality Data, 2020). In general, the accidents leading to these injuries are caused by faulty vehicles, unskilled drivers, carelessness of road users, and overall speeding. To help deal with life-threatening traffic injuries such as the ones listed above, certain supplies and materials are needed to combat the pain and issues that result. For instance, to deal with deep lacerations, sterile gauze, or cloth as well as medical tape are needed to stop or control blood flow while preventing infection and keeping the area clean. For broken bones, a type of splint or cast is needed to keep the bone stable and in place to prevent further injury. In many cases, the displaced or broken bone needs to be put back into place before a splint or cast is used to ensure that the bone heals in the correct way. To help analyze head and spinal injuries, a small flashlight, such as the light on a phone, can be used to check the patient's pupils, and sterile cloth and linen can be used to check for blood or yellow spinal fluid coming from the head. Lastly, to help with all injuries, trauma scissors for cutting clothes and materials are necessary, as well as a tourniquet to help with blood flow from wounds, and a sterile or salt cleaning solution.

In an interview with Shannon Harvill, ER nurse at Saint Francis hospital's level one trauma center in Hartford, Connecticut, information was gathered about common accidents that enter the emergency room, and the materials and tools used to combat these issues. Shannon detailed that most car crash victims she tends to in the ER come in with blunt trauma, head and neck injuries, cuts and open wounds, and impalements. Shannon recalled that the supplies she uses most often are tourniquets, bandages, gauze and wound dressings, and splints. Shannon also explained how these injuries could be dealt with regarding pre-hospital care, specifically the idea of the golden hour for trauma. If these injuries are dealt with, or the patient is cared for in some fashion within one hour of the accident, the likelihood of survival increases significantly. Similarly, the World Health Organization Executive board explained that the improvement of organization and planning in trauma and emergency care services can greatly affect public health in this context. For instance, the board detailed those high-income countries that have made changes in their services have seen survival gains of between 8% and 50%. Even an 8% reduction in mortality saves about 400,000 lives annually (World Bank, 2021). If this was applied in conjunction with the golden hour of trauma in Sub-Saharan African countries such as Ghana, implications of life-saving changes, such as the jump bag, at a quicker rate could save hundreds of thousands of lives a year when these solutions are targeted in low-income situations.

The reasoning behind a jump bag is for easy storage, usage, and transport of materials and tools for basic life support. With a jump bag, unlike a typical fully stocked ambulance, this bag can be easily removed from the taxi and brought to the scene of an accident. This provides the caretaker with the ability to easily treat and move a patient from a hard-to-reach place that may not be accessible with a car. The other added benefit of a jump bag such as this relates to the limited space available within a Ghanaian taxi. Most taxi drivers in Ghana utilize either a Hyundai i10 or a Toyota Corolla. These cars have limited trunk space with only 361 and 252 liters of space respectively. This available space within the taxis is likely to be taken up by the personal effects of either the drivers or passengers of the taxi. With the goal of this project being the eventual adoption of this jump bag within taxis across Accra and eventually all of Ghana, ensuring that it can be used within the minimal amount of space is key.

While the size of this jump bag is important, so are the contents of the bag. To address the common injuries that we expect to see in Accra, this bag will look like jump bags that may be utilized in ambulances within the US. The current standard for bags such as these within Massachusetts is to include equipment such as gauze, a large selection of bandages, adhesive tape, medical scissors, cold packs, splints, sterile saline solution, as well as an array of diagnostic equipment such as stethoscopes and blood pressure cuffs. Although this equipment may be utilized in jump bags in the US, the goal of this project is to focus on basic medical supplies to combat road traffic injuries that uncertified taxi drivers or residents can use.

Information about the plausibility of the bag and any components being overlooked were discussed in an interview with the Ghanaian Ambassador, Baffour Adjei Bawuah. The Ambassador's initial thoughts were that the concept of the jump bag would be very helpful and many taxi and Tro Tro drivers would be very interested in assisting to implement these throughout Ghana. People do genuinely want to assist in emergencies but do not know how and by the time an ambulance arrives the patient is in serious condition. In an anecdote, the Ambassador shared that a relative of his was in an accident on the highway between two of the major cities in Ghana. He said if there was at least one person who was either involved in the accident or driving by who knew how to help in an emergency, his relative would have likely made it to the hospital and survived. The implementation of a jump bag in taxis would make residents and visitors feel valued because they know there are others on the road who know how to help in emergency situations.

The Ambassador provided specific suggestions on how the project could be improved to better meet the needs of patients with injuries from traffic accidents. The primary difficulty was that most taxi and Tro Tro drivers cannot read or write and have no training on how to assist in emergency situations or use basic first aid supplies. Supplementing the jump bag with a mandatory orientation or training video would not only teach drivers but could be available to other residents who are interested in learning how to help in emergency situations but don't want to go through the long, official National Ambulance Service training. Another consideration the Ambassador mentioned was that the bag itself would need to be made of a material that can take a lot of punishment as it will be handled by many people and potentially thrown around during an emergency. Materials such as nylon or recycled polyester that are lightweight and have high compressive strength with abrasion and wear resistance should be considered for the bag itself.

Additional suggestions pertained to the items in the bag, a name for the bag, and an avenue for saying thank you to the taxi and Tro Tro drivers who stop to help in emergency situations. The Ambassador recommended, in addition to basic first aid supplies such as bandages, splints, and tourniquets, to include general medications such as pain killers and a gadget to tell blood type. Both these additions would further increase the likelihood of survival from road traffic accidents but would be more difficult to include in the bag as access to medication is uncertain and a gadget to tell blood type would involve ABO typing and complex medical equipment. The Ambassador thought a "fancy" or "sexy" name for the bag would make it more appealing to drivers as they would think it would be "cool" to have it in their vehicle. Furthermore, the Ambassador thought that determining an avenue to thank the drivers who use the bag to help others would be a nice way to show appreciation and further increase interest in using the bag.

Concerns the Ambassador addressed about the bag were finding funding for the drivers who use the bag and whether the drivers would be interested in using the bag and stopping to help in emergency situations. The Ambassador was confident that drivers would not need to be paid as passengers in their vehicles are already being charged and passengers inside and out are already their responsibility. Although there is the concern that taxi and Tro Tro drivers might not want to participate in this project, the Ambassador was positive that everyone would want to help. He said that many people have the mindset that "whatever support you give, is the support you would expect to receive". In this case, there should be no concern about lack of interest in implementing the jump bag.

Students Abbam Nii Laitei, Timothy Keketi Wordu, and Adamu S. Doumbi from the Academic City University College in Haatso, Ghana were contacted as a resource on the ground in Ghana. Working with them as partners, the co-design process was implemented through group meetings, mutual decisions/conversations, and a proposed group effort regarding the overall jump bag project.

Methods and Materials

The methodology outlined to complete this project and develop a pre-hospital care jump bag are as follows:

1. Research current Ghanaian emergency medical service and understand the perspective of the issue through interviews with key stakeholders such as the Ghanaian Ambassador, medical professionals, taxi drivers, and residents of Accra, Ghana.

2. Finalize the concept of the jump bag and determine the contents that taxi drivers can legally use that will provide pre-hospital care from road accidents.

3. Obtain materials from E-waste sites to create the contents of the jump bag along with the bag itself.

4. Design prototypes of the jump bag contents using the gathered materials. While designing, outline step-by-step how each item was made, and which materials and tools were used to make it. Additionally, re-create the items using different materials and tools.

5. Obtain feedback from previously interviewed stakeholders and adjust the contents of the jump bag to create the most impactful product.

6. Finalize deliverable with jump bag prototype and instructions for presentation and reproduction.

After examining the current emergency medical service in Ghana, researching common injuries acquired from road accidents, and interviewing key stakeholders, as described above, the contents of the jump bag were determined, and materials were collected. The contents of the jump bag were finalized and a list of potential materials to re-create these items along with the bag itself were obtained from E-waste sites like that at Agbogbloshie in Ghana. Agbogbloshie is the largest E-waste site in the world and is located near the center of Accra, the capital and largest city of Ghana. E-waste was chosen as the main source of materials because it is easily accessible in Ghana, low-cost, and encompasses a wide variety of necessary parts such as metal, wires, plastics, and more. Also, using E-waste as the main source of materials helps to combat the health and environmental issues that come with the Agbogbloshie site.

Figure 4. Methodology.
Figure 4. Displays a visual of the step-by-step methods used in the overall project scheme.

Contents of the Jump Bag

- Tourniquet
- Stretcher/Mini-Ked
- SAM Splint/Functional Cervical Collar
- Suction Unit
- Finger Splint
- Biohazard Bag
- Pen
- Shears
- Gloves
- Triangle Bandages
- Assorted Bandages
- Bandages to Secure Impaled Objects

Of the above list materials, those that can be reproduced using E-waste are the tourniquet, SAM splint/functional cervical collar, suction unit, and finger splint. The rest of the materials were researched and the cost to include each was considered in the project budget. Prior to attending the E-waste sites in Worcester, Massachusetts, the materials originally considered for the project were those such as electronics, metal, cloth, and wires.

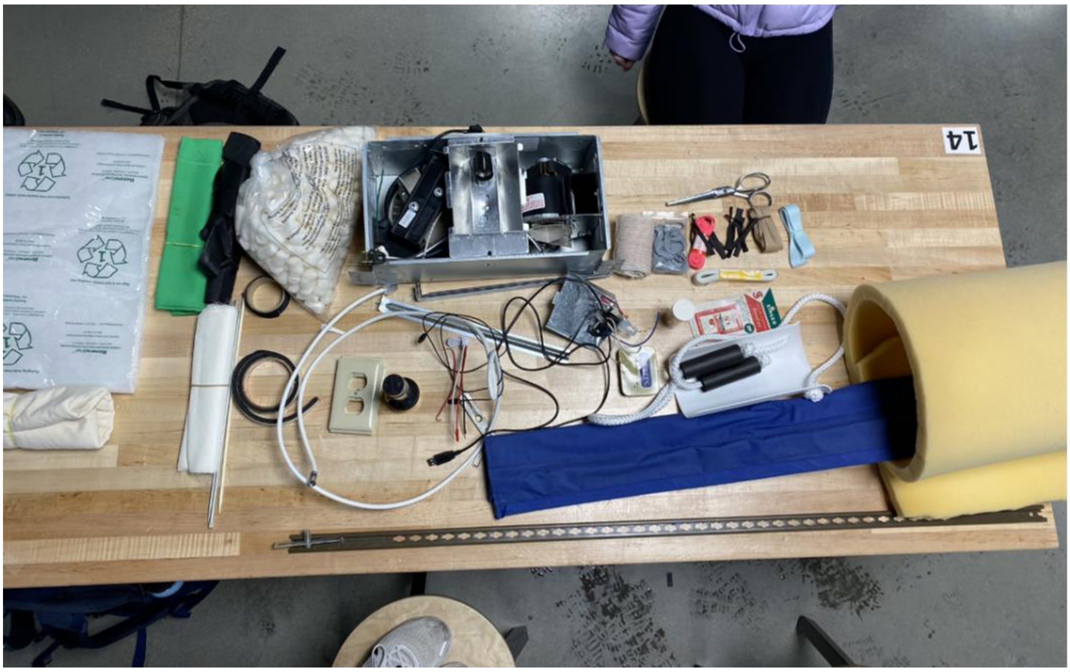

Figure 5. Materials.
Figure 5. Materials from the Wachusett Watershed Recycling Center, West Boylston, MA

The materials pictured in Figure 2 were gathered from the Wachusett Watershed Recycling Center. The materials include foam padding, copper wires, shoelaces and rope, safety pins, packing peanuts, a wall outlet, a metal fan section of an engine, scissors, cloth, miscellaneous metal parts, etc. All these materials were free from the site.

Figure 6. Computer Parts.
Figure 6. Computer parts from Responsible Electronics Recycling Center in Worcester, MA

The computer parts pictured in Figure 3 are an example of the types of E-waste at the second site that was visited. Other materials at this site included various metal parts, copper wires, old computers and iPads, motherboards, plastics, old printers, and various individual computer parts.

Additional materials that the Responsible Electronics Recycling Center recycles

- Laptops
- Servers
- Battery Backups
- LCD Monitors
- Hard Drives
- Motherboards
- Power Supplies
- Memory
- Mixed Circuitry
- Li-Ion Batteries
- Office Phones
- Cellphones
- Media Players
- Semiconductors
- All Wiring
- Modems/Routers
- Computer towers
- Circuitry Components
- Telecom Equipment
- Test Equipment
- Medical Equipment
- Printers

Based on the lack of E-waste specific supplies at the Wachusett Watershed Recycling Center, copper wire, motherboards, and additional wiring were gathered from the Responsible Electronics Recycling Center. This second E-waste site was a better representation of and contained similar materials to those in Ghana. Using the materials gathered at each site, the above-listed contents of the jump bag were prototyped and finalized as outlined in step-by-step instructions below.

Data and Results

Splint Prototype

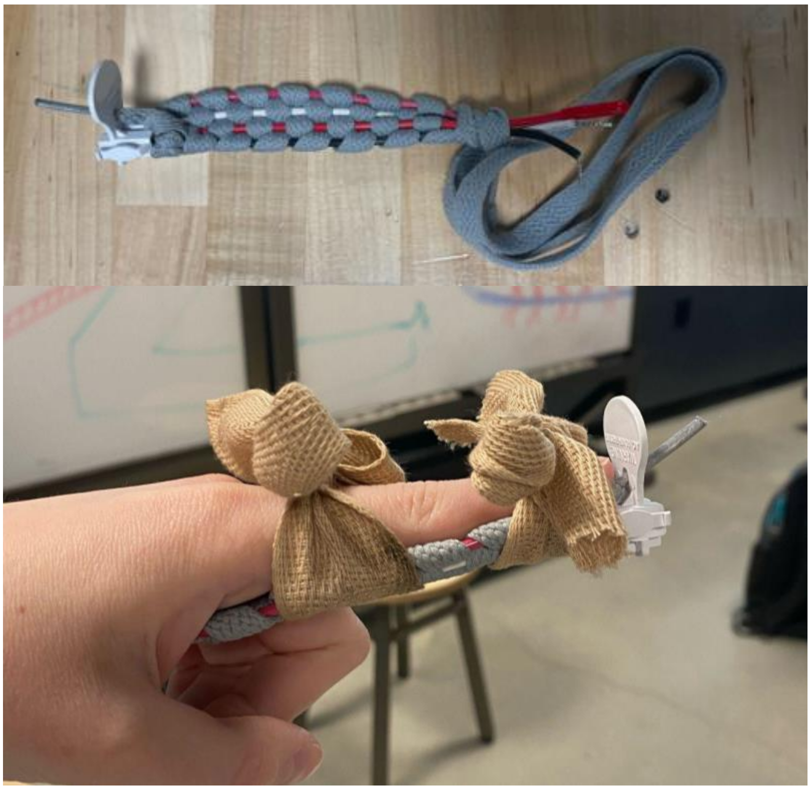

Figure 7. Splint Prototype.
Figure 7. Initial splint prototype created with malleable, but shape retaining, properties.

Materials:

- 4 copper wires, 15 cm
- 1 shoelace, 45 cm
- 2 cloth strips, 40 cm long and 3 cm wide

Tools:
No additional tools needed

Instructions:

1. Double-knot tie shoelace around one end of the four wires (left side above).
2. Weave a shoelace using the under-over pattern to the other end of the wires.
3. Double knot tie the shoelace around the other end of the four wires (right side above).

Limitations:
This design worked structurally but was too small and would not be able to be sterilized due to exposed fabrics.

<u>Finalized Leg & Arm Splint/C-Collar</u>

Figure 8. Finalized Splint
Figure 8. Final splint design created with malleable and cushioned design.

Materials:

- 10 meters of flat, three-core copper wire, cable
- 4 collective meters of flat ribbon wire
- Epoxy based adhesive
- 2.5 cm x 15 cm x 1 m piece of foam, or other available padding material
- 1 m x 0.5 m vinyl, or other water-resistant fabric
- 4 Buttons, or alternative method of fabric closure (i.e. zipper or Velcro)
- Thread

Tools:

- Wire Cutters
- Table Clamps
- Sewing Supplies

Instructions:

1. Straighten and cut the cable into 11 different pieces of equal length.
2. Organize pieces of cable adjacent to each other and secure them on a flat surface with a table clamp or alternative method of choice.
3. Isolate strips of ribbon wire that are between 6 and 6.5 mm in width.
4. Weave strips of ribbon wire in between cables to create a checkered pattern. For best results, ribbon wire strips should be long enough to weave three or five rows of the splint. Weaving with odd numbers of rows increases overall splint stability. When weaving, ensure that ribbon wire is pulled tightly to secure the cable together.
5. Secure loose ends of ribbon wire strips to the body of the splint with epoxy-based adhesive.
6. Continue until all parts of cable pieces are secured together, and trim ends of the splint as needed.
7. Trim the piece of foam to match the size of the splint.
8. Cut and sew vinyl into a pillow-case-like cover with one open seam along a singular short side.
9. Slide padding and woven wire into the vinyl cover.
10. Secure the open end of the cover with buttons or an alternative method of resealable fabric closure so that cover may be removed and washed as needed.

Prototype Tourniquet 1

Figure 9. Prototype Tourniquet 1.
Figure 9. Initial tourniquet design using string and metal.

Materials:

- 2 metal brackets
- 1 Nut and Bolt
- Ribbon

Tools:

- No additional tools needed

Instructions:

3. Tie ribbon onto one hole in metal bracket and wrap around limb
4. Pull ribbon through other side of bracket
5. Screw on bolt all the way to bracket and secure with nut
6. Screw on second bracket halfway and thread ribbon through opening
7. Tie ribbon onto second bracket and twist to tighten

Limitations:
This design was unable to be sufficiently tightened due to ribbon getting caught in the twisting mechanism.

Prototype Tourniquet 2

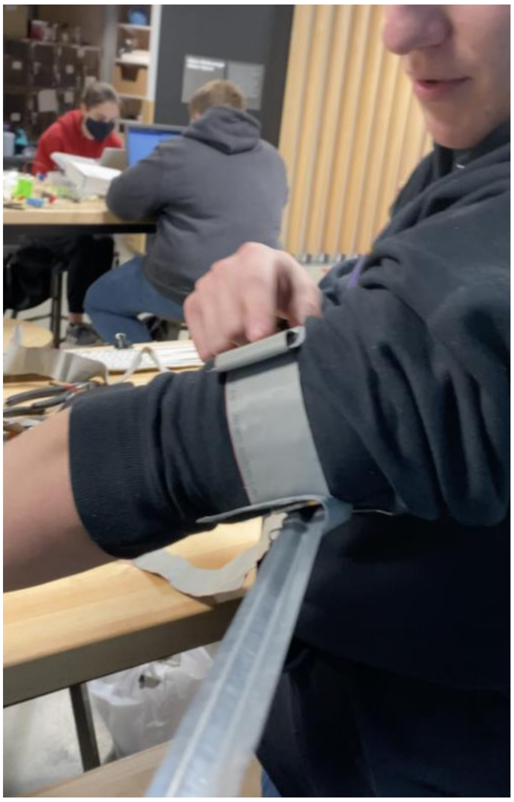

Figure 10. Prototype Tourniquet 2.
Figure 10. Second prototype tourniquet design using metal as the closure piece.

Materials:

- Ribbon wire approximately 4.5 cm by 105 cm
- Scrap/sheet metal
- Hard disk Drives
- Epoxy based adhesive

Tools:

- Metal Shears
- Hammers
- Pliers
- Vise and or clamps

Instructions:

To Create Main Buckle

1. Cut a rectangle of scrap metal measuring 5 cm by 6.35 cm and file each edge smooth

2. Punch two rectangular holes each measuring 4.5 by 1 cm
3. The above holes will be located 1.4 cm from the top and bottom on the 5 cm side of the metal sheet
4. File the edges of the holes smooth

To Create Secondary Buckle

5. Cut a second rectangle measuring 5 cm by 7.6 cm and file each edge smooth
6. Repeat steps 2-4 with this second rectangle

To Create Pressure Bar

7. Cut a third rectangle measuring 21.5 cm by 3.8 cm
8. Cut a .65 cm square out of each corner
9. Fold each side of this rectangle into a rectangular cuboid

To Assemble Tourniquet

10. Weld each corner of the pressure bar and drill a 2 mm hole on the smallest face
11. Cut one final rectangle measuring 5 cm by 2.5 cm
12. This completed part is the pressure bar plate
13. Drill a 2 mm hole in the pressure bar plate .3 cm from the top of the 5 cm side
14. Begin assembly by feeding the ribbon wire up through the first hole of the main buckle and down through the second
15. Take 7.5 cm of the working end of the ribbon wire and glue to the standing end of the ribbon wire forming a tight loop around the center bar of the main buckle
16. Feed the standing end of the ribbon wire through the secondary buckle in the same fashion outlined in step 15
17. To secure the pressure bar riveting or gluing may be used
    (a) Riveting instructions
        (i) To rivet the pressure bar, place the pressure bar plate 8 inches from the main buckle and make a hole in the ribbon wire lined up with the plate hole (Ribbon wire hole should be 22cm from the main buckle)
        (ii) For the next step, place the parts in order from top to bottom being pressure bar ribbon wire and pressure bar plate.
        (iii) Line of the ribbon wire hole plate hole and bar hole and rivet together ensuring that the secondary buckle is in between both the pressure bar and main buckle
    (b) Gluing instructions
        (i) Weld pressure bar and pressure bar plate together
        (ii) Place this welded assembly so that the pressure bar plate is flat with the ribbon wire and that the bar side of the plate is 22 cm from the main buckle
        (iii) Apply glue to the underside of the pressure bar plate and tie off the plate using small lengths of cut ribbon wire

(iv) Glue these tied off lengths to bot the plate and ribbon wire

18. Remove the magnet located within the hard drive disk with manual force
19. Glue the hard disk drive magnet onto the top bar of the secondary buckle closest to the main buckle

Limitations:

This design was able to tighten successfully, however the structure of the pressure bar was not strong enough and broke at the hinge.

<u>Finalized Tourniquet</u>

Figure 11. Finalized Tourniquet Prototype.
Figure 11. Finalized Tourniquet Prototype using a mixture of metal and string for the buckle closure.

Materials:

- Ribbon wire approximately 4.5 cm by 105 cm
- Scrap/sheet metal
- Hard disk Drives
- Shoelace
- Epoxy based adhesive

Tools:

- Metal Shears
- Hammers
- Metal File
- Drill

Instructions:

To Create Main Buckle

1. Cut a rectangle of scrap metal measuring 5 cm by 6.35 cm and file each edge smooth
2. Punch two rectangular holes each measuring 4.5 by 1 cm.
3. The above holes will be located 1.4 cm from the top and bottom on the 5 cm side of the metal sheet.
4. File the edges of the holes smooth.
5. Attach the buckle onto ribbon wire by threading ribbon wire through one side of the buckle, folding it over, and gluing it together with epoxy-based adhesive.

To Create Tightening Mechanism

6. Cut two strips of 12 cm x 1 cm metal.
7. Cut one piece of 3 x 5 cm metal and drill one hole 1 cm below the edge of a short side.
8. Isolate the voice coil from an actuator within the hard drive.
9. Place one strip of metal perpendicular to ribbon wire, approximately 5 cm below buckle, with equal amounts of excess strip length on each side of the ribbon wire. Fold excess metal up in a tri fold formation.
10. Slide the voice coil onto one end of the metal strip, and fold end flat onto the top side of the ribbon wire. Then thread the other end of the metal strip through the voice coil and secure flat onto the ribbon wire. Hammer metal flat to secure voice coil perpendicular and tightly to ribbon wire.
11. Repeat step 9 with the second strip, about 5 cm below the voice coil.
12. Using the piece of metal from step 7, fold 2 cm from the end of the metal opposite to the hole at a 90-degree angle.
13. Wrap the 2 cm folded portion around the second strip ensuring that it can slide up and down the ribbon wire but cannot be removed from the metal strip.
14. Thread a length of string or chord (shoestring used in picture above) through both the voice coil and the metal plates hole with.

Assorted Bandages

Figure 12. Bandages for bag
Figure 12. Bandages for use in the jump bag for wounds and other needs.

Materials:

- Linen cloth

Tools:

- Scissors

Instructions:

1. Cut several pieces of linen cloth into long sheets that are approximately 2 inches thick to create multipurpose bandages (swaths)
2. Cut two pieces into triangles with two short sides that are 102 cm long and one long side that is 142 cm long to create triangle bandages (slings).
3. After use, wash linen for reuse.

The materials not produced using E-waste that were part of the jump bag were the biohazard bag, pen, shears, and gloves.

Cost of Purchased Materials

Biohazard Emesis Bag	First Aid Blue Emesis Bag; 24 bags for $13.99 ● 6 for $3.50	
Pen	BIC Round Ballpoint Pen 60 pack for $5.99 ● 2 for $0.20	
Shears	Stainless Steel Bandage Shears for $1.91	
Gloves	Blue Nitrile Gloves AQL 1.5 100 pack for $21.99	

Total cost for one bag consisting of 6 biohazard emesis bags, 2 pens, 1 pair of shears, and 100 nitrile gloves: $27.6

Optional purchase locations:

Every Ready First Aid Blue Emesis Bag: meditackits.com
BIG Round Stick Xtra Life Ballpoint Pen: amazon.com
Stainless Steel Bandage Shears: cpr-savers.com
Blue Nitrile Gloves: medihands.net

Figure 13. Final Jump Bag Items
Figure 13. The final jump bag items including the multi-functional leg and arm splint, tourniquets, and assorted bandages, all created from E-waste materials, or gathered from E-waste sites.

The student partners from ACUC worked to facilitate getting the physical bag made by local vendors in Ghana who could create a durable duffel bag that could be used as a carrier for the jump bag supplies. This bag would have a duffel bag shape and size and could be made from a variety of materials that the vendors have to choose from. This way, the bag allows for another level of community when it is made in Ghana by residents, for residents.

Discussion

The proposed jump bag and reproducible instructions created for implementation into taxis in Ghana relate to the concept of smart villages on many accounts. To recap, a smart village in its essence is an off-grid or rural community that is working to develop modern approaches to science, technology, and innovation. A smart village works to create solutions to everyday problems with the goal of improving the quality of life of its inhabitants. Relating this to the project at hand, the proposed jump bag not only targets the medical sector of rural Ghana but strives to improve the quality of life by saving the lives of those involved in traffic accidents. The jump bag strives to create a solution to one of Ghana's most deadly issues, road traffic injuries, by providing a method for pre-hospital care. Also, it highlights a method to combat environmental and health issues caused by Agbogbloshie by designing most supplies out of E-waste and recyclable, low-cost materials. This modern approach to solving real health problems targets the infrastructure of this rural area with hopes of strengthening its tools and policies from the ground up. Also, the reproducibility of the jump bag and its supplies allows for these goals to be manufactured and implemented across Ghana on a larger scale, assisting with the long-term stability of the country.

The creation of this bag would not have been possible without key information and validation from interviewees and student partners in Ghana who all played a role in ensuring the best outcome for the bag. The interview with Shannon Harvill allowed for the gaining of insight into a real-world trauma center, and what quality pre-hospital care should look like. With this information, the concept of the jump bag and its contents were determined with the most common injuries and fatalities in mind. Furthermore, the interview with the Ghanaian Ambassador helped to conceptualize the goals of this project and the most thoughtful plan of implementing it. Specifically, the Ambassador's suggestions about bag improvement, passion, and interest in the project as well as validation ensured that the work being completed was on track for the overall goals of the project, and that the problems in Ghana were being addressed properly through the proposed co-design solutions. Lastly, the student partners from ACUC worked alongside this project to help with decisions about the bag itself, and future implementations of the project at their university. The ACUC students will be taking over with the completion of the project here at WPI and will continue working towards re-creating the first aid supplies out of E-waste and making connections with taxi drivers in Ghana through their university.

The overall process of this project strives to reflect the ideals of co-design and tackle a participatory approach to solution design where all members are treated equally and included in the operations. Due to Covid-19 restrictions, this project was completed remotely rather than on the ground in Ghana, which led to restrictions and issues with the overall process. Ideally, this project would have been done in collaboration with all stakeholders at every section of the methods to ensure a strong co-design path with everyone being involved in decision making. Due to the remote aspect of this project, getting in contact with stakeholders such as medical professionals, taxi drivers, and students was nearly impossible to do in a timely fashion for each section of the design process. Thus, an amendment to the project methodology was made which included feedback from stakeholders as the project ended in order to gain any final suggestions for improvements, validation, and means for continuing the project further.

Although this project did not encompass the typical co-design model, the best was done with the time and resources that were available while working to create the most valuable and useful outcome thousands of miles away from Ghana. In the future, this project, and others like it, would hopefully be completed working with partners at every stage of the process rather than only at the end to ensure that all voices and opinions are present in the overall scheme and outcome of the deliverable. The co-design process is crucial to the success and continuation of the development of smart villages, and the amendments to this ideology still resulted in a helpful and innovative path to creating a smart village in Ghana.

In conjunction with the concepts of smart villages and co-design, the ideals of generative justice were played upon throughout this project. Generative justice consists of the idea that value is created and circulated by people in a community that are in control of this circulation and value. Generative justice ensures that the only forces affecting the creation and circulation of value are coming from within. This allows for a stable and sound foundation for the distribution and perpetuation of resources in smart villages and other communities. Regarding this project, the principles of generative justice are applied because the jump bag and its contents can be fully implemented, created, and controlled by the users in Ghana. Ghana has the E-waste resources to produce all necessary equipment by hand and with other tools while being in complete control of its applications in taxis, and empowerment of others, all highlighting the standards of generative justice. While there is more to be done on this project in the future, it can be changed and strengthened to better fulfill the goals of generative justice. However, the overall proposed process allows for the complete creation, circulation, and control of the resources and values that the jump bag contains by the people of villages in Ghana, paving the way towards a more generatively just society.

Conclusion

Overall, this project has successfully completed the desired co-design process of an E-waste based jump bag and instructions for reproduction that could be implemented in taxis in Ghana. With these E-waste based tools and instructions, it is the hope that these methods and goals can be further implemented into taxis in Ghana while also empowering and expanding into other sectors of society. Also, it is hoped that student partners from ACUC and other members of the community can take this project further to provide pre-hospital care to places that need it most, while also highlighting other issues such as pollution and waste.

Although the bag was successful in creating necessary BLS tools that work and function properly, there are some ways in which it could be improved for the future. Each tool was only created once using certain materials that were gathered for this project. However, on a larger scale, each tool would need to be created more than once using different materials/methods to determine the best one for the job and ensure that the right materials are accessible to the people producing it. Because Ghana deals with E-waste, the materials used in this project were mostly E-waste based, however it would be necessary to do an inventory check on the supplies in the area. Also, other important improvements include the addition of an E-waste based stretcher and suction unit, two tools that are necessary for implementing proper pre-hospital care. Due to the time constraints of this project, these two items were not able to be completed. Lastly, the bag would benefit from the addition/creation of a blood typing device, per the Ambassador's recommendation, that would help the responders learn ahead of time what blood type they would need. In this regard, mandatory first aid training would be beneficial, such as a pamphlet or video, along with the bag that would provide information on how to properly use the tools in the bag.

In the future, this bag could be implemented in ways to continue the generative justice process and the creation of smart villages. This first aid jump bag could be used in places other than taxis, such as public buildings around the city to ensure that medical supplies can be accessible to people at any time, not just on the way to the hospital. Therefore, this bag could target health issues beyond traffic accidents, and each bag could be tailored to where the bag was located, and the issues present at that location. Alongside these bags could also be an avenue to thank the taxi drivers and residents who are participating in the manufacturing and usage of the tools in the pre-hospital care bag. Further, this bag could be manufactured and produced in other countries outside of Ghana, and the tools could be made from the supplies that are most prevalent in that area. Although Ghana has issues with E-waste and recycling, not all countries will, so the materials used would have to be specific to the place. Alongside the implementation of these bags could be the facilitation of first aid training courses for residents and students of villages using this bag as an example/learning device during the sessions. These improvements and implementations of the proposed jump bag are valuable avenues to the continuation of smart village creation and the application of generative justice.

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Student Partners in Ghana at Academic City University College
Abbam Nii Laitei, Student at Academic City University College
Timothy Keketi Wordu, Student at Academic City University College
Adamu S. Doumbia, Student at Academic City University College

Interview Contacts
Shannon Harvill, ER nurse level one trauma center in Hartford, Connecticut
Baffour Adjei Bawuah, Ghanaian Ambassador

Worcester, Massachusetts, USA Partners
Robert Krueger, Worcester Polytechnic Institute Professor, Development Design Lab, Advisor
Hermine Vedogbeton, Advisor
Fofana Mustapha, Advisor

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