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# Recruiting older participants: evaluating the role of message framing in willingness to enroll in wearable robot experiments

Clio Yuen Man Cheng[a,b] and Vivian W. Q. Lou[a,b]

[a]Department of Social Work and Social Administration, The University of Hong Kong, Hong Kong, China; [b]Sau Po Centre on Ageing, The University of Hong Kong, Hong Kong, China

**ABSTRACT**
Willingness to enroll in experiments plays a vital role in user-centered design, particularly in emerging domains such as wearable robots for daily living assistance, where recruiting older adults poses challenges. Guided by the integration of prospect theory and the senior technology acceptance model, this study aims to investigate the persuasive effects of message framing, specifically the valence (gain: positive framing versus loss: negative framing), in the form of flyers on older adults' willingness to participate in real-life wearable robot experiments. The survey data were collected from 176 online participants ($M_{age}$ = 61.05; *SD*=6.49). Multivariate analysis of variance indicates that gain-framed messages significantly influence perceived health benefits ($F(1, 174) = 14.363$, $p < .001$, $\eta^2 = .09$, 95% CI: .03-1.00). However, message frames do not directly impact the perceived effectiveness of flyers or willingness to enroll. Mediation analysis reveals that gain-framed messages enhance older adults' willingness to enroll in wearable robot experiments through their perception of health benefits (IE: $\beta = -.19$, 95% CI: −.38– −.06, $p = .017$). This study contributes to the understanding of the persuasive effects of message framing on older adults' willingness to enroll in wearable robot experiments, ultimately fostering advancements in the field and enhancing health outcomes and well-being for older adults.

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Komalsingh Rambaree, Department of Social Work and Criminology, University of Gävle, Gavle, Sweden

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## Introduction

Enhancing willingness to enroll in real-life experiments among potential users is crucial for developing novel assistive technologies such as wearable robots, yet researchers have not yet surmounted this barrier (Merkel & Kucharski, 2019). Wearable robots or exoskeletons are powered devices designed to be worn by individuals to augment their physical abilities or assist with specific tasks (Lowe et al., 2019). As the utilization of robotic devices has expanded to encompass military (Proud et al., 2020), industrial (Ralfs et al., 2023), and healthcare (Morris et al., 2023) domains, a burgeoning need has emerged for wearable robots capable of assisting individuals in performing daily living tasks, driven by the worldwide trend of population aging (Scott et al., 2018; World Health Organization [WHO], 2018). The global wearable robots market is projected to grow from USD 1.24 billion in 2023 to USD 14.67 billion by 2030, with a compound growth rate of 42.2% (Fortune Business Insights, 2023; Mordor Intelligence, 2023). Concerted efforts have been witnessed in recent years, ranging from full-body exoskeleton for physical assistance (Christensen et al., 2019), ankle exoskeleton for ambulation assistance (Fang et al., 2022), hip exoskeleton for walking function improvement (Jayaraman et al., 2022), to intelligent robotics for daily assistance (Lou et al., 2023), among community-dwelling older adults. Despite sustained initiatives, the acceptance and adoption of wearable robots by potential users remain notably subdued.

Low usability (e.g. discomfort over time, bulky in size, or restrictive for daily use), safety concerns, appearance, and a lack of perceived usefulness (in terms of health benefits) have been identified as

**CONTACT** Clio Yuen Man Cheng cliocym@connect.hku.hk Department of Social Work and Social Administration, Jockey Club Tower, Centennial Campus, The University of Hong Kong, Pokfulam, Hong Kong, China

major reasons for the low acceptance of wearable robots (Chen et al., 2023; Luciani et al., 2023; Morris et al., 2023; Shore et al., 2022), which should all have been addressed before product marketization, with full engagement of potential users such as older adults (Merkel & Kucharski, 2019; Shah et al., 2021). The low enrollment of older adults in wearable robot experiments, including idea generation, prototype design and development, as well as prototype testing, has detrimental implications for research and development endeavors (Cheng et al., 2022). It undermines the generalizability of findings, diminishes statistical power, and impedes the advancement of customized solutions (Chen et al., 2023; Luciani et al., 2023; Morris et al., 2023; Shore et al., 2022). More importantly, the ultimate goal to enhance the quality of life of older adults will be hindered and a large sum of investment in wearable robots will be wasted (Cheng et al., 2022). The senior technology acceptance model (STAM) is a theoretical framework that focuses on understanding and predicting older adults' acceptance and adoption of technology by considering their unique characteristics, such as attitudinal beliefs, control beliefs, gerontechnology anxiety, and health conditions (Chen & Chan, 2014; Chen & Lou, 2020). While the STAM has been widely adopted to predict technology acceptance among older adults, it falls short of examining factors related to the most vital part of technology development, that is the willingness to enroll in experiments in older adults.

We propose to use the prospect theory to guide our study as message framing has been found to influence recruitment in research and intervention studies (Machado et al., 2019; Speight et al., 2021), details will be discussed in a later section. Message framing refers to the strategic presentation of information or messages in a way that emphasizes either the potential gains or losses associated with a particular decision or action, influencing individuals' perceptions and attitudes towards the subject matter (Gallagher & Updegraff, 2012; Gisbert-Pérez et al., 2022). This is therefore reason to believe that message frames could be effective in enhancing the willingness to enroll in wearable robot experiments in older adults. However, to our best understanding, no prior research has examined what type of message frames (i.e. gain versus loss) should be highlighted, and in what way. The present study therefore explores the efficacy of gain- versus loss-framed messages (presented as visual messages on flyers) on the willingness to enroll in wearable robot experiments, focusing on plausible outcomes: gains obtained if using the wearable robots versus losses suffered if not using the wearable robots. First, the study asks which message frames will be more conducive to perceived health benefits. Second, we seek to understand if the perceived effectiveness of stimuli differed, after exposure to either gain- or loss-framed messages presented in flyers advertising real-world wearable robot experiments. We also examine the way message framing predicts willingness to enroll in wearable robot experiments in older adults.

### *Study context*

The global population aging trend is irreversible. The number of people aged 65 years and over will rise from 761 million in 2021 to 1.6 billion in 2050, accounting for around 22% of the total world population (United Nations, 2023). Mobility is an important component of healthy aging (World Health Organization [WHO], 2015), however, around 35% of persons aged over 70 are affected by mobility limitations (Webber et al., 2010). China is also experiencing a rapid demographic shift, with an estimation of tripling its elderly population between 2015 and 2050, with more than 8% of its total population comprised of older adults aged 80 years and over (OECD, 2017). A recent study found that the standardized prevalence of mobility limitation in community-dwelling older adults in China was 30.4% (Wang et al., 2024). Hong Kong, a special administrative region in China, is expected to have 2.52 million (33.3%) older adults in 2039 (Census & Statistics Department, 2020). According to the latest statistics, there were 295,600 persons with physical disabilities in Hong Kong, and 78.1% were older adults aged 65 or above (Census & Statistics Department, 2022). Among some 244,000 persons with restrictions in body movement, 54.6% required assistance from others, 47.4% were using a wheelchair, and 45.1% were using a crutch or walking stick to assist in mobility (Census & Statistics Department, 2022).

Assistive technologies such as wearable robots cannot reverse mobility impairments, but they have huge potential to improve older adults' mobility and enhance their overall functionality and independence (Scott et al., 2018; WHO, 2018). Since 2017, the gerontechnology field has been developed through significant government and industry initiatives (Wong et al., 2017). For instance, the government earmarked HKD 1 billion to provide subsidies for non-governmental organizations to procure, rent, and trial-use technology products for older adults (Social Welfare Department, 2023). Despite considerable efforts, a recent report revealed that gerontechnology research within universities is one of the major gaps in the gerontechnology ecosystem development (Wong et al., 2021). Another evaluation report suggested that there is a need to enhance older adults' involvement in gerontechnology such as enrolling them in real-life experiments, thus raising the awareness and perceived usefulness of the products (Yee & Lit, 2021). Asia-Pacific is the leader in the research and development of wearable robot technology and is expected to account for the largest market, with Hong Kong as one of the key leaders in the Asia-Pacific region share (Mordor Intelligence, 2023; Xi et al., 2020). Against this background, Hong Kong serves as an ideal location for conducting our study due to its significant advancements in the field of wearable robot technology and its proactive approach to promoting gerontechnology initiatives. In this paper, we propose an innovative framework to enhance the willingness to enroll in wearable robot experiments in older adults.

### *Prospect theory and message framing in health communication*

Prospect theory, proposed by Kahneman and Tversky (1979) and originated in behavioral economics, provides a theoretical framework for understanding individuals' decision-making processes and their responses to different message frames. In health communication, gain-framed messages emphasize obtaining gains and/or avoiding losses when performing an action, while loss-framed messages highlight foregoing gains and/or suffering losses when not performing an action (Guenther et al., 2020). Extensive research has applied prospect theory to investigate the effects of gain- versus loss-framed messages on attitudes, beliefs, and behaviors related to health promotion and preventive measures (Gallagher & Updegraff, 2012; Pența & Băban, 2017; Rothman et al., 2006).

Previous studies have found that gain-framed messages are more effective in promoting preventive behaviors, such as regular exercise and healthy eating habits (Carvalho et al., 2022; Yadav et al., 2021). These messages focus on the potential gains individuals can achieve through health-promoting behaviors, such as improved well-being, disease prevention, and increased longevity (Guenther et al., 2020). Conversely, loss-framed messages tend to be more effective in promoting detection behaviors, such as cancer screenings and early detection practices (Bosone & Martinez, 2017; O'Keefe & Wu, 2012). They emphasize the potential losses or negative consequences individuals may face if they fail to engage in recommended behaviors, such as increased risk of illness or reduced quality of life. Unfortunately, enrollment in real-life experiments is neither a preventive nor detective behavior, it is therefore imperative to address this gap and provide evidence to enhance engagement of potential users.

While the existing literature has contributed valuable insights into the effects of gain- versus loss-framed messages, several limitations remain. Most studies have primarily focused on younger adult populations, leaving a gap in understanding how message framing influences health-related decisions among older adults (Guenther et al., 2020). Furthermore, the majority of research has investigated general health behaviors (Pența & Băban, 2017) and ignored the fact that technological advancement opened a new health arena for exploration (Babič et al., 2021; Davis et al., 2020). There is a need for more context-specific studies, such as examining the impact of message framing in the context of assistive technologies like wearable robot experiment enrollment among older adults. Addressing these gaps will provide a more comprehensive understanding of how message framing influences health-related decisions across diverse populations and contexts.

### *Wearable robots and the role of message framing in willingness to enroll*

Wearable robots, also known as exoskeletons, are a unique and emerging technology with the potential to enhance mobility, functional abilities, and quality of life among older adults (Bützer et al., 2021). These robotic devices are designed to provide physical support and assistance, augmenting or restoring individuals' movements and capabilities (Lowe et al., 2019). Real-life wearable robot experiments offer opportunities for older adults, the potential users, to experience the benefits of this technology first-hand and offer immediate feedback for prototype development (Ármannsdóttir et al., 2020; Lou et al., 2023).

*Perceived health benefits* have been found to have a positive influence on technology acceptance, such as mHealth apps (Palos-Sanchez et al., 2021). It can be operationalized as attitudinal beliefs in the STAM—the first and only technology acceptance model targeting older adults—focusing on the perceived usefulness of gerontechnology in terms of health benefits (Chen & Chan, 2014; Chen & Lou, 2020). In the context of wearable robot experiments, older adults may have concerns about the potential health outcomes and impacts of this new assistive technology in their later lives, particularly improvements in performing daily living activities by enhancing mobility functions. Investigating how different message frames influence older adults' perceptions of the health benefits associated with wearable robots can inform the development of persuasive recruitment materials that effectively communicate the potential positive impacts on health and well-being, without raising ethical concerns (Speight et al., 2021).

*Perceived effectiveness* of recruitment materials, such as flyers, is another important factor in older adults' decision-making processes (Mikels et al., 2020). Flyers are commonly used to inform and recruit participants for experiments or intervention studies (Machado et al., 2019; Speight et al., 2021). Message framing can influence older adults' perceptions of the effectiveness of these flyers in conveying the necessary information and motivating their willingness to enroll. Understanding the role of message framing in shaping older adults' perceptions of the perceived health benefits associated with wearable robots and the perceived effectiveness of recruitment materials is crucial to increasing their *willingness to enroll* in real-life experiments.

## Methods

### Sample and procedure

This study was approved by the Human Research Ethics Committee of the University of Hong Kong. Upon scanning the QR code or accessing the recruitment link provided on a recruitment poster, potential participants were directed to an initial page that concisely outlined the objectives of the study. Subsequently, on the following page, participants provided written informed consent online. To qualify for this study, participants had to be (1) Hong Kong residents aged 50 to 74, (2) residing in the community setting in Hong Kong (i.e. not residing in an institutional setting), (3) able to read Traditional Chinese, (4) able to complete a survey and without color blindness, and (5) free from any known cognitive issues such as dementia.

Following the indication of consent, individuals underwent a brief screening process to ascertain their eligibility based on the predetermined inclusion and exclusion criteria delineated earlier. Participants who did not meet the eligibility criteria were gratefully acknowledged and their involvement in the study was discontinued, while those who met the criteria progressed to the main phase of the study. The eligible participants were then randomly assigned to one of the four conditions (see Figure 1) utilizing the built-in randomizer feature in Qualtrics (2023). Subsequently, they received instructions to dedicate a minimum of one minute to reading the provided wearable robot experiment flyer before proceeding to the subsequent section. Finally, participants were given a registration link that directed them to the real-life wearable robot experiment (details elsewhere: https://i-reach.hku.hk/). If enrolled in the current study and passed a data quality check (detailed below), they were compensated with an HKD50 (i.e. around USD6.39) supermarket coupon.

We set a target of gathering approximately 180 questionnaires, and initially, 186 individuals completed the survey. Additionally, to uphold the validity of the questionnaire, we excluded surveys that cannot pass the data quality check (i.e. provided more than two wrong answers for the check item 'This is a check item. Please select 2.'). Eventually, a total of 176 full questionnaires were involved in the data analysis. Participants were 106 women and 70 men, and the average age was 61.05 years (ranging from 50 to 74 years, SD = 6.49). About half (46.59%) of the participants had secondary education, and 32.4% of participants attained a bachelor's degree or above. Meanwhile, 27.8% of participants reported inadequacy in self-perceived financial status. Over half (56.8%) of participants reported poor or fair health status.

### Wearable robot flyers development

This work is part of a larger study of the first author. Four flyers (see Figure 1) were created using Canva, an online design tool for creating professional-looking visuals (Canva, 2023). The message embedded in the flyers was developed based on (a) 11 in-depth interviews on daily activities


**Figure 1.** Wearable robot experiment flyers. (A) and (C) are gain-framed flyers, differed in section one in terms of year vs day. (B) and (D) are loss-framed flyers, differed in section one in terms of year vs day.

challenges and technology perceptions with older adults aged 50 or over, (b) a pilot survey conducted with 30 older adults, and (c) updated literature review (Chen et al., 2023; Guenther et al., 2020; Kim, 2022).

The gain-framed flyers emphasize obtaining gains and avoiding losses by using wearable robots. For instance, the focal message, 'Using wearable robots will increase your ability in performing daily activities', was followed by several additional gain-framed items (e.g. 'improve upper and lower limb mobility', 'increase independent and autonomous living level'). The loss-framed flyers emphasize foregoing gains and suffering losses of not using wearable robots. For instance, the focal message, 'Not using wearable robots will decrease your ability in performing daily activities', was followed by a few loss-framed items (e.g. 'deteriorate upper and lower limb mobility', 'decrease independent and autonomous living level').

## Measurement

### Willingness to enroll

Participants were asked to rate how interested they were in joining a wearable robot experiment after the fourth section of the flyers (see Figure 1). Each participant rated how interested they were on a 1 (not at all) to 6 (extremely) scale, adapted from prior literature (Mikels et al., 2020).

### Perceived health benefits

To measure perceived health benefits of the wearable robots, we adapted three items from an existing study (Palos-Sanchez et al., 2021) and adjusted them to match the message frames. In the gain-framed conditions, the sentences were 'Using the wearable robots can improve your mobility performance (lower limb; first item)/(upper limb; second item)' and 'Using the wearable robots can improve your performance in daily activities'. In the loss-framed conditions, the sentences were 'Not using the wearable robots can worsen your mobility performance (lower limb; first item)/(upper limb; second item)' and 'Not using the wearable robots can worsen your performance in daily activities'. Participants respond as to the extent they agree with each statement on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). An overall score was calculated by averaging the three items, such that higher scores indicated a higher perceived health benefit of wearable robots ($\alpha$ = .89).

### Perceived effectiveness of flyers

Participants were asked to rate how effective the four flyer elements were in convincing them to accept the wearable robots (as described above and demarcated in Figure 1). Each participant rated how effective the flyers were on a 1 (very ineffective) to 6 (very effective) scale, following prior literature (Mikels et al., 2020). A composite score was calculated by averaging the four items, such that higher scores indicated a higher perceived effectiveness of flyers ($\alpha$ = .82).

### Demographic information

Participants were asked to provide demographic information including age (in years), gender (0 = female; 1 = male), and education level (0 = primary or below; 1 = secondary; 2 = higher diploma or associate degree; 3 = bachelor; 4 = master or above). A single item was used to assess perceived financial status in terms of adequacy, each participant rated on a 0 (very inadequate) to 3 (very adequate) scale. Additionally, a single item was used to assess self-rated health (1 = poor; 2 = fair; 3 = good; 4 = very good; 5 = excellent; Idler & Benyamini, 1997).

## Statistical analysis

Our analyses focused on the role of perceived health benefits in the influence of gain- versus loss-framed messages on willingness to enroll in a real-life wearable robot experiment. First, we examined the influence of gain- versus loss-framed messages on perceived health benefits, perceived effectiveness of the flyer, and willingness to enroll in the wearable robot experiment. Next, analyses examined whether perceived health benefits and/or perceived effectiveness predicted willingness to enroll in the wearable robot experiment. Finally, we conducted a mediation analysis to examine if there was an indirect effect of gain- versus loss-framed messages on willingness to enroll in the wearable robot experiment. Given there were no group differences in the perceived effectiveness of flyers and demographic information (see Table 1), all analyses were conducted without control variables. All analyses were conducted in R (R Core Team, 2023).

# Results

## Influence of message frame on perceived health benefits, perceived effectiveness, and willingness to enroll

A multivariate analysis of variance was conducted to examine the effect of the message frame on perceived health benefits, perceived effectiveness of the flyers, and willingness to enroll in the wearable

**Table 1.** Participants' characteristics by message frame condition (N = 176).

| | Gain-framed ($n = 86$) *M (SD)* | Loss-framed ($n = 90$) *M (SD)* | Statistic | *p* |
|---|---|---|---|---|
| Age (in years) | 60.79 (6.54) | 61.29 (6.48) | $t(174) = -.508$ | .612 |
| Gender | 60.5% F, 39.5% M | 60.0% F, 40.0% M | $X^2(1) = .003$ | .950 |
| Education level, *n(%)* | | | $X^2(4) = 1.267$ | .867 |
| Primary or below | 8 (9.3%) | 6 (6.7%) | | |
| Secondary | 39 (45.3%) | 43 (47.8%) | | |
| Higher diploma/Associate degree | 13 (15.1%) | 10 (11.1%) | | |
| Bachelor | 11 (12.8%) | 14 (15.6%) | | |
| Master or above | 15 (17.4%) | 17 (18.9%) | | |
| Financial status, *n(%)* | | | $X^2(3) = 1.733$ | .630 |
| Very inadequate | 0 (0.0%) | 1 (1.1%) | | |
| Inadequate | 21 (24.4%) | 27 (30.0%) | | |
| Adequate | 63 (73.3%) | 60 (66.7%) | | |
| Very adequate | 2 (2.3%) | 2 (2.2%) | | |
| Health status, *n(%)* | | | $X^2(4) = 3.071$ | .546 |
| Poor | 2 (2.3%) | 4 (4.4%) | | |
| Fair | 50 (58.1%) | 44 (48.9%) | | |
| Good | 22 (25.6%) | 32 (35.6%) | | |
| Very good | 9 (10.5%) | 8 (8.9%) | | |
| Excellent | 3 (3.5%) | 2 (2.2%) | | |

**Table 2.** The influence of message frame on perceived health benefits, effectiveness of flyers, and willingness to enroll.

| | Gain-framed ($n = 86$) | Loss-framed ($n = 90$) | Statistic | | | |
|---|---|---|---|---|---|---|
| | *M (SD)* | *M (SD)* | *df* | *MS* | *F* | *p* |
| Perceived health benefits | 3.93 (.53) | 3.55 (.78) | 1, 174 | 6.551 | 14.363 | < .001 |
| Effectiveness of flyers | 4.62 (.81) | 4.58 (.81) | 1, 174 | .048 | .073 | .788 |
| Willingness to enroll | 4.52 (1.27) | 4.51 (1.33) | 1, 174 | .006 | .004 | .951 |

robot experiment (see Table 2). The analysis revealed a significant effect of gain versus loss frame on perceived health benefits ($F(1, 174) = 14.363$, $p < .001$, $\eta^2 = .09$, 95% CI: .03-1.00), such that gain frames evoked more perceived health benefits of the wearable robots. Considering possible health status differences in perceived health benefits, an additional one-way analysis of variance (ANOVA) was conducted. Perceived health benefits did not differ by health status ($F(1, 174) = .391$, $p = .533$). Regarding the other measures, the message frame did not have an effect on perceived effectiveness or willingness to enroll.

## *Did perceived health benefits or perceived effectiveness of flyers predict willingness to enroll?*

Two separate regression analyses examined if perceived health benefits or perceived effectiveness of flyers (note that these two measures were correlated, $r = .397$, $p < .001$). The first regression examined if perceived health benefits predicted willingness to enroll in the wearable robot experiment. This analysis revealed that the more positive perceived health benefits of the wearable robots, the greater willingness there was in enrolling the wearable robot experiment ($\beta = .616$, SE = .133, $p < .001$, 95% CI: .35–.89, $\eta^2 = .11$). The second analysis examined whether perceived effectiveness of flyers predicted willingness to enroll in the wearable robot experiment. This analysis revealed that higher perceived effectiveness of flyers significantly predicted increased willingness to enroll in wearable robot experiments ($\beta = .496$, SE = .116, $p < .001$, 95% CI: .27–.73, $\eta^2 = .10$).

## *Did message frame have an indirect effect on willingness to enroll in the wearable robot experiment via perceived health benefits?*

Given that message frame had a direct effect on perceived health benefits but not perceived effectiveness of flyers, the analyses only examined the former. A mediation analysis examined whether there was an indirect effect of gain- versus loss-framed messages on willingness to enroll in wearable robot experiment (Figure 2), following Hayes' model 4 (Hayes, 2013). Additionally, this analysis used the 'lavaan' package (Rosseel, 2023) in R to estimate the causal mediation effect (indirect effect) and direct effect. Both indirect and direct effect estimates were computed using 10,000 bootstrapped samples, and the 95% CI was computed by determining the effects at the 2.5$^{th}$ and 97.5$^{th}$ percentiles. Compared to the loss frame, the gain frame was associated with increased willingness to enroll in the wearable robot experiment via perceived health benefits (IE: $\beta$ = −.26, 95% CI: −.47– −.11, $p$ = .004). The indirect effect remained significant even when controlling for perceived effectiveness of flyers (IE: $\beta$ = −.19, 95% CI: −.38– −.06, $p$ = .017).

## Discussion

This research set out to examine the influence of message frames (gain versus loss) on willingness to enroll in wearable robot experiments among older adults. The results of this study revealed that gain-framed messages led to significantly higher perceived health benefits of the wearable robots compared to loss-framed messages. However, message frame did not have a significant direct effect on perceived effectiveness of the flyers or willingness to enroll in the wearable robot experiment. Further analysis showed that both perceived health benefits and perceived effectiveness independently predicted a greater willingness to enroll in the wearable robot experiment. Additionally, a mediation analysis demonstrated that message frame indirectly influenced willingness to enroll via perceived health benefits.

### *Theoretical implications*

The finding that gain-framed messages led to higher perceived health benefits is consistent with a substantial body of previous research on the persuasive power of gain-framed messages in promoting positive health behaviors (Li et al., 2022; Murayama et al., 2023; Yadav et al., 2021). Numerous studies have consistently demonstrated that gain-framed messages, which emphasize the potential benefits and improvements associated with a behavior or intervention, are more effective in influencing individuals' attitudes and intentions compared to loss-framed messages (Guenther et al., 2020; Kim et al., 2022). For example, (Guenther et al., 2020) conducted a meta-analysis of health message framing studies and found that gain-framed messages were more persuasive than loss-framed messages across various health domains, including exercise, diet, and disease prevention. Similarly, (Kim et al., 2022) investigated the effects of gain- and loss-framed messages on smoking cessation and observed that gain-framed messages led to higher intentions to quit smoking compared to loss-framed messages. Moreover, a gain-framed graphics flyer has been found to predict a higher willingness to authorize research contact programs (Speight et al., 2021).

Unlike prior studies that raised ethical concerns, such as worries about manipulating information about research or experiments (Speight et al., 2021), our study adds to the existing literature by demonstrating that emphasizing the potential gains and improvements associated with using wearable robots

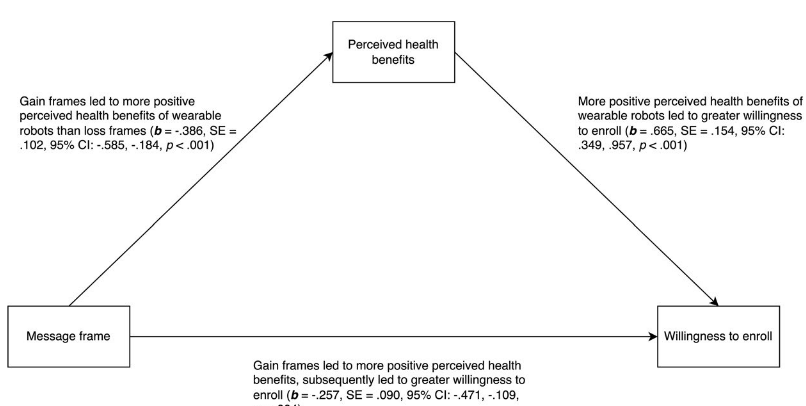


**Figure 2.** Indirect effect analyses examining the role of perceived health benefits in the effect of message frame on willingness to enroll. Note: These statistics are reported without controlling for perceived effectiveness.

can enhance willingness to enroll in real-life experiments through perceived health benefits. This aligns with the principles of prospect theory, which suggests that individuals are more motivated by behaviors that are framed in terms of gains rather than losses (Tversky & Kahneman, 1981). This positive impact of gain-framed messages on perceived health benefits can be attributed to their ability to evoke optimistic perceptions, hope, and positive emotions, which in turn, enhance individuals' attitudes and intentions toward the promoted behavior (Guenther et al., 2020). Therefore, our findings contribute to a growing body of research supporting the effectiveness of gain-framed messages in health promotion contexts and extend this understanding to the domain of wearable robot experiment enrollment among older adults. Future research should also explore whether message framing influences the acceptance and adoption of wearable robots in this population.

Contrary to some previous literature, our results did not show a direct effect of message frame on perceived effectiveness of the flyers or willingness to enroll (Machado et al., 2019; Speight et al., 2021). This discrepancy may be attributed to the specific characteristics of our sample, which consisted of older adults. Older adults are known to exhibit unique cognitive and motivational processes that can interact with message framing effects differently than younger populations. For instance, research has shown that older adults tend to prioritize emotional well-being and the avoidance of losses in decision-making contexts (Liu et al., 2019; Mikels et al., 2020). This age-related emphasis on emotional well-being and loss avoidance may diminish the persuasive impact of message framing on perceived effectiveness and willingness to enroll, in our study. To gain a more comprehensive understanding of message framing effects in older adults, future research could investigate these potential age-related differences in a more detailed manner, such as the interplay of age groups and message framing effects.

### *Practical implications*

Despite the application of a myriad of funding and initiatives to develop a gerontechnology ecosystem, the acceptance and adoption of gerontechnology remains low, mainly attributed to insufficient engagement of older adults in the development stage (Wong et al., 2021; Yee & Lit, 2021). This research provides an applied contribution by identifying an effective way to frame messages aiming to increase the willingness to enroll in wearable robot experiments among older adults. Namely, the results of this study suggest that gain-framed messages can enhance the perceived health benefits of wearable robots, which can provoke a greater willingness to enroll in real-life experiments.

The current study is to our knowledge the first to test the efficacy of message frames (i.e. gain versus loss) on willingness to enroll in wearable robot experiments among older adults. Conducting the study in the community affords a degree of ecological validity that cannot be achieved in a controlled or hypothetical environment (Gneezy, 2017). Considering that the findings have been obtained in a real-world environment, capturing participants' actual willingness to enroll in wearable robot experiments, they hold significant practical implications for a wide range of professionals, practitioners, and policymakers (van Heerde et al., 2021). Particularly, gerontechnology product designers and researchers should follow our framework to engage potential users during the development stage. Furthermore, given the scalability and cost-effectiveness of message framing, our results are valuable to public health organizations, policymakers, and media outlets that promote gerontechnology. To maximize the involvement of potential users in gerontechnology development, researchers and policymakers may want to deliver messages phrased as gains—that is, benefits the users will obtain if using the product, rather than drawbacks the users will suffer if not using the product—evidenced in our study. Acknowledging the uniqueness of each gerontechnology product, we would not be remiss to not mention the importance of replication of this work as a precursor to implementation.

### *Limitations and directions for Future research*

Our study offers valuable insights into the influence of message framing on the willingness to enroll in real-life wearable robot experiments for older adults. However, several limitations should be acknowledged. Firstly, our cross-sectional design restricts our ability to establish causal relationships between variables and examine changes in perceptions and actual behaviors over time. Future research employing longitudinal designs can provide a better understanding of the temporal dynamics of message framing effects on actual enrollment in wearable robot experiments among older adults. Secondly, our sample consisted of a specific group of older adults who completed the survey online, which introduces potential selection bias and limits the generalizability of our findings. Future studies should strive to include more diverse samples, encompassing individuals from varying technological familiarity and different socio-demographic backgrounds. Additionally, our study relied on self-report measures, which are subject to response biases. A prior study showed that negative text-based advertisements were effective at attracting attention among individuals with the greatest concern for environmental matters, captured using eye-tracking technology, (Gómez-Carmona et al., 2021). Incorporating objective measures or behavioral outcomes such as eye tracking in future research can provide a more comprehensive understanding of participants' attitudes and actions towards wearable robot experiments. Moreover, the flyers used in this study focused on a specific type of wearable robotic device, namely mobility devices worn on either the upper or lower limb. Thus, our findings are limited to this particular class of devices, and caution should be exercised when generalizing the results to other types of wearable robots. Finally, the statistical analyses conducted in our study were based on aggregate scores across the presented body locations (upper and lower limbs). This approach may overlook potential differences in participants' responses to message framing when considering specific body locations. It is important to acknowledge this limitation and consider the need for further investigation into the differential effects of message framing on willingness to enroll in wearable robot experiments corresponding to specific body locations that require support.

## Conclusion

In summary, this study is not only of great significance to understanding the persuasive effects of message framing on older adults' willingness to enroll in real-life wearable robot experiments but also a pioneer work that lays the foundation for future research in this area. By emphasizing the potential health benefits, we can enhance strategies for recruiting older adults for wearable robot experiment enrollment. These findings contribute to the existing literature and offer valuable insights into enhancing the willingness to enroll in wearable robot experiments which is crucial in a user-centered design. Future research should explore additional factors influencing the willingness to enroll and investigate the generalizability of these findings to diverse populations and technological contexts. Overall, this study highlights the potential for leveraging message framing techniques to enhance older adults' engagement in wearable robot experiments and promote advancements in this field.

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## Author's contributions

C.Y.M.C. conceptualized the study, collected and analyzed the data, produced the original draft of the manuscript. V.W.Q.L. obtained resources for the study. All authors read the drafts of the manuscript and contributed to the revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

## Disclosure statement

The authors report that there are no competing interests to declare.

## Informed consent statement

Informed consent was obtained from all participants in the study.

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## About the authors

***Miss Clio Yuen Man Cheng*** is a PhD candidate at the Department of Social Work & Social Administration, The University of Hong Kong. She is also a student fellow of Sau Po Centre on Ageing, The University of Hong Kong. Currently, she is engaging in a transdisciplinary project to develop intelligent robotics for elderly assistance. Her research focuses on gerontechnology acceptance and adoption.

***Professor Vivian W. Q. Lou*** is a Professor at the Department of Social Work & Social Administration, The University of Hong Kong. She is also the Director of Sau Po Centre on Ageing, an Honorary Clinical Associate in the Centre on Behavioral Health, The University of Hong Kong. Prof. Lou studied widely on family caregiving, active ageing, and their health impacts and is the first Chinese scholar who received the AGESW Career Achievement Award endowed by The Association for Gerontology Education in Social Work.

## ORCID

Clio Yuen Man Cheng http://orcid.org/0000-0001-9665-9878
Vivian W. Q. Lou http://orcid.org/0000-0001-7000-1306

## Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## References

Ármannsdóttir, A. L., Beckerle, P., Moreno, J. C., Asseldonk, E. H. F. V., Manrique-Sancho, M.-T., Del-Ama, A. J., Veneman, J. F., & Briem, K. (2020). Assessing the involvement of users during development of lower limb wearable robotic exoskeletons: A survey study. *Human Factors*, *62*(3), 351–364. https://doi.org/10.1177/0018720819883500

Babič, J., Laffranchi, M., Tessari, F., Verstraten, T., Novak, D., Šarabon, N., Ugurlu, B., Peternel, L., Torricelli, D., & Veneman, J. F. (2021). Challenges and solutions for application and wider adoption of wearable robots. *Wearable Technologies*, *2*, e14. https://doi.org/10.1017/wtc.2021.13

Bosone, L., & Martinez, F. (2017). When, how and why is loss-framing more effective than gain- and non-gain-framing in the promotion of detection behaviors? *International Review of Social Psychology*, *30*(1), 184–192. https://doi.org/10.5334/irsp.15

Bützer, T., Lambercy, O., Arata, J., & Gassert, R. (2021). Fully wearable actuated soft exoskeleton for grasping assistance in everyday activities. *Soft Robotics*, *8*(2), 128–143. https://doi.org/10.1089/soro.2019.0135

Canva. (2023). *Create beautiful designs with Canva*. Canva. https://www.canva.com/

Carvalho, A. S. M., Godinho, C. I. A., & Graça, J. (2022). Gain framing increases support for measures promoting plant-based eating in university settings. *Food Quality and Preference*, *97*, 104500. https://doi.org/10.1016/j.foodqual.2021.104500

Census and Statistics Department. (2020). *Hong Kong Population Projections 2020–2069*. Census and Statistics Department. https://www.statistics.gov.hk/pub/B1120015082020XXXXB0100.pdf

Census and Statistics Department. (2022). *Hong Kong Monthly Digest of Statistics: An Analysis of Statistics on Persons with Physical Disabilities*. Census and Statistics Department, Hong Kong Special Administrative Region. https://www.censtatd.gov.hk/en/data/stat_report/product/FA100059/att/B72212FB2022XXXXB0100.pdf

Chen, K., & Chan, A. H. S. (2014). Gerontechnology acceptance by elderly Hong Kong Chinese: A senior technology acceptance model (STAM). *Ergonomics*, *57*(5), 635–652. https://doi.org/10.1080/00140139.2014.895855

Cheng, C. Y. M., Lee, C. C. Y., Chen, C. K., & Lou, V. W. Q. (2022). Multidisciplinary collaboration on exoskeleton development adopting user-centered design: A systematic integrative review. *Disability and Rehabilitation. Assistive Technology*, *19*(3), 909–937. https://doi.org/10.1080/17483107.2022.2134470

Chen, K., & Lou, V. W. Q. (2020). Measuring senior technology acceptance: Development of a Brief, 14-Item Scale. *Innovation in Aging*, *4*(3), igaa016. https://doi.org/10.1093/geroni/igaa016

Chen, K., Lou, V. W. Q., & Cheng, C. Y. M. (2023). Intention to use robotic exoskeletons by older people: A fuzzy-set qualitative comparative analysis approach. *Computers in Human Behavior*, *141*, 107610. https://doi.org/10.1016/j.chb.2022.107610

Christensen, S., Bai, S., Rafique, S., Isaksson, M., O'Sullivan, L., Power, V., & Virk, G. S. (2019). AXO-SUIT – A modular full-body exoskeleton for physical assistance. Mechanisms and Machine Science, *66*, 443–450. https://doi.org/10.1007/978-3-030-00365-4_52

Davis, K. G., Reid, C. R., Rempel, D. D., & Treaster, D. (2020). Introduction to the human factors special issue on user-centered design for exoskeleton. *Human Factors*, *62*(3), 333–336. https://doi.org/10.1177/0018720820914312

Fang, Y., Harshe, K., Franz, J. R., & Lerner, Z. F. (2022). Feasibility evaluation of a dual-mode ankle exoskeleton to assist and restore community ambulation in older adults. *Wearable Technologies*, *3*, e13. https://doi.org/10.1017/wtc.2022.12

Fortune Business Insights. (2023). *Wearable Robotic Exoskeleton Market*.

Gallagher, K. M., & Updegraff, J. A. (2012). Health message framing effects on attitudes, intentions, and behavior: A meta-analytic review. *Annals of Behavioral Medicine: a Publication of the Society of Behavioral Medicine*, *43*(1), 101–116. https://doi.org/10.1007/s12160-011-9308-7

Gisbert-Pérez, J., Martí-Vilar, M., & González-Sala, F. (2022). Prospect theory: A bibliometric and systematic review in the categories of psychology in web of science. *Healthcare (Basel, Switzerland)*, *10*(10), 2098. https://doi.org/10.3390/healthcare10102098

Gneezy, A. (2017). Field experimentation in marketing research. *Journal of Marketing Research*, *54*(1), 140–143. https://doi.org/10.1509/jmr.16.0225

Gómez-Carmona, D., Muñoz-Leiva, F., Liébana-Cabanillas, F., Nieto-Ruiz, A., Martínez-Fiestas, M., & Campoy, C. (2021). The effect of consumer concern for the environment, self-regulatory focus and message framing on green advertising effectiveness: an eye tracking study. *Environmental Communication*, *15*(6), 813–841. https://doi.org/10.1080/17524032.2021.1914701

Guenther, L., Gaertner, M., & Zeitz, J. (2020). Framing as a concept for health communication: A systematic review. *Health Communication*, *36*(7), 891–899. https://doi.org/10.1080/10410236.2020.1723048

Hayes, A. F. (2013). *Introduction to Mediation, Moderation, and Conditional Process Analysis*. Guilford Publications, Inc. https://app.readcube.com/library/7c12152c-85de-4f38-9d79-57133b718d96/item/4b766510-7632-415d-9d25-9818fa0b8aa1

Idler, E. L., & Benyamini, Y. (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior*, *38*(1), 21–37. https://doi.org/10.2307/2955359

Jayaraman, C., Embry, K. R., Mummidisetty, C. K., Moon, Y., Giffhorn, M., Prokup, S., Lim, B., Lee, J., Lee, Y., Lee, M., & Jayaraman, A. (2022). Modular hip exoskeleton improves walking function and reduces sedentary time in community-dwelling older adults. *Journal of NeuroEngineering and Rehabilitation*, *19*(1), 144. https://doi.org/10.1186/s12984-022-01121-4

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–291. https://doi.org/10.2307/1914185

Kim, J. (2022). Gain-loss framing and social distancing: Temporal framing's role as an emotion intensifier. *Health Communication*, *38*(11), 2326–2335. https://doi.org/10.1080/10410236.2022.2067943

Kim, J., Song, H., Merrill, K., Jr., Jung, Y., & Kwon, R. J. (2022). If you quit smoking, this could happen to you: investigating framing and modeling effects in an anti-smoking serious game. *International Journal of Human–Computer Interaction*, *38*(8), 730–741. https://doi.org/10.1080/10447318.2021.1970429

Li, J., Tang, Z., & Gong, Z. (2022). Does the message frame promote people's willingness to vaccinate when they worry about side effects from the COVID-19 vaccine? Evidence from an online survey experiment in China. *Health Communication*, *38*(8), 1688–1696. https://doi.org/10.1080/10410236.2022.2028469

Liu, X., Shuster, M. M., Mikels, J. A., & Stine-Morrow, E. A. L. (2019). Doing what makes you happy: Health message framing for younger and older adults. *Experimental Aging Research*, *45*(4), 293–305. https://doi.org/10.1080/0361073X.2019.1627491

Lou, V. W. Q., Cheng, C. Y. M., Chen, K., Or, C. K. L., Hu, Y., & Xi, N. (2023). Applying an innovative user-centric co-creation (UC3) approach in developing intelligent wearable robots for elderly assistance: From a transdisciplinary lens. *Structural Health Monitoring*, *2023*, 2023–2035. https://drive.google.com/file/d/1pwr0kOjmj7N-Cp6EBjOomkQIJ-OCXpuQ/view?usp=sharing https://doi.org/10.12783/shm2023/36966

Lowe, B. D., Billotte, W. G., & Peterson, D. R. (2019). ASTM F48 formation and standards for industrial exoskeletons and exosuits. *IISE Transactions on Occupational Ergonomics and Human Factors*, *7*, 230–236. https://doi.org/10.1080/24725838.2019.1579769

Luciani, B., Braghin, F., Pedrocchi, A. L. G., & Gandolla, M. (2023). Technology acceptance model for exoskeletons for rehabilitation of the upper limbs from therapists' perspectives. *Sensors (Basel, Switzerland)*, *23*(3), 1721. https://doi.org/10.3390/s23031721

Machado, N. M., Gomide, H. P., Bernardino, H. S., & Ronzani, T. M. (2019). Facebook recruitment of smokers: Comparing gain- and loss-framed ads for the purposes of an Internet-based smoking cessation intervention. *Cadernos de Saude Publica*, *35*(10), e00151318. https://doi.org/10.1590/0102-311x00151318

Merkel, S., & Kucharski, A. (2019). Participatory design in gerontechnology: A systematic literature review. *The Gerontologist*, *59*(1), e16–e25. https://doi.org/10.1093/geront/gny034

Mikels, J. A., Young, N. A., Liu, X., & Stine-Morrow, E. A. L. (2020). Getting to the heart of the matter in later life: The central role of affect in health message framing. *The Gerontologist*, *61*(5), 756–762. https://doi.org/10.1093/geront/gnaa128

Mordor Intelligence. (2023). *Wearable robots market size & share analysis—Growth trends & forecasts (2024–2029)*. Mordor Intelligence. https://www.mordorintelligence.com/industry-reports/wearable-robots-and-exoskeletons-market

Morris, L., Diteesawat, R. S., Rahman, N., Turton, A., Cramp, M., & Rossiter, J. (2023). The-state-of-the-art of soft robotics to assist mobility: A review of physiotherapist and patient identified limitations of current lower-limb exoskeletons and the potential soft-robotic solutions. *Journal of NeuroEngineering and Rehabilitation*, *20*(1), 18. https://doi.org/10.1186/s12984-022-01122-3

Murayama, H., Sasaki, S., Takahashi, Y., Takase, M., & Taguchi, A. (2023). Message framing effects on attitude and intention toward social participation in old age. *BMC Public Health*, *23*(1), 1713. https://doi.org/10.1186/s12889-023-16555-1

O'Keefe, D. J., & Wu, D. (2012). Gain-framed messages do not motivate sun protection: A meta-analytic review of randomized trials comparing gain-framed and loss-framed appeals for promoting skin cancer prevention. *International Journal of Environmental Research and Public Health*, *9*(6), 2121–2133. https://doi.org/10.3390/ijerph9062121

OECD. (2017). Demographic trends. In *Health at a glance 2017: OECD indicators*. OECD Publishing. https://doi.org/10.1787/health_glance-2017-73-en

Palos-Sanchez, P. R., Saura, J. R., Martin, M. Á. R., & Aguayo-Camacho, M. (2021). Toward a better understanding of the intention to use mHealth apps: Exploratory study. *JMIR mHealth and uHealth*, *9*(9), e27021. https://doi.org/10.2196/27021

Pența, M. A., & Băban, A. (2017). Message framing in vaccine communication: A systematic review of published literature. *Health Communication*, *33*(3), 299–314. https://doi.org/10.1080/10410236.2016.1266574

Proud, J. K., Lai, D. T. H., Mudie, K. L., Carstairs, G. L., Billing, D. C., Garofolini, A., & Begg, R. K. (2020). Exoskeleton application to military manual handling tasks. *Human Factors*, *64*(3), 527–554. https://doi.org/10.1177/0018720820957467

Qualtrics. (2023). *Qualtrics* [Computer software]. https://www.qualtrics.com

R Core Team, R. C. (2023). *R: A language and environment for statistical computing*. https://www.R-project.org/

Ralfs, L., Hoffmann, N., Glitsch, U., Heinrich, K., Johns, J., & Weidner, R. (2023). Insights into evaluating and using industrial exoskeletons: Summary report, guideline, and lessons learned from the interdisciplinary project "Exo@Work. *International Journal of Industrial Ergonomics*, *97*, 103494. https://doi.org/10.1016/j.ergon.2023.103494

Rosseel, Y. (2023). *lavaan: Latent variable analysis*. https://cran.r-project.org/web/packages/lavaan/index.html

Rothman, A. J., Bartels, R. D., Wlaschin, J., & Salovey, P. (2006). The strategic use of gain—and loss-framed messages to promote healthy behavior: How theory can inform practice. *Journal of Communication*, *56*(suppl_1), S202–S220. https://doi.org/10.1111/j.1460-2466.2006.00290.x

Scott, R. A., Callisaya, M. L., Duque, G., Ebeling, P. R., & Scott, D. (2018). Assistive technologies to overcome sarcopenia in ageing. *Maturitas*, *112*, 78–84. https://doi.org/10.1016/j.maturitas.2018.04.003

Shah, S. G. S., Nogueras, D., Woerden, H. C. v., & Kiparoglou, V. (2021). Evaluation of the effectiveness of digital technology interventions to reduce loneliness in older adults: Systematic review and meta-analysis. *Journal of Medical Internet Research*, *23*(6), e24712. https://doi.org/10.2196/24712

Shore, L., De Eyto, A., & O'Sullivan, L. (2022). Technology acceptance and perceptions of robotic assistive devices by older adults—Implications for exoskeleton design. *Disability Rehabilitation: Assistive Technology*, *17*(7), 782–790. https://doi.org/10.1080/17483107.2020.1817988

Social Welfare Department. (2023). *Innovation and technology fund for application in elderly and rehabilitation care*. https://www.swd.gov.hk/en/pubsvc/rehab/cat_fundtrustfinaid/itfund/

Speight, C. D., Gregor, C., Ko, Y.-A., Kraft, S. A., Mitchell, A. R., Niyibizi, N. K., Phillips, B. G., Porter, K. M., Shah, S. K., Sugarman, J., Wilfond, B. S., & Dickert, N. W. (2021). Reframing recruitment: Evaluating framing in authorization for research contact programs. *AJOB Empirical Bioethics*, *12*(3), 206–213. https://doi.org/10.1080/23294515.2021.1887962

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science (New York, N.Y.)*, *211*(4481), 453–458. https://doi.org/10.1126/science.7455683

United Nations. (2023). *World Social Report 2023: Leaving no one behind in an ageing world*. United Nations. https://desapublications.un.org/publications/world-social-report-2023-leaving-no-one-behind-ageing-world

van Heerde, H. J., Moorman, C., Moreau, C. P., & Palmatier, R. W. (2021). Reality check: Infusing ecological value into academic marketing research. *Journal of Marketing*, *85*(2), 1–13. https://doi.org/10.1177/0022242921992383

Wang, G., Zhou, Y., Zhang, L., Li, J., Liu, P., Li, Y., & Ma, L. (2024). Prevalence and incidence of mobility limitation in Chinese older adults: Evidence from the China health and retirement longitudinal study. *The Journal of Nutrition, Health & Aging*, *28*(3), 100038. https://doi.org/10.1016/j.jnha.2024.100038

Webber, S. C., Porter, M. M., & Menec, V. H. (2010). Mobility in older adults: A comprehensive framework. *The Gerontologist*, *50*(4), 443–450. https://doi.org/10.1093/geront/gnq013

Wong, S. Y. S., Shui, K. C. W., Tsang, N. S. Y., Chen, M. M. J., & Wang, S. Y. Y. (2017). *Gerontechnology Landscape Report*. Our Hong Kong Foudation. https://www.ourhkfoundation.org.hk/sites/default/files/media/pdf/healthtech_eng_cover_ss.pdf

Wong, S., Shui, K., Tan, J., Qamar, M., & Tsang, A. (2021). *Healthcare and ageing policy research report: Building an age-friendly city embedding gerontechnology into everyday life*. Our Hong Kong Foundation. https://ourhkfoundation.org.hk/sites/default/files/media/pdf/OHKF_Gerontech_report_en.pdf

World Health Organization. (2015). *World Report on Ageing and Health*. World Health http://apps.who.int/iris/bitstream/handle/10665/186463/9789240694811_eng.pdf

World Health Organization. (2018). *Assistive technology*. https://www.who.int/news-room/fact-sheets/detail/assistive-technology

Xi, N., Wang, W., Chen, Y., Wang, Z., Or, C., Lou, V. W. Q., Hu, Y., Li, W. J., Lai, K. W. C., Choi, Y. K., Pan, J., Vellaisamy, A. L. R., & Lam, C. L. K. (2020). *Intelligent Robotics for Elderly Assistance in Hong Kong*. https://www.ugc.edu.hk/eng/rgc/funding_opport/trs/funded_research/trs10_lay_sum.html#402_20

Yadav, R., Yadav, M., & Mittal, A. (2021). Effects of gain-loss-framed messages on virtual reality intervened fitness exercise. *Information Discovery and Delivery*, *50*(4), 374–386. https://doi.org/10.1108/IDD-04-2021-0051

Yee, H. H. L., & Lit, K. K. (2021). *Promoting the development of gerontechnology in Hong Kong* (CAHMR Working Paper Series No. 2, Issue 1, 2021). The Hong Kong Polytechnic University, College of Professional and Continuing Education, School of Professional Education and Executive Development, Centre for Ageing and Healthcare Management Research. http://weblib.cpce-polyu.edu.hk/apps/wps/assets/pdf/cw20210102.pdf