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Design of a Social Innovation Addressing People Experiencing Homelessness in Los Angeles, California

Madeline Strauss[1] and Bradley Boelman[#]

[1]Calabasas High School, USA
[#]Advisor

ABSTRACT

Over 46,000 people sleep on the streets each night in Los Angeles, California (LA). This number has increased in recent years and is expected to continue rising. Given this apparent crisis of unsheltered homelessness in the city, the purpose of this research was to develop a social innovation to provide services to people experiencing homelessness (PEH) in LA. The researcher followed a two-stage research methodology adapted from Bapat et al. (2023) framework for frugal engineering. In Stage #1, the researcher collected sources from different search engines relating to homelessness in LA, and coded them according to seven different themes to identify the current needs of the city's PEH. In Stage #2, the researcher chose one theme, sanitation, and the claims that corresponded to it and used them to design a social innovation catering to design criteria set based on the research done by Dickinson et al. (2016), Bapat et al. (2023), and Wodiczko & Lurie (1988). Ultimately, the researcher designed an innovation called the "Liquid Lifeline," which is a wearable water bladder equipped with straps for carrying, a water spout, and a straw. The researcher designed this product to cater to the water-related needs of unsheltered PEH in LA. Despite limitations to the research method regarding time and budgetary restraints and inherent subjectivity, the researcher feels confident that the "Liquid Lifeline," if widely manufactured and distributed in LA, would be very successful in improving the quality of life of unsheltered PEH in the city.

Introduction

Homelessness in Los Angeles County (LA County), California, has drastically increased in recent years. In 2023, LA County had over 75,518 homeless people, 46,260 of whom were in the city of Los Angeles (LA) (Weber, 2023). These numbers reflect a 9% increase in homelessness versus 2022 (Weber, 2023).

Historically, LA has experienced high rates of homelessness. A California State University, Los Angeles Study found that this is rooted in steadily rising housing prices and decreasing job opportunities between the 1980s and today (Gross, 2021, p. 2).

The Problem

According to Randall Kuhn and faculty of the University of California, Los Angeles's School of Public Health, 75% of people experiencing homelessness (PEH) in Los Angeles County live unsheltered on the streets, in tents, or in encampments (Kuhn et al., 2020, p. 3). This is in part due to the lack of shelter space. Per professors Donley and Wright from the University of Central Florida, many homeless shelters across the country operate at or above capacity (Donley & Wright, 2012, p. 289).

However, extensive research demonstrates that many PEH voluntarily live on the street. Donley & Wright (2012) suggest that lack of safety, companionship, and freedom, and experiences of objectification and infantilization by staff all contribute to PEH rejecting residence opportunities in shelters (pp. 290-295).

Nevertheless, living unsheltered harms the health of PEH. Unsheltered homelessness correlates with mental illness, substance abuse, infectious disease, reproductive health deficiencies, accelerated aging, and early-onset geriatric conditions (Kuhn et al., 2023, p. 3; Padwa et al., 2023, p. 1236).

The Solution

When Karen Bass was elected mayor in December 2022, she was eager to enact new programs to relocate more PEH into housing. Bass's biggest project, "Inside Safe," provides individual motel or shelter rooms and health and emotional services to PEH who voluntarily leave encampments (Karlamanga, 2024). This project has proven to be very expensive, with the city spending $1.3 billion on housing PEH in 2023 alone (Blood, 2023). Unfortunately, research demonstrates that Bass's efforts were not worth the cost, as only around 2,000 of the 46,260 PEH in LA were put into interim housing through the program, and fewer than 400 transferred to permanent housing (Blood, 2023; Weber, 2023; Karlamangla, 2024). Further, of the 2,000 put into interim housing, one in three at some point left the system, and the rest remain yearning for permanent housing (Blood, 2023).

Next Steps

Despite best efforts, tens of thousands of people in LA remain unsheltered. Due to rising rates of evictions and the end of COVID-19 aid for low-income households, rates of unsheltered homelessness are expected to continue rising in upcoming years (Blood, 2023).

To assist needy unsheltered homeless populations in LA, given the lack of widespread solutions that cater to the masses, it is time to think outside of the box. As explained below, the use of frugal design techniques to provide services to PEH via unconventional methods can help achieve this goal.

Literature Review

The source that most informed the researcher's initial concept of using frugal design techniques to assist PEH in LA was David Lurie & Krzysztof Wodiczko (1988)'s "Homeless Vehicle Project" designed at the Massachusetts Institute of Technology. In this project, the professors aimed to "fill a dangerous gap in [homeless] shelter needs" by designing a mobile, personal shelter (Wodiczko & Lurie, 1988, p. 55). Wodiczko & Lurie (1988)'s design incorporated a wash basin, chair, bed, and storage (p. 65). Wodiczko & Lurie (1988) designed the "Homeless Vehicle" as a conceptual proposal meant for further researchers to elaborate on, rather than as a final project in itself (p. 61).

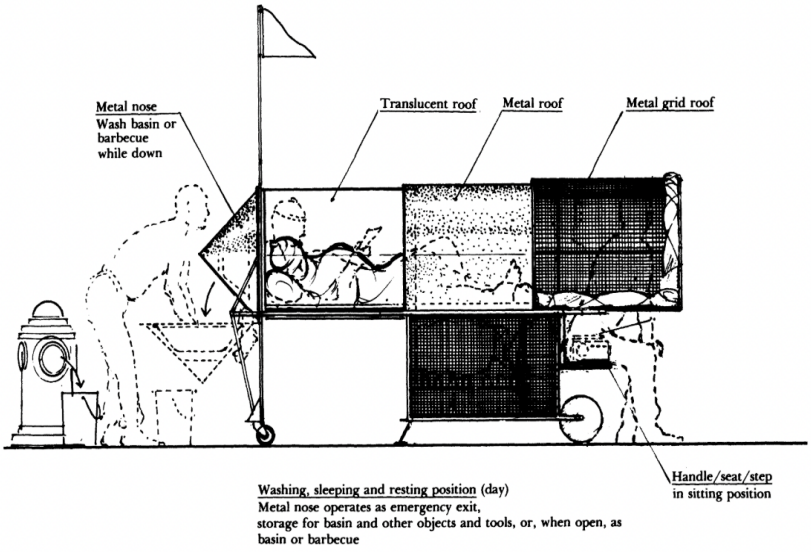

Figure 1. Wodiczko & Lurie (1988) "Homeless Vehicle" (p. 65).

Wodiczko & Lurie (1988) noted that they designed their vehicle considering interviews with adult male PEH in New York City, but did not explicate a clear methodology they used to do so (p. 61).

Though this was a novel concept at the time, many succeeding researchers have expanded on this idea by creating innovative, personal portable shelters. For example, Whitaker et al. (2018) developed a sleeping bag using repurposed textiles from factories in Northwest Arkansas, but had established the idea for their product before conducting formal research; the paper discussed the design of the product using the given materials (p. 3). Dickinson et al. (2016) designed a portable homeless shelter based on criteria established by reviewing previous research—including the "Homeless Vehicle"—but did not elaborate on how the criteria were established, and in their paper discussed interviews conducted with PEH on the amendment of their original prototype. In all, existing literature regarding the concept of designing devices to assist unsheltered PEH is abundant; however, there is scant literature regarding methodologies used to develop such.

The existing literature that most clearly outlines a replicable methodology for designing such a product was a 2023 study conducted by Salil Bapat and colleagues at Purdue University's School of Mechanical Engineering. Bapat et al. (2023) define the term frugal engineering as "a holistic approach of engineering addressing present glocal tech-socio-economic needs with frugal characteristics, principles, and methods to continuously produce/manufacture [social] innovations"; "social innovations" refer to products that meet a social need (e.g., the "Homeless Vehicle" and other portable shelter prototypes) (p. 267). Bapat et al. (2023) recognized the lack of a frugal engineering design and manufacturing process methodology in existing literature, and as a result, curated a "design framework for applying frugal engineering methodology to design, fabricate, and deliver a potential solution for societal cause" (p. 267). By contrast, most prior social innovations were developed using "nonsystematic improvisation process(es)," and products developed using such methods are not typically accepted among professional developers and firms (Bapat et al., 2023, p. 267).

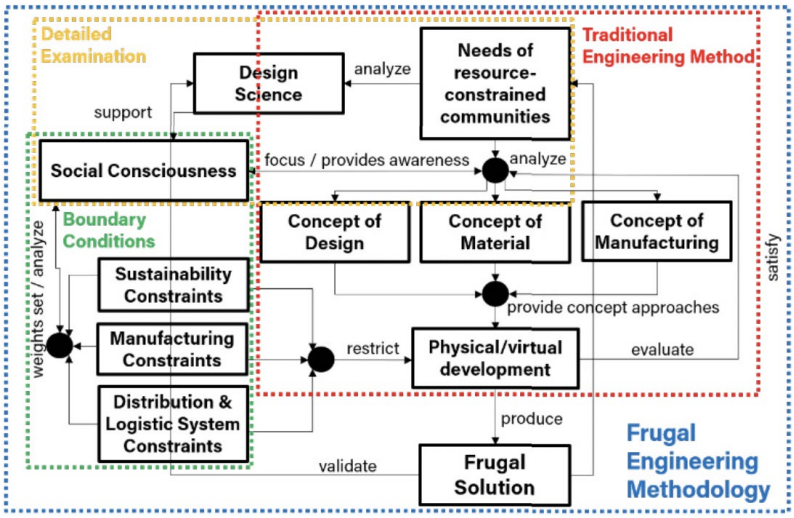

Figure 2. Bapat et al. (2023) framework for "Frugal Engineering Methodology," illustrated as a flow chart (p. 267).

In their construction of the "Frugal Engineering Methodology," Bapat et al. (2023) aimed to reduce the complexity and increase the simplicity and agility of the design process (pp. 267-268). This was due to the researchers' recognition that social innovations are frequently fabricated while battling resource and cost constraints (Bapat et al., 2023, p. 267). Bapat et al. (2023) simplified the framework illustrated in Figure 2 into a five-stage product development plan: 1. Identification of Needs; 2. The Concept for Design, Materials, and Manufacturing; 3. Prototyping; 4. Testing; 5. Launch (p. 267).

The researchers tested this methodology by applying it to the development of a wearable tent for unsheltered PEH (Bapat et al., 2023, p. 268). They concluded that the method was efficient, and asserted that it would prove useful to further research as it is customizable in "its implementation toward a specific application" (Bapat et al., 2023, p. 270).

Though their method was novel, the product that Bapat et al. (2023), and Wodiczko & Lurie (1988), developed was not. Other researchers have developed portable shelters for PEH over the past several decades, including "the 'urban caterpillar' (Young, 2010), 'cardboard origami' (Peters, 2013), 'hobo haven' (TrendHunter Art & Design, 2016), 'wearable dwelling' (Varagur, 2016), and paperboard disaster shelters (Samuels, 2015)" (Dickinson et al., 2016, p. 56).

Though Dickinson et al. (2016) also developed a portable shelter, they followed a unique creative process. Dr. Joan Dickinson, professor of interior design at Radford University, had students design prototypes of portable homeless shelters and selected one to analyze in this research paper (Dickinson et al., 2016, p. 53). The students designed the prototype based on research conducted on existing street shelters and interviews with PEH design, to justify every component of their prototype (Dickinson et al., 2016, p. 53). For example, the prototype was influenced in part by Wodiczko & Lurie (1988)'s research; the students concluded from the "Homeless Vehicle" that transportation is an important function of street shelters, and therefore ensured that their prototype could condense easily to be carried by hand (Dickinson et al., 2016, p. 58).

The Gap

The frugal design of products for PEH is a unique field of research that is generally lacking in methodological focus. Wodiczko & Lurie (1988) provided the foundation for research in this field nearly four decades ago, and

numerous researchers have followed, with Bapat et al. (2023) being the first to establish a coherent and replicable framework for developing such a product. Dickinson et al. (2016) highlighted the necessity of incorporating previous research and user input to strengthen the effectiveness of a social innovation targeted to unsheltered PEH. But as Bapat et al. (2023) asserted, "the need for frugal innovations and thus frugal engineering is eminent to address this problem as resources are extremely limited and effectiveness and affordability need to be utmost" (p. 268). Thus, much more research is necessary to increase the number and maximize the efficiency of frugally designed products for PEH.

The need for additional research is particularly crucial for the city of Los Angeles, considering the magnitude of the homelessness crisis in the city, which has only been exacerbated by the COVID-19 pandemic, and has not been alleviated by Mayor Bass's new programs (Blood, 2023; Karlamanga, 2024).

Review of existing literature confronted this researcher with the following question: "Based on the current resources and restraints that shape the lives of unsheltered PEH in LA, how can one develop a social innovation to most effectively and efficiently provide necessary services to this population?" This question has evolved to become the central focus of the researcher's creative process.

Methodologies

The researcher's main design framework follows Bapat et al. (2023)'s framework for frugal engineering. However, due to time and financial constraints, the researcher only completed steps 1-2, "Identification of Needs" and "The Concept for Design, Materials, and Manufacturing," to create an initial plan for a design that is capable of being critiqued and expanded on by succeeding researchers. Additionally, due to aforementioned constraints and the abundance of existing prototypes for portable shelters, the researcher focused solely on creating a smaller social innovation to address a single need of unsheltered PEH. As Figure 1 demonstrates, Wodiczko & Lurie (2023)'s "Homeless Vehicle" addressed multiple challenges confronting PEH. It addressed sanitary needs by incorporating a wash basin, storage needs by incorporating a "metal nose", and, of course, shelter needs by incorporating a long compartment for sleeping; all of these components were designed according to needs identified in the interviews (p. 61). By contrast, this researcher's main focus was to design a social innovation to address one specific need of unsheltered PEH, in LA in particular.

Identification of Needs

The first step in the frugal engineering process is the "Identification of Needs". To ensure the proposed social innovation addresses the needs of unsheltered PEH to the greatest extent possible, this researcher elected to review a wide range of sources to identify a clear need for unsheltered PEH requiring a solution, before formulating a product concept.

The first step was to determine what overarching need the researcher was seeking to resolve. According to the *U.S. National Library of Medicine*, the biggest threats to the health of PEH are: 1. Healthcare; 2. Food; 3. Safety; 4. Violence; 5. Stress; 6. Sanitation; 7. Weather ("Homelessness and Health").

Thus, the researcher utilized these concepts in conducting Internet research using the terms: "Los Angeles homeless healthcare/food/safety/violence/stress/sanitation/weather".

The researcher ensured the relevance of their results by only considering articles from between January 1 2023 and January 31 2024. They analyzed reliable news articles and peer-reviewed studies to incorporate a wide range of credible sources.

To locate relevant media sources, the researcher input one of the seven key phrases into the Google search engine at a time. They reviewed the results, which were populated in order of predicted relevance, and selected only the links of articles that passed the CRAAP test, an evaluation method designed at California State University, Chico, to ensure the reliability of sources ("Evaluating Resources and Misinformation"). Due to the

large volume of search results, they ceased evaluating sources from a search when there were three consecutive articles that did not comply with the "Relevance" criterion.

Table 1. CRAAP Test Criteria ("Evaluating Resources and Misinformation").

Criterion	Description
Currency	An article must have been published any time from January 1st 2023 to January 31st 2024.
Relevance	An article must have a title that implies that it contains information relevant to the key phrase used to search for it.
Authority	An article must have come from a credible source.
Accuracy	An article must contain qualifications to demonstrate that the information it presents has been reviewed by (an) other trusted source(s).
Purpose	An article must contain factual information only, as opposed to opinion or propaganda.

To locate relevant peer-reviewed sources, the researcher input each of the seven key phrases seriatim into *Google Scholar*, *EBSCO*, and *JSTOR*. The researcher used these databases because they were all free for the researcher to access, and the researcher only selected articles that passed the CRAAP test. Again, due to the large volume of search results, they ceased evaluating sources from a search when there were three consecutive articles that did not comply with the "Relevance" criterion.

After collecting sources, the researcher reviewed each one and coded each according to the following themes, which reflect the predominant health risks to PEH.

Table 2. Themes of Analysis. The researcher defined each theme according to the definition of the words by Merriam-Webster Dictionary.

Theme	Definition
Healthcare	"Efforts made to maintain, restore, or promote someone's physical, mental, or emotional well-being especially when performed by trained and licensed professionals" (Merriam-Webster, 2024).
Food	"The fact or an instance of being unable to consistently access or afford adequate food" (Merriam-Webster, 2024).
Safety	"The condition of being safe from undergoing or causing hurt, injury, or loss" (Merriam-Webster, 2024).
Violence	"The use of physical force so as to injure, abuse, damage, or destroy" (Merriam-Webster, 2024).

Stress	"A physical, chemical, or emotional factor that causes bodily or mental tension" (Merriam-Webster, 2024).
Sanitation	"The promotion of hygiene and prevention of disease by maintenance of sanitary conditions" (Merriam-Webster, 2024).
Weather	"The state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness" (Merriam-Webster, 2024).

For media sources, the researcher read each article in its entirety. For peer-reviewed sources, the researcher read the sections titled "findings," "analysis," "conclusions," to ensure an efficient analysis. To confirm the soundness of results, they applied a theme to each piece of information presented in accordance with the following criteria.

Table 3. Inclusion-Exclusion Criteria for Thematic Analysis.

Criteria	**Requirements**
Inclusion	Claims of problems PEH face Claims of ways that PEH lives are improved
Exclusion	Statistics Personal experiences Claims that apply only to certain demographic groups Claims relating to shelters/sheltered PEH

The researcher also noted whether the information was something beneficial or detrimental to unsheltered PEH in LA.

See the Appendix for the complete thematic analysis spreadsheet. The thematic analysis was modeled after Dickinson et al. (2016)'s analysis of interviews of unsheltered PEH regarding the student prototyped portable shelter (p. 66).

In total, the research yielded 74 "claims" of information, most of which encompassed multiple themes. After the coding process concluded, the researcher deleted duplicate claims that were derived from multiple sources.

The goal of this research was to develop a social innovation to assist PEH by filling *a* gap in their needs. As stated by the *National Library of Medicine*, all seven themes coded for present major threats to PEH. Given the parameters of this project, the researcher was unable to design innovations catering to each of the themes, and thus had to select one; they created the following data-informed questions to bolster their selection.

Table 4. Data-Informed Questions Informing the Researcher's Selection of a Theme on Which to Cater the Innovation.

Number	**Question**
1	Is there a wide gap between the positive and negative claims of this theme?

2	Are there enough claims regarding this theme to make informed decisions regarding the design of a social innovation?
3	Is there a clear problem that needs to be addressed within the results of this theme?

Based on the answers to these questions, the researcher ultimately decided that designing a social innovation addressing sanitary needs of unsheltered PEH in LA would be the most effective way to service the population. While there is some subjectivity inherent in these questions, the researcher feels confident in their choices, due to the following justifications.

The research yielded 38 claims regarding healthcare: 18 positive and 20 negative. The small difference demonstrates that copious solutions to the problems regarding this theme exist. The claims regarding this theme were plentiful. Further, there was more than one identifiable problem within this theme that needed to be addressed; the claims concerned various issues relating to drug use and health. Thus, the researcher did not design an innovation catering to healthcare.

The research yielded 45 claims regarding safety: 16 positive and 29 negative. The gap between the positive and negative effects illustrates that there are significantly more problems regarding this theme than solutions. The claims regarding this theme were plentiful. Further, there was more than one identifiable problem within this theme that needed to be addressed; the claims concerned various issues relating to health and violence. Thus, the researcher did not design an innovation catering to safety.

The research yielded 9 claims regarding violence: 1 positive and 8 negative. The gap illustrates that there are significantly more problems regarding this theme than solutions. However, the claims regarding this theme were so few—<25% of all collected claims—that the researcher concluded that they lacked sufficient knowledge of the topic to attempt to address it. The claims also concerned a single, identifiable problem—PEH being physically attacked on the streets. Nonetheless, due to the aforementioned paucity of claims, the researcher did not design an innovation catering to violence.

The research yielded 24 claims regarding stress: 8 positive and 16 negative. The gap illustrates that there are significantly more problems regarding this theme than solutions. The claims regarding this theme were plentiful. Further, there was more than one identifiable problem within this theme that needed to be addressed; the claims concerned various issues relating to drug use, mental illness, trauma, and inadequate living conditions. Thus, the researcher did not design an innovation catering to safety.

The research yielded 17 claims regarding weather: 4 positive and 13 negative. The gap illustrates that there are significantly more problems regarding this theme than solutions. The claims regarding this theme were so few—<25% of all collected claims—that the researcher concluded that they lacked sufficient knowledge of the topic to attempt to address it. Regardless, the claims concerned a single, identifiable problem—harsh weather conditions. Nonetheless, due to the aforementioned paucity of claims, the researcher did not design an innovation catering to weather.

The research yielded 18 claims regarding food: 3 positive and 15 negative. The gap illustrates that there are significantly more problems regarding this theme than solutions. However, the claims regarding this theme were so few—<25% of all collected claims—that the researcher concluded that they lacked sufficient knowledge of the topic to attempt to address it.
Regardless, the claims concerned a single, identifiable problem—undernutrition. Nonetheless, due to the aforementioned paucity of claims, the researcher did not design an innovation catering to food.

The claims relating to sanitation satisfied all of the researcher's requirements. The research yielded 24 claims regarding sanitation: 4 positive and 20 negative. The gap illustrates that there are significantly more problems regarding this theme than solutions. The claims regarding this theme were plentiful. The claims also concerned a single, identifiable problem—lack of clean water. Thus, the researcher decided to design a product to address the sanitary needs of unsheltered PEH in LA.

With that, the first stage of the creative process concluded.

The Concept for Design, Materials, and Manufacturing

Following Bapat et al. (2023)'s framework for frugal engineering, the researcher must develop criteria to guide the design and ensure that all conditions will be met before designing the social innovation. Below is a list of "boundary conditions for a frugal engineering approach" developed by Bapat et al. (2023) (p. 268). These conditions serve as a general, flexible guideline for the design process.

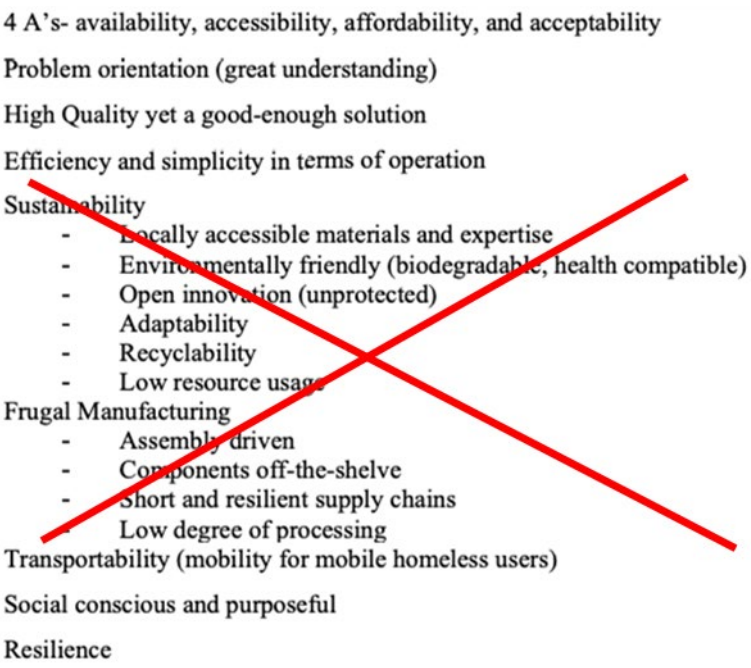

Figure 3. "Boundary Conditions for a Frugal Engineering Approach" (Bapat et al., 2023, p. 268).

The next steps involve designing specific criteria informed from the aforementioned boundary conditions. As previously stated, the researcher concluded that they could effectively design a social innovation to help provide clean water for PEH in LA to drink and wash with. Thus, the desired functionality of the innovation is a water-carrying vessel. Table 4 represents design considerations for the innovation, and were set based on the boundary conditions, Bapat et al. (2023)'s sample criteria and product concept (p. 268), and Wodiczko & Lurie (1988) and Dickinson et al. (2016)'s product concepts.

Table 5. Design Criteria for the Social Innovation. Bapat et al. (2023) established "Physical Criteria" as well, but the researcher deduced that would not be necessary as this innovation is not yet to be prototyped.

Criteria	Requirements
Functional	Multifunctionality Simplicity Mobility

Emotional	Aesthetics Wearability Comfort

The researcher then designed the product, based on the claims coded for sanitation, the boundary conditions, and the established criteria.

Creation

The researcher designed a water-carrying vessel for transporting water that can be used for drinking and washing, called the "Liquid Lifeline". The researcher created several hand drawings of the innovation that mimicked the types of drawings that Wodiczko & Lurie (1988) drew to demonstrate the design of their product to clearly communicate the concept of the innovation (pp. 64-67). Below is an in-depth analysis of the "Liquid Lifeline" and its alignment with the developed criteria.

Analysis

Below are the drawings of the "Liquid Lifeline".

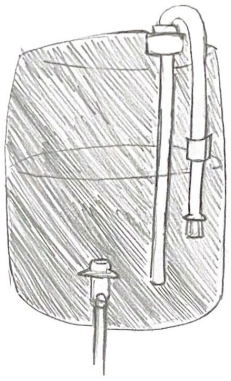

Figure 4. "Liquid Lifeline" initial illustration. This drawing does not illustrate the shoulder straps component of the innovation.

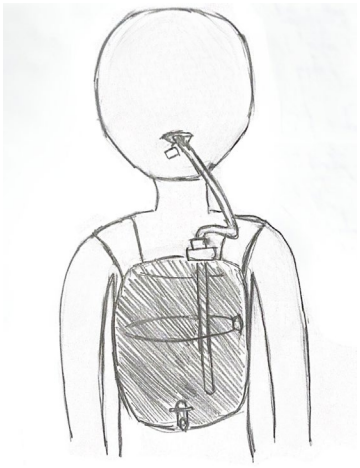

Figure 5. Demonstration of how the "Liquid Lifeline" is worn, and how the straw is used.

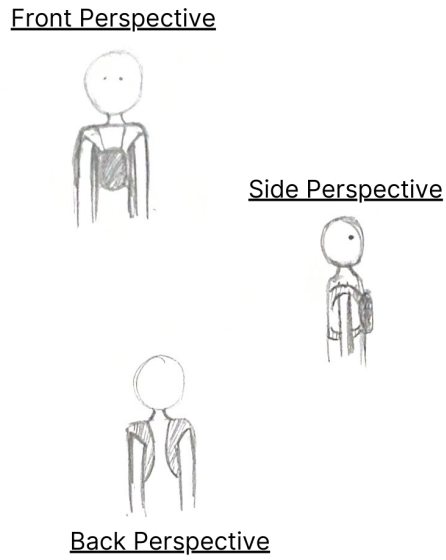

Figure 6. Profiles of the "Liquid Lifeline" being worn.

The product consists of an opaque, flexible water bladder with attached straw, connected to the bladder by a removable cap. The straw can be secured by a snap-on latch when not in use. At the bottom of the bladder is a spout that pours water when pressure is applied to its top button. The bladder is secured by two thick straps that allow for the user to wear it on their front.

Following Dickinson et al. (2016)'s research, each component of the "Liquid Lifeline" is justified by the coded claims regarding the theme of "sanitation".

Table 5. Results of the thematic analysis, only regarding sanitation. The citations for the sources stated can be found in the "References" section of the paper. For reference, "WaSH" means "Water, Sanitation, and Hygiene".

Claim	Negative vs Positive	Theme
PEH resort to defecating and urinating in buckets inside of their tents when they do not have access to public restrooms.	Negative	Sanitation
Many PEH resort to getting water from fire hydrants because they lack other sources.	Negative	Food; Safety; Sanitation
Many PEH do not have the resources to store water to use at night.	Negative	Food; Sanitation
PEH report having limited access to water for handwashing during the day.	Negative	Safety; Sanitation
PEH often do not know when they can access clean water next.	Negative	Food; Stress; Sanitation
"Water Drop LA" delivers free bottles of water to PEH in Skid Row once every week.	Positive	Food; Sanitation
"Water Box" is a company that provides PEH in Skid Row with refillable gallon bottles that they can fill up at free water stations also provided by the company.	Positive	Food; Sanitation
PEH have higher-than-average rates of chronic disease.	Negative	Healthcare; Safety; Food; Sanitation
PEH frequently face dehydration.	Negative	Food; Sanitation; Healthcare
Public water fountains are few, and the ones that do exist are often dysfunctional.	Negative	Food; Sanitation
Since many PEH do not have access to public restrooms at night, they are forced to urinate and defecate in public spaces.	Negative	Sanitation
Many PEH lack shower services.	Negative	Sanitation
Many PEH lack laundry services.	Negative	Sanitation
The lack of WaSH services increases PEH risk of suffering from bacterial infections.	Negative	Healthcare; Food; Safety; Sanitation

The lack of WaSH services negatively impacts the mental health of PEH.	Negative	Healthcare; Food; Safety; Stress; Sanitation
The lack of WaSH services decreases the chance for employment of PEH.	Negative	Food; Stress; Sanitation
The lack of WaSH services increases PEH risk of suffering from skin conditions.	Negative	Healthcare; Food; Safety; Sanitation
The lack of WaSH services increases PEH risk of suffering from urinary tract infection.	Negative	Healthcare; Food; Safety; Sanitation
Public handwashing facilities available to PEH frequently lack supplies.	Negative	Healthcare; Safety; Sanitation
PEH experience higher rates of infectious diseases.	Negative	Healthcare; Sanitation
PEH are at risk of contracting water-borne illnesses during storms.	Negative	Food; Safety; Sanitation; Weather
Heavy rainstorms can contaminate sources of water relied on by PEH.	Negative	Healthcare; Food; Safety; Sanitation; Weather
Nonprofits hand out new drug paraphernalia to PEH so that they do not get ill from used equipment.	Positive	Healthcare; Safety; Sanitation
The “Inside Safe” program works to clean up trash from encampments.	Positive	Safety; Sanitation

Below is an in-depth analysis of the product and its application to the criteria defined in the previous section.

Alignment to Functional Criteria

The first criterion under “Functional Criteria” is multifunctionality. In incorporating this criterion, the researcher considered the products developed in two of the foundational sources. Wodiczko & Lurie (1988) addressed this by incorporating a wash basin, chair, bed, and storage in the “Homeless Vehicle” (p. 65); Bapat et al. (2023) addressed this by creating a street shelter that could be used for sleeping at night and shelter from harsh weather during the day (p. 269).

This research found that most public water fountains in LA are inoperable (Anthony et al., 2024, p. 1). Most PEH do not even have the luxury of having a single, dependable water source (Gradeja, 2023). Further, LA public facilities are frequently contaminated from being exposed to severe weather, putting users at risk of contracting water-borne illnesses (Anthonj et al., 2024, p. 19). Thus, PEH frequently face dehydration (Portillo

et al., 2023, p. 10). To address these risks, the researcher incorporated a straw in the innovation to make drinking water constantly accessible to the user. The user can unscrew the cap connected to the water bottle to fill up the bladder whenever and wherever they can access clean water, without worrying about scavenging later. Therefore, this function of the "Liquid Lifeline" aims to prevent the user from suffering from dehydration by preserving access to drinking water.

Moreover, the research concluded that the lack of hand washing negatively impacts unsheltered PEH's health. Many of the few public restrooms/facilities that exist in LA are dysfunctional and/or lack supplies (Anthoj et al., 2024, p. 10). PEH in LA consequently report having limited access to water for hand washing, which correlates with higher rates of infectious diseases, and bacterial and skin infections (Portillo et al., 2023, pp. 1-10; Anthoj et al., 2024, p. 2) Thus, the researcher incorporated a water spout attached to the bladder of the "Liquid Lifeline". The user pushes the button on the spout, enabling water to be used to wash directly or to fill a basin. This component allows the user flexibility to wash with a controlled quantity and direction of water.

This ties into the second criterion under "Functional Criteria"—simplicity. The researcher incorporated this criterion considering the product developed by Dickinson et al. (2016), as they addressed this by making their innovation collapsable for easy operation (p. 58).

The user needs to be able to drink or wash using the "Liquid Lifeline" at any given time. Therefore, the innovation must be easy to operate. The researcher included typical and foolproof features as simple as a straw and a spout with one button used to operate.

The third criterion under "Functional Criteria" is mobility. The researcher incorporated this criterion considering the products developed by all three foundational sources. Wodiczko & Lurie (1988) addressed this by putting their "Homeless Vehicle" on wheels so it can be rolled (p. 65); Dickinson et al. (2016) addressed this by attaching straps to their prototype so it could be carried (like a purse) when folded (p. 58); Bapat et al. (2023) addressed this by enabling their street shelter to be folded into a jacket that can be worn (p. 269).

The struggle for PEH to access water is intensified at night, because many lack the resources to store water (Portillo et al., 2023, p. 16). Further, due to a lack of public restrooms, many times PEH resort to defecating and urinating in buckets inside of their tents (Portillo et al., 2023, p. 1). For this reason, it was important that the "Liquid Lifeline" bring clean water to the user. The innovation allows for the user to carry it by wearing it using the two straps as demonstrated. This way, a user can bring water wherever they need to drink or wash with water at their convenience.

Alignment to Emotional Criteria

The "Emotional Criteria" relates to the convenience and appearance of the product; Essentially, even if the product serves a function, to meet these criteria, users must be willing to actually use it.

The first criterion under "Emotional Criteria" is aesthetics. The researcher incorporated this criterion considering the product developed by Dickinson et al. (2016), who addressed this by coloring the prototype green to blend into natural surroundings, and by enabling the prototype to be folded into a tasteful purse (p. 58).

Since a user will wear the product in public settings, it should be visually appealing. Accordingly, the researcher designed the "Liquid Lifeline" so that the product would expand to hold water when necessary, but when empty, would flatten to be compact.

The second criterion under "Emotional Criteria" is wearability. The researcher incorporated this criterion considering the products developed by Bapat et al. (2023) and Dickinson et al. (2023) who, to recall, addressed this by making their prototypes foldable into a jacket and purse, respectively (p. 269; p. 58).

Carrying a large load of water on one's body can be heavy. Thus, the user has the ability to control how much they carry; the bladder can be filled up partially, if it eases wearability for the user. Furthermore, the "Liquid Lifeline" can be placed into a wagon for transportation over long distances.

The third criterion under "Emotional Criteria" is comfort. The researcher incorporated this criterion considering the product developed by Bapat et al. (2023), who addressed this by designing their product, when folded into a jacket, to have ample armpit ventilation (p. 270).

Correspondingly, the researcher recognized the importance of prioritizing comfort to ensure that the "Liquid Lifeline" was pleasant to wear. Therefore, the "Liquid Lifeline" has two thick straps that allow for the user to wear the product comfortably and offset some of the heavy weight on their front. Further, the straps enable the product to be worn similarly to a backpack but forward-facing, to enable movement.

Conclusion

Throughout this study, the researcher followed Bapat et al. (2023)'s "Frugal Engineering Methodology" to create a product to improve the quality of life of PEH in LA. After analyzing literature published in 2023, the researcher identified a gap in sanitary services provided to this population. The researcher then designed a concept for the "Liquid Lifeline" to answer the question: "Based on the current resources and restraints that shape the lives of unsheltered PEH in LA, how can one develop a social innovation to most effectively and efficiently provide necessary services to this population?"

The researcher is confident that the "Liquid Lifeline" would be useful if distributed to PEH in LA. However, as previously stated, the lack of funding and time precluded prototyping and implementing the product at this juncture.

One limitation of this study was the exclusion of literature. Due to the large volume of articles generated from these search results, the researcher ceased evaluating sources from a search after three consecutive articles failed the CRAAP test. If the researcher continued reviewing articles in a search, additional articles may have been relevant, and the inclusion of additional information from these articles in the thematic analysis could have affected the selection of a theme and design of the innovation.

Another limitation concerns subjectivity in some of the aspects of the creative process. This may have impacted the selection of literature using the CRAAP test, because while the test outlines specific criteria to determine the reliability of sources, different researchers may express different judgments and apply those criteria differently. This potential for subjectivity is apparent in the researcher's coding methodology during the thematic analysis. If other researchers replicated this research, the themes applied to claims may have been slightly different.

Subjectivity was also present during the researcher's selection of a need that the innovation was designed to address. The *National Library of Medicine* stated that all of the seven themes assessed pose significant threats to the health of PEH; the researcher's methodology could have allowed them to select any of the other six themes to address via frugal engineering. Therefore, the selection of sanitation was a preference based on the justifications detailed in the "Methodology" section, and did not need to be methodologically considered.

Another potential limitation is that the data-informed questions that the researcher used to select a theme did not consider that there were fewer articles addressing sanitation than there were addressing some of the other themes. Although the researcher concluded that they gathered sufficient data regarding sanitation, only a handful of sources informed the design of this product. On the other hand, it could be argued that the relative paucity of articles on the subject (but abundance of claims identified) shows that there is a lack of attention brought to the very real sanitary needs of PEH, thus strengthening the necessity for a product like the "Liquid Lifeline".

Nevertheless, the researcher is confident that the creative process followed was sound and resulted in an innovation that would effectively address a very real need of PEH in LA. They hope that subsequent research will result in the prototyping, amendment, manufacturing, and distribution of the "Liquid Lifeline" given its justified necessity and efficiency. Subsequent research should also consider the thematic analysis to develop

social innovations to address the other six themes, as they all involve relevant struggles of unsheltered PEH in LA that are not addressed by the "Liquid Lifeline".

Even if they do not use the information that this researcher collected, subsequent researchers should replicate this creative process, taking new data into account, particularly given the general lack of existing literature elaborating on a replicable methodology to achieve a frugally designed product like this one (Bapat et al., 2023, p. 267). Homelessness in LA is a complex and dynamic issue; much has changed for PEH in the city in 2023 with the addition of Mayor Bass's new programs, the end of COVID-19 aid for low-income households, and rising rates of evictions, and the expected increase in rates of homelessness in LA in upcoming years (Karlamanga, 2024; Blood, 2023). Subsequent researchers who take later information into account will thus likely identify different claims than this research did, even if they replicate this creative process.

Later researchers should also consider the emotional impact that resource insecurities and the design of the innovation have on PEH (Portillo et al., 2023, p. 15). Dickinson et al. (2016) considered user opinion in amending the design of their innovation, and they requested several changes to the initial design (p. 53). This is because, being the intended users of the product and the ones living unsheltered, their opinions matter most.

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