Jun 8th, 9:00 AM - Jun 12th, 5:00 PM

Designing the service exposome: Applying the D4L Unclock Framework to longevity challenges

Sheng-Hung Lee
University of Michigan, Urban Technology; d-mix lab

Citation

Lee, S. (2026) Designing the service exposome: Applying the D4L Unclock Framework to longevity challenges, in Simeone, L., Gray, C. M., Verhoeven, A., de Götzen, A., Bakırlıoğlu, Y., Zohar, H., Stead, M., and Buwert, P. (eds.), *DRS2026: Edinburgh*, 8–12 June, Edinburgh, United Kingdom. https://doi.org/10.21606/drs.2026.741

Designing the service exposome: Applying the D4L Unclock Framework to longevity challenges

Sheng-Hung Lee

[a]University of Michigan Urban Technology
[b]d-mix lab

*Corresponding author e-mail: shdesign@umich.edu

doi.org/10.21606/drs.2026.741

Abstract: In an emerging longevity society, reimagining social infrastructure has become increasingly essential. The World Health Organization (2025) projects that the global population aged 60 and over will nearly double from 12% in 2015 to 22% by 2050, raising urgent questions about how people live and interact with services over time. This study introduces the service exposome, extending Wild's (2005, 2012) exposome concept to consider the cumulative service-related exposures that shape well-being across the lifespan. Using the Design for Longevity (D4L) Unclock Framework—a tool that helps designers explore intersections across longevity, service, system, design, technology, and society—the research examines how early-stage design processes can uncover longevity-related needs. Drawing on two participatory workshops and survey data from 16 undergraduate design students at the Massachusetts College of Art and Design and Northeastern University, the findings suggest that the D4L Unclock Framework and service exposome concept can guide longevity-inclusive, systemic, and experiential design interventions.

Keywords: Design for Longevity; service exposome; participatory design; human-centered design

1. Introduction

We are entering a longevity society (Scott, 2021). According to the United Nations World Population Prospects 2024, by 2080, people aged 65 and older are expected to outnumber those aged 18 and under. By the late 2070s, this group is projected to reach 2.2 billion—surpassing the number of children—and by the 2030s, individuals aged 80 and above will outnumber infants under one year. Even in countries with younger populations, the proportion of older adults is expected to continue growing over the next 30 years. This disruptive demographic shift (Coughlin, 2014) calls for systemic transformation across social infrastructure (Golden, 2022; Cipolla et al., 2016), from mobility (Palmieri et al., 2024) and aging in place (Lin et al., 2024) to health care (Attia & Gifford, 2023), finance (Lee, F. Coughlin, Hodara, & C. Yang, 2024), workspace (Susan Nicholas et al., 2024; Thoring et al., 2024; Savut & Demirkan, 2014), and education (Vincent-Lancrin, 2008). Preparing for a

longevity society (Lee & Sicklinger, 2024) requires inclusive frameworks and evidence-driven approaches that address both individual and environmental dimensions over time. To frame these transformations more holistically, this study draws on the exposome paradigm (Wild, 2012; 2005) to preliminarily examine how cumulative environmental and service-system exposures shape human experience across the life course.

1.1 Service exposome

The exposome encompasses the totality of environmental exposures an individual experiences from conception to death and the cumulative influence of those exposures on their physical health and emotional well-being. The concept, introduced by Christopher Paul Wild (2012; 2005), highlights the need to complement genomic data with comprehensive assessments of environmental factors to better understand disease etiology. The exposome is typically divided into three domains: 1. General external — social capital, education, socioeconomic status, psychological stress, and physical environments (urban–rural, climatic); 2. Specific external — radiation, infectious agents, pollutants, diet, lifestyle, occupation, and medical interventions; and 3. Internal — metabolism, hormones, microbiome, inflammation, oxidative stress, and ageing.

Building on this foundation, Woods et al. (2025) extended the concept to the urban exposome, focusing on the spatiotemporal monitoring of environmental and health indicators. Similarly, Andrianou and Makris (2018) compared and integrated urban and human exposomes through a case study in Limassol, Cyprus. Given the absence of peer-reviewed studies on the service exposome, the author hypothesized that the totality of service-system exposures individuals encounter across life stages shapes their service experiences, blueprints, and systems. This experimental paper explores the notion of service exposome through the Design for Longevity (D4L) Unclock Framework (Lee, 2025b), which comprises three pillars—longevity, service, and system—viewed through the lenses of design, technology, and society (Figure 1). The framework guided 16 Boston-based participants, aged 19-29, in articulating their insights and linking them to their team projects and research interests.

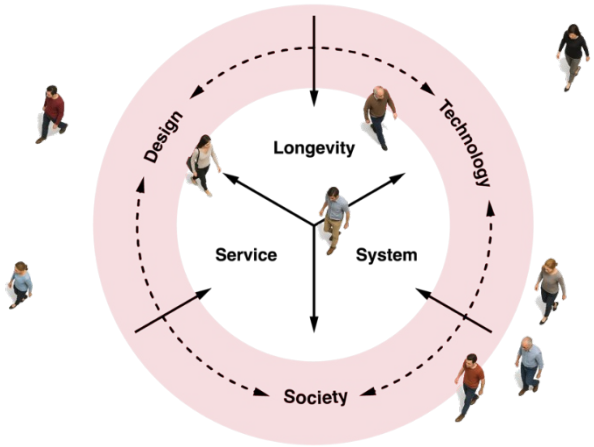

Figure 1 The study employs the D4L Unclock Framework to further examine the concept of the service exposome (diagram adapted from Lee, 2025).

1.2 Design for Longevity

Drawing on a preliminary literature review spanning product lifecycle design, financial planning, and gerontology, Design for Longevity (D4L) is interpreted as a lens for identifying longevity-oriented design opportunities and envisioning products, services, and experiences that enable people to thrive across their lifespan in the context of shifting age demographics (Lee, 2026; Lee et al., 2023). Distinct from design for linearity (purchase–use–dispose) or design for circularity (resource optimization within closed loops) (Ellen MacArthur Foundation & IDEO, 2017), D4L emphasizes the co-evolutionary relationship between service providers (e.g., organizations), service recipients (e.g., users), and design systems across life stages and scales—from products to services to cities. To clarify these differences, Table 1 outlines three design paradigm shifts—linearity, circularity, and longevity—across core considerations, design intentions, temporal orientation, and representative literature.

Table 1. The paradigm shifts from linearity, circularity, and longevity

	Design for Linearity	**Design for Circularity**	**Design for Longevity**
Core Consideration	Efficient production and consumption within product-centric systems	Sustainable circulation of materials and products	Supporting human flourishing across extended lifespans within human–technology–society systems
Design Intension	Linear production and consumption (purchase–use–dispose) emphasizing efficiency and economic growth	Closed-loop systems (reduce–reuse–recycle) emphasizing sustainability and resource regeneration	Life-course design and societal resilience supporting long, healthy, and meaningful lives
Temporal Orientation	Short-term consumption cycles; mass production and cost optimization	Medium-term product and material lifecycles emphasizing durability, repairability, and recyclability	Long-term, multigenerational futures emphasizing adaptability, life transitions, wellbeing, and societal impact
Key Reference	Industrial production and consumption paradigm (Ulrich et al., 2026; Simon, 1978; Papanek, 1971; Vance, 1966)	Circular economy (Møller Haase & Laursen, 2023; Stahel, 2016; Ellen MacArthur Foundation & IDEO, 2017; McDonough & Braungart, 2002)	Longevity economy (Coughlin, 2017); Transformation economy (Pine II, 2026); Life-course design (Lee, 2026; Lutz, 2022)

Building on this theoretical foundation, the D4L Unclock Framework (Figure 2) introduces three pillars and three lenses as an experimental model to advance the discussion of the concept of service exposome. The framework provides participants with flexibility to reimagine the short and long hands of the traditionally defined clock. The use of the term “unclock”—and its accompanying visual metaphor—signals that the perception of time is not necessarily linear or continuous, but rather contextual and evolving.

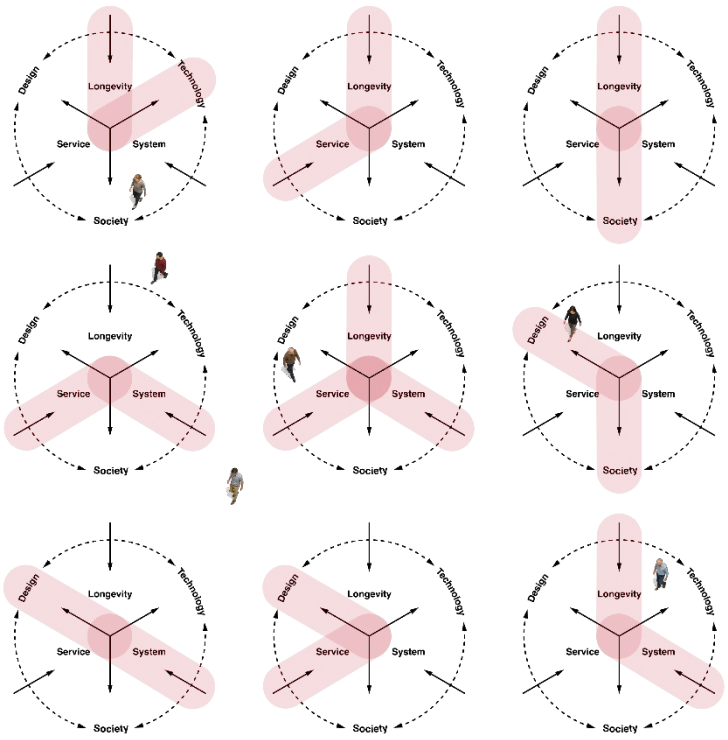

Figure 2 Nine possible configurations for applying the D4L Unclock Framework (diagram adapted from Lee, 2025).

The author used Bluebikes—formerly Hubway, Boston's bicycle-sharing system (Figure 3)—as a case study to operationalize the D4L Unclock Framework, which integrates three pillars (longevity, service, and system) and three lenses (design, technology, and society). The Longevity pillar examines accessibility across ages and abilities: How do design features accommodate users over time? For instance, Bluebikes could better serve families by offering easily attachable children's seats. The Service pillar focuses on user journeys and transitions between touchpoints. Bluebikes exemplify seamless service integration through its app-based rental and return process for both analog and electric bikes. The System pillar highlights interconnections among infrastructure, environment, and policy. Bluebike stations often occupy nodes linking parks, playgrounds, and transit networks, reinforcing their role in a broader urban mobility system.

Figure 3 Bluebikes, Boston's bicycle-sharing system (Photo credit: Sheng-Hung Lee).

Across the lenses, the Design lens assesses how physical and cognitive features foster safety, trust, and equitable access. For instance, the current seat height adjustment range on Bluebikes does not adequately accommodate users with shorter or taller body proportions (e.g., children or tall adults). Furthermore, the bicycles could better support riders' needs by incorporating additional space for device placement (e.g., GPS navigation) and water bottle storage. The Technology lens raises questions about inclusivity and dependency on digital tools: Bluebikes primarily serves smartphone users, thereby limiting access for those using traditional payment methods. Finally, the Society lens considers social norms, culture, and policies that shape behaviour—such as public expectations and policies regarding helmet use, and city efforts to expand dedicated bike lanes.

1.3 D4L Cards

The D4L Cards were originally co-designed and developed by designers and scholars from the Massachusetts Institute of Technology (MIT) AgeLab, Northeastern University's College of Arts, Media and Design, and Moholy-Nagy University of Art and Design (MOME) Social Design Hub (Lee, 2025a; Csernák & Lee, 2024; Lee et al., 2023), drawing on insights from more than 50 expert interviews on service design and longevity planning. The 12 cards encompass key themes: mobility, home, community, education, health, family, future, investment, risk, trust, care, and communication. Each card presents longevity-relevant scenarios, thought-provoking questions, and illustrative visuals.

Similar to the D4L Unclock Framework, the printed cards serve as structured tools to help participants navigate abstract and complex longevity planning challenges while engaging with the emerging notion of the service exposome. During the workshops, the D4L Cards effectively facilitated dialogue among participants, who wrote down their initial reflections and design ideas about the concept of service exposome on Post-it Notes (Figure 4).

Figure 4 The 12 D4L Cards served as participatory prompts, used in conjunction with the D4L Unclock Framework to help participants think holistically about the service exposome (Photo credit: Sheng-Hung Lee).

2. Case study

This preliminary study investigates how the concept of the service exposome can be collectively explored through the Design for Longevity (D4L) Unclock Framework (Lee, 2025b) and D4L Cards. Two 2.5-hour participatory design workshops were conducted with students from the Massachusetts College of Art and Design (MassArt) Industrial Design Department and Northeastern University's College of Arts, Media, and Design (CAMD). Pre-survey data (n = 16) showed that most participants were in their second year (47%) or fourth year (47%), with one participant in their third year and no freshmen. The gender distribution was 38% male and 63% female. Most respondents had not heard of the terms "human exposome" (81%) or "urban exposome" (88%). Table 2 summarizes participants' demographics.

Table 2. Demographic information of the recruited participants.

University	**MassArt**	**CAMD**
# of participants	n=7	n=9
Workshop date	September 29, 2025	September 11, 2025
Workshop time	16:30~18:30 EST	14:00~16:00 EST
Year of study	All are fourth-year undergraduate students.	The group is composed of one fourth-year, one third-year, and seven second-year undergraduates.
Gender	4 males, 3 females	2 males, 7 females
Major	Industrial design	Interaction design, computer science, and business

2.1 Workshop flow and experience

To ensure consistency and scalability, both workshops followed five standardized procedures: 1. recruitment, 2. pre-survey, 3. workshop, 4. documentation, and 5. analysis. The target participants were young adults aged 19–29, allowing us to explore how individuals in early adulthood envision their future selves. Prior to each session, participants completed a five-minute pre-survey assessing their understanding of the human and urban exposome and related longevity concepts. Participants then formed teams of two to three for collaborative concept exploration and discussion.

The workshops were held in university classrooms that provided privacy and basic supplies, including Post-it notes, Sharpies, letter-size paper, foam core board, scissors, and other stationery. Figure 5 illustrates one of the in-person participatory workshop settings, with workshop materials prepared in a medium-sized classroom at the Massachusetts College of Art and Design. Each in-person session lasted approximately 2.5 hours, structured as follows:

1. **Introduction** (30 minutes): Overview of the exposome concept, including its history and implications.
2. **Hands-on session** (45–60 minutes): Teams used foam-core-printed D4L Unclock Frameworks and 12 D4L Cards to articulate and visualize their interpretations of the service exposome. The framework guided participants

in structuring overarching themes, while the cards offered life-relevant prompts and scenarios to support discussion and clarify complex ideas.

3. **Idea sharing and reflection** (45–60 minutes): Each team presented for about 10 minutes, sharing their understanding of the service exposome and D4L, along with reflections on the effectiveness of the framework and cards.

Figure 5 In-person participatory workshop held in a medium-sized classroom at the Massachusetts College of Art and Design (Photo credit: Jake Belcher).

Following the workshops, the author analysed and synthesized data from pre-surveys, photographs, and field notes. Acting as both host and observer, the author employed a think-aloud protocol (Charters, 2003; Ericsson & Simon, 2002) to document participants' verbal and behavioural interactions during the sessions. For qualitative analysis, the collected data were coded and synthesized using constructivist grounded theory (Charmaz, 2025). Preliminary themes were identified and compared with survey findings to support the interpretive claims. Table 3 provides an overview of the five-step workshop process.

Table 3. Overview of workshop flow and explanation

Steps	**Explanation**
1. Recruitment	Sixteen undergraduate students from MassArt and CAMD were recruited to participate in two workshops.
2. Pre-survey	Participants completed a 5-minute pre-survey before the in-person workshop.
3. Workshop	Each 2.5-hour session included: 1. an introduction to the exposome concept; 2. team discussions using the D4L Unclock Framework and D4L Cards; and 3. idea sharing.
4. Documentation	The author applied think-aloud method, photographed participants' work and collected completed D4L Unclock Framework templates.
5. Analysis	Verbal and behavioural data were derived from pre-survey responses and workshop documentation, including photos, video recordings, and observation notes, and subsequently analysed.

2.2 Research result

This section presents the pre-survey results and workshop observations. In the pre-survey, 16 participants were asked to imagine building a LongevityTech City to gauge their understanding of longevity-related issues and their future selves. In response to the question, "Which areas are most critical for building a LongevityTech City?" the top three choices in Figure 6 were public transportation and mobility (16%), community and social engagement (15%), and housing and the built environment (14%).

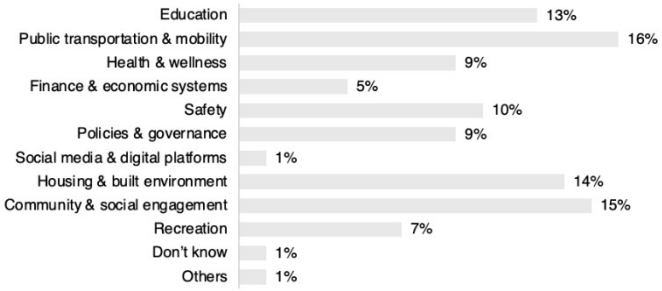

Figure 6 Pre-survey result of the question "Which of the following areas are most critical for building a LongevityTech City? (Select all that apply)"

In response to the question, "When you hear the term LongevityTech City, what are the top three keywords that come to mind?" participants' answers were grouped into ten themes. Community was mentioned most frequently (17%), followed closely by technology, accessibility, and urban (each 14%), while the remaining themes each accounted for 7% (Figure 7).

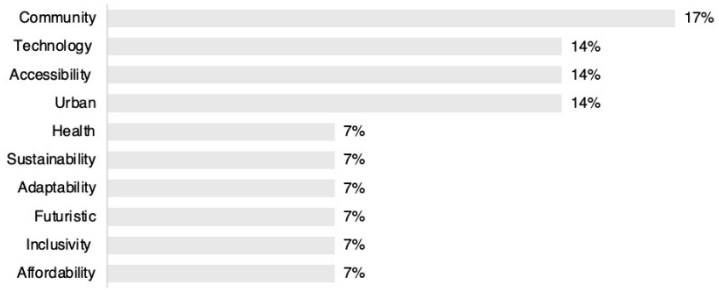

Figure 7 Pre-survey result of the question "When you hear the term LongevityTech City, what are the top three keywords that come to mind?"

In the pre-survey, two open-ended questions were used to explore participants' interpretations of "LongevityTech City" and its relationship to D4L and the emerging concept of the service exposome. When asked, "In your own words, what does LongevityTech City mean to you?" responses reflected technological, social, and individual perspectives.

Some emphasized technology: *"a city that utilizes technology to support both current and future generations"* or *"a place where people can live long, healthy lives through technology."* Others focused on community*:* "an inclusive city that caters to everyone's needs, regardless of background or ability." Individual-centered responses described it as *"an urban space centered around human connection through age-appropriate, user-friendly tech"* and *"a city where all walks of life and ages can experience fully."*

A few responses reflected a concept of the service exposome, linking longevity with time, adaptability, and sustainability: *"a city planned to last centuries, adaptable to future technologies"* or *"an ever-changing city that supports citizens' well-being sustainably."* One participant elaborated: *"a proposal for urban societies that integrate technologies, services, and systems to support aging populations flexibly across life stages."* A small number expressed uncertainty, such as *"I don't know; this looks like a trademarked term."*

In addition to the pre-survey, the study captured and synthesized workshop observations using a think-aloud approach. Sixteen participants worked in pairs, using the 12 D4L Cards as conversation prompts to map their interests within the D4L Unclock Framework. During the 2.5-hour workshop, the author joined team discussions to explore participants' reasoning behind specific placements and interpretations of the clock hands. The author summarized the key findings into three themes: ambiguity, future-oriented thinking, and dynamic condition.

Ambiguity: Although the D4L Unclock Framework comprises three pillars (longevity, service, and system) and three lenses (design, technology, and society), participants found it challenging to identify which dimensions best aligned with their interests or research when considering the concept of service exposome. More scaffolded, step-by-step instructions are needed to help them connect the framework to specific research questions, projects, or domains.

Future-oriented thinking: In both workshops, the D4L Unclock Framework and 12 D4L Card scenarios prompted participants to move beyond current conditions and consider longer-term futures. This structure supported multi-temporal reflection, allowing participants to imagine how experiences and needs may evolve across ages, life stages, and extended timeframes.

Dynamic condition: Throughout the workshop and subsequent reflections, participants engaged with the D4L Unclock Framework as a dynamic condition rather than a static form. They iteratively mapped, layered, and reinterpreted the framework—sometimes redrawing it multiple times with added colours, annotations, and conceptual layers. In doing so, they shifted away from the traditional notion of fixed temporal sequencing and instead used the framework as a "colour palette" for visualizing complexity, interdependencies, and multi-perspectival reasoning (Figure 8).

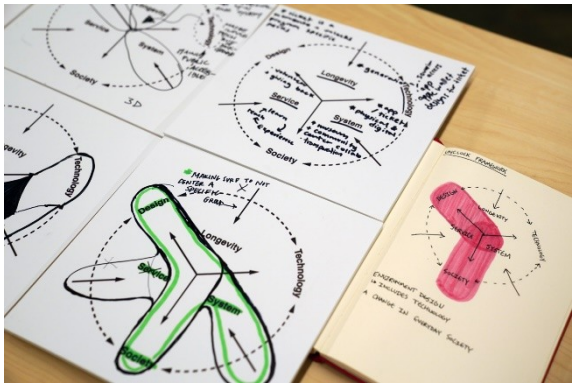

Figure 8 Participants using the D4L Unclock Framework to map their interests and explore the concept of the service exposome. The framework is context-dependent (Photo credit: Sheng-Hung Lee).

3. Discussion

3.1 D4L Unclock Framework as a cognitive scaffold

The findings reveal that while the service exposome remains an emerging and abstract construct, the D4L Unclock Framework offers a productive entry point for exploring its implications in design education and practice. Participants initially found mapping longevity-related themes challenging, underscoring the conceptual openness of both "service exposome" and "LongevityTech City." This ambiguity, though challenging, prompted reflection and dialogue—key components of participatory and speculative design inquiry (Anthony Dunne & Raby, 2013; Sanders & Stappers, 2008).

The workshop observations and discussion with participants suggest that the D4L Unclock Framework can function as a cognitive scaffold to support systems thinking across temporal scales. The shift toward future thinking illustrates participants' intuitive movement from problem identification to anticipatory reasoning, resonating with service design's focus on envisioning future touchpoints (Meroni & Sangiorgi, 2011). The in-sequence theme further reflects how participants negotiated the framework's visual metaphor—not as a literal clock, but as a dynamic palette enabling plural temporalities and interdependencies. Moreover, the two participatory workshops highlighted how early-stage designers interpret longevity as both a personal and systemic concern. This aligns with the broader agenda of D4L (Lee, F. Coughlin, Hodara, C. Yang, et al., 2024), which advocates for an integrative view that bridges product, service, and city scales. By linking the service exposome to D4L, the study extends prior discourse on the urban exposome (Woods et al., 2025; Andrianou & Makris, 2018), situating design as a methodological bridge between environmental and social determinants of well-being.

3.2 Service exposome as a life-course design lens

The concept of the service exposome offers a new analytical lens for service design research (Penin et al., 2026) by foregrounding the cumulative exposure of individuals to multiple service systems (Suoheimo et al., 2025) across the life course. While existing service design methods, such as customer journey maps, service blueprints (Bitner et al., 2008), or touchpoint analysis, typically focus on interactions within a single service context or a limited time frame, the service exposome concept shifts attention to how diverse services (e.g., mobility, health, finance, education, and community infrastructure) collectively shape human well-being over time. In this sense, the service exposome enables designers and researchers to examine how service environments interact across scales and life stages, revealing patterns of inclusion, exclusion, and long-term support that may remain invisible when services are analysed in isolation.

Within this study, the D4L Unclock Framework (Lee, 2026) functioned as a cognitive scaffold that helped participants map these relationships across longevity, service, and system pillars through the lenses of design, technology, and society. By encouraging participants to consider how service experiences accumulate and evolve, the framework supported a shift from short-term problem solving toward life-course and systemic reasoning. By strategically using the D4L Unclock Framework, the service exposome concept extends prior discussions of the urban exposome (Andrianou & Makris, 2018; Wild, 2012; Wild, 2005) by introducing a

design-oriented perspective that links cumulative service exposure with participatory and anticipatory design practices for longevity-oriented futures.

4. Further study

This paper contributes to design research by conceptualizing the service exposome as a framework for mapping cumulative service-system exposures that shape human experiences of longevity. Future research should expand the demographic and disciplinary diversity of participants to test the generalizability of the D4L Unclock Framework beyond design education contexts. Incorporating longitudinal and cross-cultural data could uncover how the service exposome varies across life stages and geographic settings. Additionally, integrating digital ethnography (Pink et al., 2016) and data-driven mapping (e.g., sensor data, mobility traces, service blueprints) could operationalize the service exposome as a measurable construct.

Collaboration with public-sector and industry partners could further translate the framework into actionable design tools for longevity-oriented policymaking, urban planning, and service innovation (Selloni, 2025; Cipolla et al., 2016). A future iteration of this research could involve prototyping a service exposome atlas, which would visualize the cumulative exposure of individuals to service systems across time and contexts, providing a design-driven parallel to existing environmental and health exposome models relevant to longevity. Subsequent studies could further articulate the longevity planning relationship between exposome theory and design outcomes by investigating methods to quantify, model, and intervene in cumulative service exposures through design practice.

5. Conclusion

This experimental study demonstrates the potential of the Design for Longevity (D4L) Unclock Framework as a generative medium for conceptualizing the service exposome and longevity-related design challenges. Drawing on insights from two participatory workshops, the findings reveal how participants engaged with technological, social, and individual dimensions, encouraging systemic and temporal thinking about D4L. Three key insights—ambiguity, future-oriented thinking, and dynamic condition—highlight the framework's value in cultivating reflexive and anticipatory mindsets among emerging designers. By bridging design methods with exposome thinking, this preliminary research contributes to the evolving discourse on how service systems shape human well-being over time. It positions design not merely as a tool for problem-solving, but as an epistemological approach for understanding exposure, adaptation, and intergenerational continuity in a longevity society.

Acknowledgements: The author acknowledges the generous research support from Massachusetts College of Art and Design (MassArt), Northeastern University College of Arts, Media and Design (CAMD), MIT AgeLab, MIT Ideation Lab, and d-mix lab.

6. References

Andrianou, X. D., & Makris, K. C. (2018). The Framework of Urban Exposome: Application of the Exposome Concept in Urban Health Studies. *Science of The Total Environment*, *636*, 963–967. https://doi.org/10.1016/j.scitotenv.2018.04.329

Anthony Dunne, & Raby, F. (2013). *Speculative Everything*. The MIT Press. JSTOR. http://www.jstor.org/stable/j.ctt9qf7j7

Attia, P., & Gifford, B. (2023). *Outlive: The Science and Art of Longevity* (First edition). Harmony.

Bitner, M. J., Ostrom, A. L., & Morgan, F. N. (2008). Service Blueprinting: A Practical Technique for Service Innovation. *California Management Review*, *50*(3), 66–94. https://doi.org/10.2307/41166446

Charmaz, K. (2025). *Constructing Grounded Theory* (Third edition). Sage.

Charters, E. (2003). The Use of Think-aloud Methods in Qualitative Research An Introduction to Think-aloud Methods. *Brock Education Journal*, *12*(2). https://doi.org/10.26522/brocked.v12i2.38

Cipolla, C., Prestes Joly, M., Watanabe, B., Zanela, F., & Tavares, M. (2016, May 24). Service Design for Social Innovation: The Promotion of Active Aging in Rio De Janeiro. *ServDes 2016: Service Design Geographies*. ServDes 2016: Service Design Geographies. https://doi.org/10.21606/servdes2016.41

Coughlin, J. F. (2014). Disruptive Demography: The New Business of Old Age. In P. H. Irving & R. Beamish (Eds.), *The Upside of Aging* (1st ed., pp. 51–62). Wiley. https://doi.org/10.1002/9781118691823.ch4

Coughlin, J. F. (2017). *The Longevity Economy: Unlocking the World's Fastest-Growing, Most Misunderstood Market* (First edition). PublicAffairs.

Csernák, J., & Lee, S.-H. (2024). Prototyping Future Visions of Vulnerable Youth Through Design for Longevity and Gender Equity. *diid*, *1*(82). https://doi.org/10.30682/diid8224d

Ellen MacArthur Foundation, & IDEO. (2017). *The Circular Design Guide*. https://www.ellenmacarthurfoundation.org/circular-design-guide/overview

Ericsson, K. A., & Simon, H. A. (2002). *Protocol Analysis: Verbal Reports as Data* (rev. ed., 4. pr). The MIT Press.

Golden, S. W. (2022). *Stage (Not Age): How to Understand and Serve People Over 60-the Fastest Growing, Most Dynamic Market in the World*. Harvard Business Review Press.

Lee, S.-H. (2025a). Boundary Objects: Reimagining Design for Longevity and Gender Equality. In C. Sedini (Ed.), *Gender Perspectives for a Renewed Design Culture: Unveiling Dynamics in Academic, Professional and Civic Lives of Women* (pp. 77–93). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-88554-9_8

Lee, S.-H. (2025b). Design Future Longevity: Unclocking Time, Age, and Society. *Design Management Institute (DMI): Review*, *36*(2). https://www.dmi.org/store/viewproduct.aspx?id=26399991

Lee, S.-H. (2026). *D4L: Exploring Design for Longevity*. Springer Cham. https://link.springer.com/book/9783032158499

Lee, S.-H., F. Coughlin, J., Hodara, S., & C. Yang, M. (2024, June 23). *Enhancing Financial Education for Longevity through Service Design*. DRS2024: Boston. https://doi.org/10.21606/drs.2024.364

Lee, S.-H., F. Coughlin, J., Hodara, S., C. Yang, M., L. De Weck, O., Klopfer, E., & Ochsendorf, J. (2024, June 23). *Design for Longevity Literature Review in Product Lifecycle, Financial Planning, and Gerontology*. DRS2024: Boston. https://doi.org/10.21606/drs.2024.363

Lee, S.-H., Hodara, S., Coughlin, J. F., Yang, M., Chen, Y.-C., Lin, Y.-C., & Liou, S.-N. (2023, November 22). Designing Healthcare Services for Longevity. *Narratives of Love Towards Healing, Transformation, and Transcendence*. Cumulus Beijing 2023.

Lee, S.-H., & Sicklinger, A. (2024). Design for Longevity: People, Process, and Platform. *diid*, *1*(82). https://doi.org/10.30682/diid8224a

Lin, Y.-T., Chen, W.-C., Yu, H.-T., & Cho, I.-T. (2024, June 23). *Spatial Distribution, Characterization, and Policy Opportunities for Taiwan's Solo Elderly: A Big Data Approach*. DRS2024: Boston. https://doi.org/10.21606/drs.2024.366

Lutz, D. (2022). *The Life-centred Design Guide*. Damien Lutz.

McDonough, W., & Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things*. North Point Press.

Meroni, A., & Sangiorgi, D. (2011). *Design for Services* (0 ed.). Routledge. https://doi.org/10.4324/9781315576657

Møller Haase, L., & Laursen, L. N. (2023). *Designing for Longevity: Expert Strategies for Creating Long-Lasting Products*. Routledge.

Palmieri, S., Ianniello, A., & Bisson, M. (2024, June 23). *Key-Drivers to Design Urban Mobility Services for Silver Age and Age-Friendly Cities.* DRS2024: Boston. https://doi.org/10.21606/drs.2024.315

Papanek, V. (1971). *Design for the Real World: Human Ecology and Social Change*. Pantheon Books.

Penin, L., Prendiville, A., & Sangiorgi, D. (Eds.). (2026). *The Bloomsbury Handbook of Service Design: Plural Perspectives and a Critical Contemporary Agenda* (1st edition). Bloomsbury Visual Arts. https://doi.org/10.5040/9781350330313

Pine II, B. J. (2026). *The Transformation Economy: Guiding Customers to Achieve Their Aspirations* (1st ed). Harvard Business Review Press.

Pink, S., Horst, H. A., Postill, J., Hjorth, L., Lewis, T., & Tacchi, J. (2016). *Digital Ethnography: Principles and Practice*. SAGE.

Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the New Landscapes of Design. *CoDesign*, *4*(1), 5–18. https://doi.org/10.1080/15710880701875068

Savut, N., & Demirkan, H. (2014, April 9). Priority Setting For Service Design in Age-Friendly Cities: The City of Ankara. *ServDes 2014: Service Future*. ServDes 2014: Service Future. https://doi.org/10.21606/servdes2014.1

Scott, A. J. (2021). The Longevity Society. *The Lancet Healthy Longevity*, *2*(12), e820–e827. https://doi.org/10.1016/S2666-7568(21)00247-6

Selloni, D. (2025, October 6). A New Generation of Collaborative Public Services. *ServDes 2025: Empowering Diversity, Nurturing Lasting Impact*. ServDes 2025: Empowering Diversity, Nurturing Lasting Impact. https://doi.org/10.21606/servdes2025.11

Simon, H. A. (1978). *The Sciences of the Artificial* (Paperback ed., 6. print). M.I.T. Pr.

Stahel, W. R. (2016). The Circular Economy. *Nature*, *531*(7595), 435–438. https://doi.org/10.1038/531435a

Suoheimo, M., Jones, P. H., Lee, S.-H., & Sevaldson, B. (Eds.). (2025). *Systemic Service Design*. Taylor & Francis Routledge [Imprint].

Susan Nicholas, D., Singh, T., Deshpande, T., Prabhakar, A., Wenrick, R., & Allen-Handy, A. (2024, June 23). *Intergenerational Creative Spaces, Co-living, Community: Design for Longevity*. DRS2024: Boston. https://doi.org/10.21606/drs.2024.1249

Thoring, K., Kornherr, P., & Kurz, M. (2024, June 23). *Designing Future Workspaces for Cognitive Aging*. DRS2024: Boston. https://doi.org/10.21606/drs.2024.330

Ulrich, K. T., Eppinger, S. D., & Yang, M. C. (2026). *Product Design and Development* (Eighth edition). McGraw Hill.

Vance, P. (1966). *The Waste Makers: Tells the Startling Facts Behind the American Philosophy and Practices of Deliberate Waste*. Pocket Books.

Vincent-Lancrin, S. (2008). What is the impact of demography on higher education systems? A forward-looking approach for OECD countries. In *Higher Education to 2030* (Vol. 1, pp. 41–103).

Wild, C. P. (2005). Complementing the Genome with an "Exposome": The Outstanding Challenge of Environmental Exposure Measurement in Molecular Epidemiology. *Cancer Epidemiology, Biomarkers & Prevention*, *14*(8), 1847–1850. https://doi.org/10.1158/1055-9965.EPI-05-0456

Wild, C. P. (2012). The Exposome: From Concept to Utility. *International Journal of Epidemiology*, *41*(1), 24–32. https://doi.org/10.1093/ije/dyr236

Woods, T., Palmarini, N., Corner, L., Barzilai, N., Maier, A. B., Sagner, M., Bensz, J., Strygin, A., Yadala, N., Kern, C., Ward, P., Ferrucci, L., Bischof, E. Y., Barker, R., Shiels, P. G., Guiot, G., Monti, J., Justice, J., Kennedy, B. K., & Furman, D. (2025). Cities, Communities and Clinics Can Be Testbeds for Human Exposome and Aging Research. *Nature Medicine*, *31*(4), 1066–1068. https://doi.org/10.1038/s41591-025-03519-8

About the Author:

Sheng-Hung Lee, Ph.D. is an Assistant Professor of Urban Technology at the University of Michigan and Director of d-mix lab. Trained in both design and engineering, his work explores how technology and human-centered design can shape more equitable and longevity-ready societies.