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Submitted to: JMIR Aging
on: January 30, 2025

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Abstract

Background: In Latin American countries (LAC), the prevalence of non-communicable diseases (NCD) has increased rapidly in the last decades. Mobile health (mHealth) applications are now widely available at low cost with easy implementation, offering an opportunity to encourage healthy lifestyles in older adults. However, currently, there are no available mHealth applications that integrate multimodal lifestyle interventions adapted to Chilean older adults.

Objective: This study aims to describe the development and validation of the mHealth NeoMayor, a mHealth application designed to promote healthy lifestyles, cardiovascular and brain health in Chilean older adults.

Methods: NeoMayor was developed iteratively, including feedback from users, a multidisciplinary team of clinicians, researchers, and software developers. Using Lean UX methodology, we ensured user involvement throughout the design and validation process. The research was conducted in two phases. In the Design & Development phase, we created and adapted evidence-based recommendations. In the validation phase, we did a pilot study to assess usability, adherence, and cardiovascular health. Sixty functionally independent and cognitively healthy participants used the NeoMayor App for two months. Clinical and cognitive assessments were conducted before and after app use. We conducted 26 co-creation sessions with users, consulted experts, did a literature review, and collaborated with a team of app developers to create a functional prototype.

Results: The mean age of the participants was 71 ± 15 years, 83% were women, with an average of 9.8 ± 3.6 years of education. After two months of intervention, usability testing indicated high engagement and adherence, with an average app use of 6 minutes per day twice a week. Participants showed improvements in global cardiovascular health, with a mean increase in the Life´s Essential 8 cardiovascular health (CVH) index score from 64 ± 10 to 68 ± 11 ($p<0.001$), with reductions in systolic blood pressure (10 mmHg); waist circumference reduction (7 cm); increased HDL cholesterol levels; improvements in the self-report questionnaires on Physical Activity and Diet; increased score in the Short Physical Performance Battery (SPPB); faster sit to stand and gait speed tests. The app was optimized for broad compatibility with Android devices, safe data collection and storage, and compliance with data privacy regulations following good clinical practices. The final product is ready for a randomized controlled trial.

Conclusions: This study represents the first initiative in Chile to develop and validate a mHealth tool to promote healthy lifestyles, cardiovascular, and brain health in older adults, offering an effective, accessible, and affordable solution for promoting healthy aging in LAC.

(JMIR Preprints 30/01/2025:71936)
DOI: https://doi.org/10.2196/preprints.71936

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Abstract.

Background: *In Latin American countries (LAC), the prevalence of non-communicable diseases (NCD) has increased rapidly in the last decades. Mobile health (mHealth) applications are now*

widely available at low cost with easy implementation, offering an opportunity to encourage healthy lifestyles in older adults. However, currently, there are no available mHealth applications that integrate multimodal lifestyle interventions adapted to Chilean older adults.

Objective: *This study aims to describe the development and validation of the mHealth NeoMayor, a mHealth application designed to promote healthy lifestyles, cardiovascular and brain health in Chilean older adults.*

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Conclusion: *This study represents the first initiative in Chile to develop and validate a mHealth tool to promote healthy lifestyles, cardiovascular, and brain health in older adults, offering an effective, accessible, and affordable solution for promoting healthy aging in LAC.*

Keywords: mHealth; healthy aging; non-communicable diseases; brain health; dementia prevention.

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Background

Accelerated aging in the last decades, particularly in lower and middle-income countries (LMIC), has led to an increase in the prevalence of non-communicable diseases (NCD) in adults (1, 2). Cardiovascular diseases and dementia are now the leading causes of disability in people aged 70 years and older (3, 4). In Latin America and the Caribbean (LAC), dementia prevalence is projected to rise by 200-300% in the next 30 years (5). Globally, about 80% of cardiovascular disease risk factors are potentially modifiable (5, 6), while approximately 54% of dementia risk factors are also potentially modifiable in LAC countries (7). This highlights the urgent need for preventive initiatives aimed at reducing the burden of cardiovascular diseases and dementia (8).

Increasing evidence supports the effectiveness of multi-domain healthy lifestyle interventions - including physical activity, healthy diet, cognitive stimulation, social engagement, and health control- to treat and prevent NCDs, reduce stroke risk, and enhance cognitive reserve (9-11). In Chile, despite the presence of public primary prevention programs for NCD, there has been a significant increase in the prevalence of diabetes and obesity in the past decade (12, 13). These poor outcomes of Chilean prevention campaigns could be attributed to their limited outreach, low population adherence, and several challenges in their implementation (14), including healthcare inequities (15).

To improve this implementation gap in health promotion, Mobile health (mHealth) platforms have emerged as promising tools for promoting healthcare, mHealth includes all medical practices supported by mobile devices such as smartphones, tablets, and wearable sensors, thus, they are easily accessible, widely available, have affordable costs, and easily implementable (16-18). Recent evidence supports the effectiveness of web-based and smartphone interventions to promote cardiovascular health in adults (16, 19), providing insights into designing user-friendly and accessible health technologies for older adults (20, 21). In high-income countries, there are several initiatives to promote a healthy lifestyle through the use of mHealth (22). Although many of these mHealth solutions could be easily used by young adults, there are several barriers for the mHealth use in older adults, reducing the effectiveness in this demographic group (21, 23). This barriers include lower digital literacy and technological skills (24), physical and cognitive limitations (21, 25), lack of trust and privacy concerns (26), and cost and technology access (23). Regarding technology access, in Chile in 2022, , 65% of older adults own smartphones (reaching to 82% in

people of 60-69 years old), and 60 % had home internet access, which reaches 90% if they live with younger people (27-30). Educational level is the most important factor related to technology use in Chile's older adults, possibly associated with technology use skills, and technology access (29). Therefore, the design of mHealth tools targeting older adults should incorporate a user-centered approach, considering their physical and cognitive capacities and technological skills (31). Prior research recommends solutions that are intuitive, easy to navigate, supported by healthcare professionals and accessible, such as those with large interfaces and simplified interactions (32, 33). However, to date, in Chile, in spite of having relatively good access to smartphones there is an absence of mHealth solutions for promoting a healthy lifestyle adapted to fit older adults. Our main hypothesis was that health care content delivered through a mobile application, co-created using participatory design methodologies, based on a multi-intervention approach, will be easy to use and would improve cardiovascular health in older adults.

We aim to describe the development and validation of NeoMayor, a software for mobile phones, co-created with older adults, who promote healthy lifestyle habits, NCD management, and enhance cardiovascular and brain health in older adults.

Methods

Study design

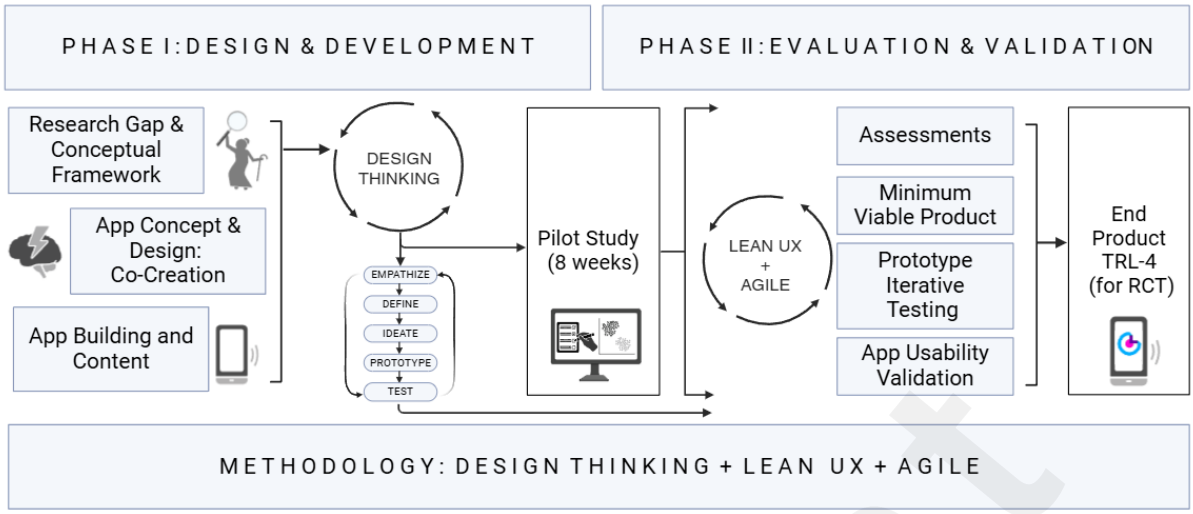
The development and validation of NeoMayor was planned using a user-center design (31). The study was organized in two phases: Phase I: Design & Development, using Lean UX methodology with older users; and Phase II: Validation of the prototype, which involved a 2-month pilot study where participants used NeoMayor on their smartphones. In total, this process lasted 27 months, from February 2022 to April 2024, *Figure 1*.

Phase I. Design and Development.

The NeoMayor App was developed as a mobile app to promote a healthy lifestyle for improving cardiovascular and brain health among older adults in Chile. From the outset, this app design provides personalized lifestyle recommendations based on the baseline health status. Its structure has a secure electronic database compliant, with clinical data privacy standards (34).

Figure 1. Theoretical model of user experience used in NeoMayor Study. *Two phases of the NeoMayor App study: I. Design and Development; and II. Evaluation and Validation. Abbreviations: RCT: Randomized Controlled Trial. Created in https://BioRender.com.*

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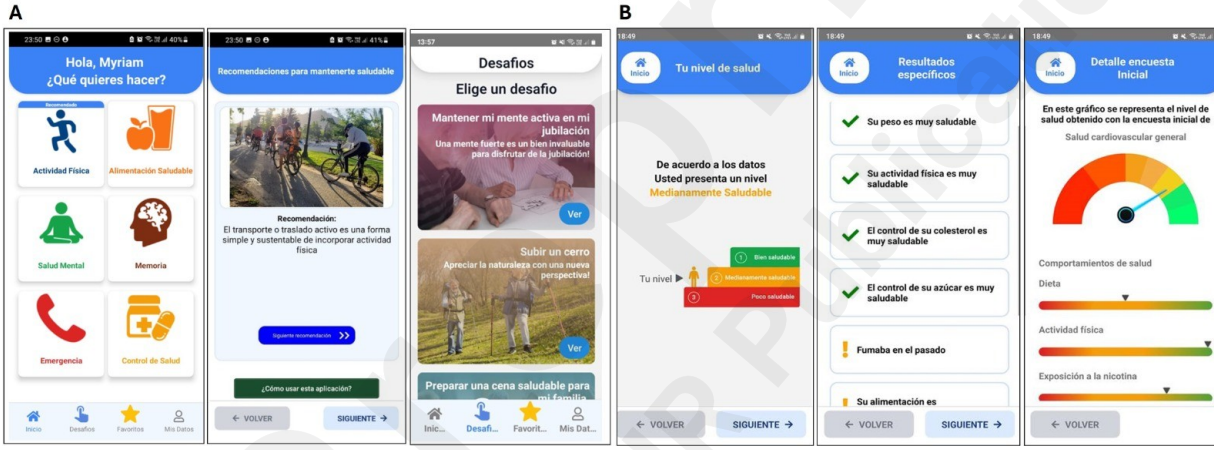


The clinical multidisciplinary team, including experts in neurology, geriatrics, physical therapy, nutrition, psychology, and biomedical sciences, led the creation of the NeoMayor App and collaborated closely with software developers to design and program the software. In the design thinking process, we began by identifying user needs (empathy approach) and analyzing existing health technologies (definition approach). After gathering theoretical information, hypotheses were formulated and proposed content by clinical teams, then validated by expert peers. The content creation was based on multiple guidelines, such as the WHO recommendations for integrated care for older people (35), the WHO guidelines for risk reduction of cognitive decline and dementia (35, 36), the Chilean Cardiovascular Health Program (37), and the American Heart Association (AHA) Life´s Essential 8 (38). The AHA Life´s Essential 8 promote self-care recommendations to control eight modifiable risk factors by adopting a healthy lifestyle: “Eat Better”; “Be More Active”, “Quit Tobacco”, “Get Healthy Sleep”, “Manage Weight”, “Control Cholesterol”,” Manage Blood Sugar”, and “Manage Blood Pressure”. Each of these risk factors could be measured on a semiquantitative scale from 0 to 100 (the poorest to the healthiest respectively) which average corresponds to the global Cardiovascular Health Index (CVH index) (25). We chose to use the CVH index as our main outcome because it has been validated as a good predictor of cardiovascular events (39) and brain health and risk of dementia (40), but also, as it is composed of only modifiable risk factors, it could change in time, making it a good parameter to track progress in cardiovascular health over time (38). We adapted the CVH index into a mobile questionnaire that provides health level feedback, and shapes recommendations accordingly. Participants were categorized into optimal (score 79-100), moderate (score 50-79), and poor (score<50) using graphic images (*Figure 2A*). The App recommended periodical assessments to monitor cardiovascular health changes over time.

The content for lifestyle was structured into six modules: physical activity, healthy eating, mental health (41, 42), memory and health control (6, 37, 38) (Figure 2 B), based upon guidelines from

WHO (43, 44) and the Chilean Ministry of Health (37) and the AHA Life´s Essential 8 (38). In addition, an emergency module was incorporated at the request of participants, who wanted quick access to emergency numbers and official resources, on legal and health benefits. The App content was delivered in video, audio, and educational image formats. Currently, it features a repository of 33 videos, each approximately 5 minutes long, 30 audio recordings of around 15 minutes each, and 50 educational images. The NeoMayor App included two navigation forms: the first was free navigation, where users freely choose among 6 modules in the menu screen, and the second was a challenge-based navigation form, where users set a specific goal to use the app, like “being able to climb a hill”, prompting customized targeted training suggestions that combine content from multiple modules over a determined period (Figure 2B).

Figure 2: Screens of the NeoMayor App. *A) Cardiovascular Health Categorization. B) App Initial menu, and goal-directed navigation.*



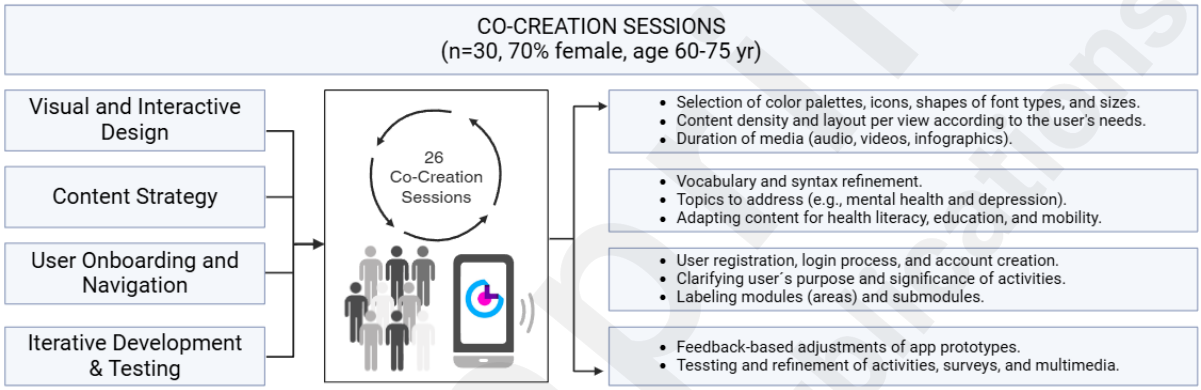
The next step was NeoMayor’s iterative refinement and development, guided by a combination of Lean UX (45), Agile (46), and Design Thinking methodologies (47). The selection of Lean UX and Design Thinking was intentional, given their strong alignment with the specific challenges and needs of older adults. These user-centered frameworks, continuous feedback integration, empathy-based exploration of user experiences, and rapid prototyping essential for optimizing usability and ensuring the App’s relevance for older adults with a medium and high digital literacy level (48). Lean UX allowed rapid iteration to refine accessibility features such as color contrast, touch target size, and interface clarity (49). In parallel, Design Thinking fostered co-creation through structured empathy and ideation stages, ensuring that the final product resonated with older users lived experiences (50). Low-fidelity prototypes of the NeoMayor App were iteratively refined to emphasize accessibility, intuitive navigation, and content clarity.

As part of this co-creative/co-constructive process (51), we implemented several interface

adjustments, including high-contrast colors, large touch targets, simplified gestures, and accommodating motor and cognitive needs. This combined approach enabled the development of a tool that is not only clinically robust, but also practical, intuitive, and acceptable to older adults across a spectrum of technological familiarity. Classification algorithms and user surveys guide further guided customization of the user experience.

We performed 26 co-creation sessions with approximately 30 older adults to validate language, content, and user interface elements. These sessions provided critical feedback on layout, navigation and instructional clarity, which shaped the app's design (*Figure 3*).

Figure 3. Co-Creation Sessions. *The NeoMayor iterative participative design process. Created in https://BioRender.com.*



After finalizing the content, the software development team generated both front-end and back-end components. The software was built with the open-source React Native framework for cross-platform compatibility on Android devices and Django Administration on Web Intelligence Centre servers for secure data handling. Once compiled with Gradle, the NeoMayor App was validated via Google Play Console and released on the Play Store as a downloadable application.

Throughout the iterative design, the team (users, clinicians, designers, and engineers) validated content, navigation flow, and overall user experience. As suggested by pivotal literature in software development (52) we applied Micro usability tests (MTUs) to evaluate ease of navigation, icon comprehension, and text readability, which provided insights on interface improvements leading to high-contrast designs, labeled icons, and enlarged touch targets (*Figure 3*). Thus, the NeoMayor App was evaluated in terms of usability, functionality, and efficacy at the prototype level, achieving positive results across all evaluated sections. After 12 months, we obtained a minimum viable product (MVP) of NeoMayor a mobile app that classifies each participant according to his/her cardiovascular health and mobility and offers personalized content organized into six modules.

Phase II. Evaluation & Validation (Pilot study).

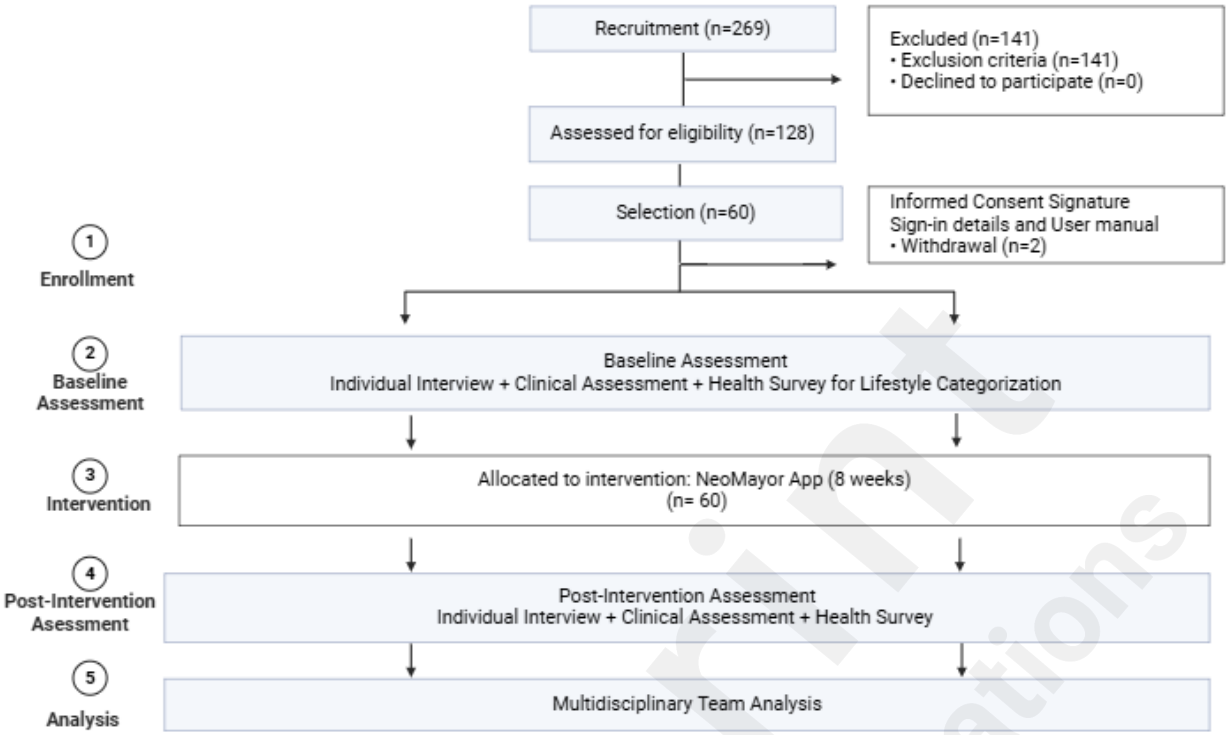
Participants

We recruited functionally independent older adults aged between 60 to 77 years, living in Santiago, Chile, who were able to read, write, and use technology (digital skills sufficient to use independently a mobile smartphone) (Figure 4). Subjects were recruited through voluntary sign-up notices from ambulatory programs of the Hospital Clínico de la Universidad de Chile, civil society representatives of the Servicio Nacional de Personas Mayores (SENAMA), and the Advisory Committee of the Instituto Nacional de Geriatría (INGER). Printed posters of invitation were distributed in various community and public spaces across Santiago of Chile. To qualify for inclusion, participants had to present a moderate to high cardiovascular risk defined as having at least three of the following cardiovascular risk factors: hypertension (last blood pressure > 140/90 or being on pharmacological treatment); diabetes or fasting glycemia > 100mg/dl; obesity (Body Mass Index (BMI)>30kg/m^2); smoking, and high total cholesterol (over 240 mg/dl). In addition, we included participants without dementia, defined as a total score >8 on the Memory, Fluency, and Orientation Test (MEFO), a 5-minute screening test for cognitive impairment validated for the Chilean population (53). The exclusion criteria included significant impairments in independent mobility, significant auditory or visual impairments; neurodegenerative diseases, untreated psychiatric disorders, and/or psychological diagnoses; and the presence of a severe or terminal illness. Participant recruitment began one month before the initiation of the pilot study. There were different participants in the two phases of NeoMayor design: those engaged in co-creation sessions, design, and development (n=30) described in the previous section, and those who participated in the pilot study (n=60). All participants in the study provided signed informed consent approved by the Scientific Ethics Review Board of the Hospital Clínico Universidad de Chile (Acta Nr. 36, OAIC 1220/21, FONDEF ID21I10096).

Pilot methodology

A database of 269 individuals who expressed interest in participating in the pilot study was established. We contacted 128 of these individuals by telephone to assess their eligibility according to the inclusion and exclusion criteria. 62 individuals (50% of those contacted) meet the inclusion criteria. Subsequently, two participants voluntarily withdrew for personal reasons, leaving a final sample of 60 participants. All the participants signed the informed consent before the pilot study.

Figure 4. Pilot Study Process. *The NeoMayor Study flowchart. Created in https://BioRender.com.*



Further on they underwent face-to-face interviews and received a complete clinical, physical, and cognitive assessment at baseline before and after the two-month NeoMayor App use period. Trained professionals (physicians, physical therapists, and psychologists) performed the assessments. For consistency, the same evaluator performed the assessments in both opportunities, blinded to adherence results. The pre and post-pilot clinical assessment lasted approximately one hour and included: a structured interview to collect demographic and sociocultural data, current health conditions, and pharmacological use; measurement of biometric data including anthropometry, blood pressure levels, blood tests (glucose and lipids levels), and the structured questionnaires to assess lifestyle habits adapted for Latin America (11): the Pittsburgh Sleep Quality Index (PSQI) (54), the Mediterranean-DASH Diet Intervention for Neurodegenerative Delay (MIND) Diet Scale (55), the International Physical Activity Questionnaire (IPAQ) (56). By using this data, we rated the CVH index, total score and 8 sub scores (38). The cognitive evaluation included the administration of the Mini-Mental State Examination (MMSE) (57), the Geriatric Depression Scale (GDS) (58), self-perception of memory scales (MCA) (59), and Memory, Fluency, and Orientation Test (MEFO), a 5-minute screening test for cognitive impairment (53). The physical performance assessment included the use of the handgrip , the 5 chair-stands test from the ICOPE mobility screening (35), the timed up and go test (TUG), the dual-task TUG; and the short physical performance battery (SPPB) (60).

NeoMayor App was installed on participants smartphones and received training in its use and a

printed user´s Manual. For those who did not have a smartphone, the project provided one. All the participants used the NeoMayor App for two months. In case of significant problems with Apps or smartphones, assistance was provided to the participants. After three weeks, half of the user group was contacted via telephone to solve any problem with the app usage. Finally, to evaluate the pilot implementation, we employed the RE-AIM (61) methodology which addresses reach, adoption, implementation, and maintenance. Once finished the pilot study, all participants completed surveys to obtain qualitative data about usability, user satisfaction, and content preferences. Further assessments will be included in further RCT.

Data management

The data was collected in a REDCap database. All the data analysis was conducted using R version 4.0.0 Arbor Day from The R Foundation for Statistical Computing Platform (64-bit, 2020-04-24), and software IBM SPSS Statistics 27. After checking the distribution of the data, descriptive statistics were performed. The continuous variables, expressed as mean SD and 95% confidence intervals (CI), and the categorical variables, as percentages and 95% CI. The potential effect of Neo mayor app use over the cardiovascular health of the participants was measured using a paired sample T test, comparing the CVH index before and after the app use (within-group analysis) (62). We calculated the effect size of the within-group changes by using Cohen's *d.*

Finally, we categorized the participants according to those who improved or not, classifying as significant improvement if the difference between the CVH index pre and post App use was > 1standar deviation from the baseline CVH index. We did a binary logistic regression to stablish which were the variables related with the improvement, using as dependent variables improve or not improve, and as independent variables years of age, educational level, sex, baseline depressive symptoms and baseline cardiovascular health index.

Results

Demographic and biomedical data

Sixty older adults were included in the pilot study. The mean age was 71 ± 15 years, with an average of 9.8 ± 3.6 years of education. Women represented 83% of the sample. Most subjects use the internet at home and own an Android smartphone. We provided a smartphone for 11 participants (7 who had iPhone and 4 who do not have their own smartphone, or it were to old). The baseline characteristics of participants are detailed in Table 1.

Table 1. *Baseline Characteristics of the sample at baseline at the NeoMayor Pilot Study.*

Variables	Total n=60
Age, mean ±SD	71 ± 15
Female, n (%)	51 (82.3%)
Education ≥ 12 years, n (%)	37 (59.7%)
High Blood Pressure (HBP) (%)	35 (56,5%)
Obesity, n (%)	28 (47%)
Dyslipidemia, n (%)	47 (75,8%)
Tobacco use, n (%)	14 (22,6%)
Hypothyroidism, n (%)	14 (22,6%)
Mild vision problems, n (%)	60 (96,8%)
Mild hearing problems, n (%)	1 (1,6%)
Heart failure, n (%)	4 (6,5%)
Chronic respiratory disease n (%)	12 (19,4%)
Diabetes n (%)	14 (22,6%)
Living alone n (%)	13 (21.0%)
Has Internet access at home n (%)	57 (91.9%)
Knows how to use a smartphone n (%)	56 (90.3%)
Has Smartphone, Android n (%)	49 (79%)

Validation of the App's assessment: For validate the cardiovascular health categorization, we compared the NeoMayor App categorization and the face-to-face clinical assessment, which yielded a kappa index of 0.51 ($p<0.001$), indicating a moderate degree of coincidence between both evaluations. Additionally, we analyzed the Pearson correlation level between both assessments $r=0.692$ ($p=0.001$), indicating a good correlation in the total score of the CVH index. In the baseline cardiovascular health, our results indicate that 54 out of 60 participants (87.1%) had intermediate cardiovascular health, four had low cardiovascular health and four had optimal cardiovascular health. *Potential Effectiveness:* The average CVH index score at baseline was 64.3 ± 10.8 and significantly improved to 69.0 ± 11.03 after two months of NeoMayor App use ($p < 0.0001$; Figure 5A). Which resulted in a moderate effect size according to Cohen's d =-0.548 (-2.55 to 1.46). Participants showed significant improvements in four of the eight sub-scores of the CVH index: Blood pressure (Figure 5B), blood glucose (Figure 5C), physical activity (Figure 5D), and diet (Figure 5E). However, no significant changes were observed in BMI, blood lipids, tobacco, and sleep (Figures 5F–5I) (Table 2). Indeed, there were no changes in the number of participants who smoked. Further on, we classified the participants into those who improved and those who did not, with 33% (n=19/60) who improved. There were no significant predictors of improvement after testing the effects of age, sex, educational level, baseline depressive symptoms and baseline cardiovascular health index, but there was a tendency for a negative effect of higher baseline depressive symptoms (OR=0.69, p=0.052) and healthier baseline cardiovascular status (OR=0.94, p=0.06) in the possibility of improvement.

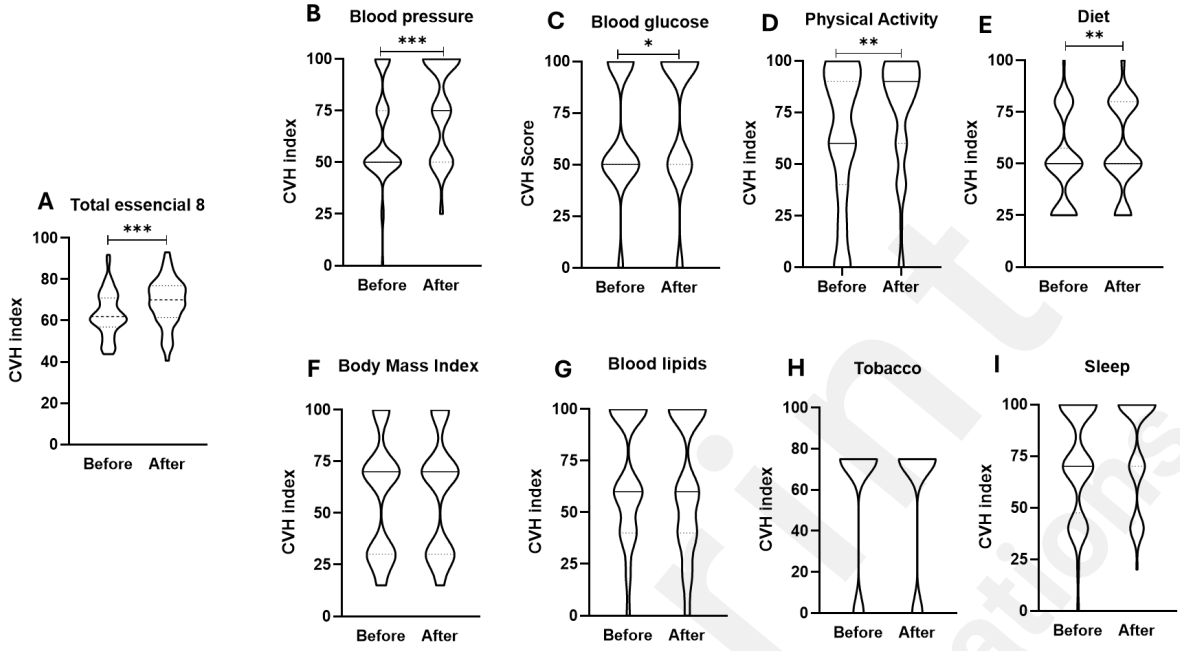
Regarding other results, we observed changes in anthropometric measurements, with an average weight reduction of 1 kg and a decrease in waist circumference of 7 cm, both indicative of improved body fat distribution. Physical performance showed improvement, with faster gait speed (an average reduction of 2 seconds), enhanced upper limb strength (measured by the handgrip test), increased

lower limb strength (measured by the 5-sit-to-stand test), and improved scores in the Short Physical Performance Battery (SPPB). Additionally, a significant reduction of 10 mmHg in systolic blood pressure was noted. Blood tests revealed a decrease in HDL cholesterol, although LDL cholesterol and triglyceride levels showed non-significant increases (Table 2).

There were no differences in the cognitive assessment or the depressive symptoms, but there was an improvement in self-perceived memory after the app use (Table 2).

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Figure 5. Changes in Cardiovascular Health index after NeoMayor use. Violin plots compare the global Cardiovascular Health (CVH) Index and its sub-scores before and after NeoMayor use. The solid line represents the media, and the hatched line represents the quartiles. A paired t-test compared the CVH index differences. *p<0.05; **p< 0.005 and ***p< 0.0001.



Qualitative results: The usability, barriers, and facilitators for using the NeoMayor App were evaluated by an iterative process between the health team and the users in co-creation sessions. Among the participants, 88% stated that their primary motivation for using the App was "to improve overall health", followed by improving physical fitness and enhancing memory. Additionally, 78.9% of users considered improving their lifestyle to be especially important, with the same percentage believing that the app helps them achieve this goal. Regarding usability, 85% of users found the app is easy and intuitive to use. For the initial health survey, 90% of users considered the personalized results delivered by the survey to be useful and easy to understand. In terms of user satisfaction, 65.7% found the App highly engaging, and 64.3% were very satisfied with their user experience. Moreover, 62.9% rated the App as highly motivating and easy to use.

Adherence: To study adherence, we monitored app usage during the first month, with an average content consumption of 12,242.6 ± 2359 seconds (204 min ± 5.9 min). Our results show that monthly usage time was close to 12,000 seconds, corresponding to around 400 seconds (6.6 min.) of App browsing per day.

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Table 2. Results: *Comparison of variables assessed before and after the NeoMayor Pilot Study.*

	Physical examination	A: Before Pilot n=60	B: After Pilot n=60	A versus B [a]
Physical examination	Weight (kg)	72 ± 14	71 ± 17	0.527
	Waist circumference (cm)	99 ± 11	92 ± 12	< 0.0001 **
	Systolic blood pressure (mmHg)	131 ± 17	121 ± 14	< 0.0001 **
	Diastolic blood pressure (mmHg)	72 ± 14	72 ± 14	0.5677
	Handgrip (kg)	25 ± 6	26 ± 6	0.476
	Five chair-stands time (seconds)	10 ± 2	8 ± 2	< 0.001 **
	SPPB (score 0 to 12)	11.3 ± 1.1	11.9 ± 0.5	< 0.001 **
	Timed Up and Go simple task (seconds)	10 ± 2	8 ± 2	< 0.001 **
	Timed Up and Go dual task (seconds)	11 ± 2	9 ± 2	< 0.001 **
Blood test	Fasting Blood Glucose	107 ± 26	104 ± 24	0.851
	Fasting Blood Total Cholesterol	192 ± 36	198 ± 43	0.165
	Fasting Blood HDL Cholesterol	57 ± 15	52 ± 14	0.0051 *
	Fasting Blood LDL Cholesterol	109 ± 34	117 ± 39	0.452
	Fasting Blood Triglycerides	134 ± 52	146 ± 67	0.426
Life's Essential 8	CVH index	63 ± 10.8	69 ± 11.3	<0.0001**
	Blood pressure	63.7 ± 23.2	77.5 ± 23.3	<0.0001**
	Blood lipids	69 ± 29.5	65 ± 32.4	0.176
	Blood glucose	65.8 ± 29.8	73.3 ± 32.5	0.038*
	Body Mass Index	58.2 ± 28.2	59.6 ± 28.1	0.378
	Physical activity	62.2 ± 34.4	76.3 ± 27.4	0.003*
	Diet	49.8 ± 21.1	57.3 ± 21.6	0.006*
	Tobacco	58.7 ± 31.1	58.7 ± 31.1	
	Sleep	73.8 ± 26.1	79.6 ± 25.1	0.066
Questionnaires And cognitive test scores	MIND food score	8 ± 2	8 ± 6	0.491
	IPAQ score	1,8 ± 0,6	2,4 ± 0,6	< 0.0001 **
	PSQI Self-reported Sleep duration	6,4 ± 1	6,4 ± 1	0.7373
	PSQI Score	8 ± 4	8 ± 4	0.7515
	MCA	5 ± 3	3 ± 2	0.016 *
	GDS	2 ± 2	2 ± 3	0.081
	MEFO	12 ± 1	12 ± 1	0.141

*Notes: Values are presented as mean ± standard deviation. Paired t-test with equal variances. ** p<0.0001; *p<0.05. Abbreviations: SPPB: Short Physical Performance Battery;; MIND: Mediterranean-DASH Diet Intervention for Neurodegenerative Delay; PSQI: the Pittsburgh Sleep Quality Index; MCA: self-perception of memory scales; GDS: Geriatric depression scale; MEFO: Memory, Fluency, and Orientation test.*

Discussion

In this study, we described the design, development, and validation of the mHealth software NeoMayor, the first app developed for promoting healthy lifestyles and brain health in Chilean older adults. It was created as a comprehensive software solution aimed at promoting healthy lifestyle habits and enhancing cardiovascular and brain health in older adults by using multi-component lifestyle interventions. NeoMayor App categorizes users' cardiovascular health profiles based on a survey inspired by the AHA´s Life´s essential 8, adapted and validated in this pilot study. Further on, the app delivers personalized recommendations and content covering physical activity, nutrition, mental health, memory, and general health management for a healthy brain promotion (63),

providing a personalized guide to healthier living. This structured and systematic development process, combined with the validation of the content and design, allows for potential replication in other mHealth applications, particularly for populations with limited digital literacy or access to health technologies (51). This allows us to consider the barriers and facilitators to adopting mHealth-mediated strategies described in the literature (21, 26, 27).

Although there are several international initiatives for promoting health care in older adults, most of them are developed in HIC, thus are not designed for populations with lower educational levels, which need special adaptations and a cultural validation to fit their necessities (64). In this sense NeoMayor is the first software adapted for Chilean older adults for integral healthcare promotion.

Regarding the adherence, the average daily usage time of NeoMayor app was notably higher (6,6 minutes per day) than that reported in other studies of older adults using mobile apps (2 minutes per day), suggesting a high level of engagement with the platform (65) which could be related with the high technological skills and high motivation of the participants that used the app. One important factor to consider in the adoption of mHealth technology is technology-related anxiety (66) in people with limited digital literacy, which may require positive management to encourage use of apps(17). Even though this study included participants with functional independence and cognitive ability and were required to possess basic digital technology skills, for a broader impact on coverage of older people with low digital literacy or cognitive issues (67), other strategies could include healthcare or coach-assisted mHealth in cases of moderate mHealth alphabetization or social digital barriers to engagement and health literacy empowerment (68).

The findings of the pilot study suggest that using the NeoMayor App led to improvements in both metabolic health and lifestyle habits, which are key indicators of the potential app's effectiveness (69). The improvements observed in blood pressure (with a reduction in 10mmHg of systolic blood pressure), blood glucose, physical activity, and diet, key elements in the prevention of cardiovascular disease and other non-communicable diseases, represent a relevant finding that should be confirmed in a larger-scale randomized controlled trial (62). Although we did not find significant changes in body mass index, participants had a significant reduction in waist circumference, which is more closely related to cardiovascular risk than BMI (70). This is a very important result considering that 47% of the participants were obese.

The significant enhancement in functional physical performance measured by SPPB (71), gait speed alone, and sit-to-stand alone is relevant considering its critical importance in the risk reduction for physical fragility and falls in older adults (72). Moreover, the reduction in two seconds in the sit-to-stand test is a statistically significant and clinically relevant change in older Chileans, which is

associated with higher survival rates (73). These improvements in physical performance may be attributed to the physical activity module, which includes instructional videos, which is consistent with findings from previous research on the impact of video-guided physical activity interventions (51, 74). In addition, these improvements contribute to enhanced metabolic health. Also, we find an increase in memory self-perception, which could be associated with physical activity and the global cognitive activity given by the app use. It is reported that physical activity with cognitive training can improve self-perceived memory in older adults (75), and exercise is a main component of cognitive health (76).

As an additional strength, usability testing demonstrated easy user navigation, with a main menu that provided intuitive access to the app's modules. Users reported a preference for challenge-based navigation, which allowed them to set specific health goals and stay motivated.

However, minor modifications should be addressed in future iterations of the app, including engaging navigation elements, considering the importance of structural measures to change lifestyle (14, 77). As limitations of our study, we included only subjects without sensorial or cognitive impairment, with good technological skills. A projection is also to generate alternatives in the initial survey that will allow for ways to expand the intervention's applicability in the future by considering the co-design of an inclusive version of the application according to digital literacy. Additionally, since most of the participants were women, though this is a frequent proportion in similar studies (78), it may limit the external validity of our findings. This issue often arises in pilot studies where feasibility is the main objective and could be overcomed in future studies using the NeoMayor App in population-based samples. As a pilot study, the methodology used cannot establish the efficacy of NeoMayor in cardiovascular health without confounding factors, but it provides a solid foundation to start a randomized controlled trial with overcomed sample bias. Indeed, with the implementation of the design improvements, the NeoMayor product has a technology readiness level (TRL) 4 (*Figure 2*). Next phase will be to evaluate the effectiveness of NeoMayor mHealth software's on cardiovascular health and lifestyle in a randomized controlled trial, which should include at least 200 participants with different digital literacy and technological skills according to the sample estimation considering the moderate effect size over cardiovascular health found in the pilot.

Conclusions

We described the design, development, and validation of a comprehensive mHealth app for mobiles that promotes healthy lifestyle, cardiovascular and brain health in older adults. Employing a person-centered, multidisciplinary approach grounded in Lean UX and Agile methodology for co-design and

co-development. NeoMayor demonstrated good feasibility and potential effectiveness in improving cardiovascular health and physical performance that will be evaluated shortly, in a larger controlled trial. These findings indicate that NeoMayor App can provide an accessible, affordable, and implementable strategy to support healthy aging.

Acknowledgments

The authors thank the NeoMayor team, the Healthy Brain Unit personnel, the WIC team, and all participants of the co-creation sessions and testing sessions.

Disclosure Statement

The authors declare that the research was conducted without commercial or financial relationships that could create a conflict of interest.

Funding

This research was funded by the Chilean Fund for the Promotion of Scientific and Technological Development (FONDEF) grant ID2110096 (CD); and the Chilean National Agency for Research and Development (ANID) grant 21221932 for doctoral studies (MG). The APC was funded by Universidad Mayor (MG).

Author Contributions

Conceptualization, C.D.; methodology, C.D., J.M., C. SM.; software, D.C, C.A., and P.V.; validation, C.D., F.S., M.I.B.; formal analysis, C.D., J.M., M.G., V.C., and C.D.SM.; investigation, M.T., C.D., V.C., M.G., C.M., G.M., C.D.SM., C.S.M, R.B., D.P., and N.R..; resources, C.D, and M.I.B.; data curation, CD, JM, M.G.; writing original draft preparation, M.G.; writing, review and editing, M.G., V.C., M.G., C.D.; supervision, C.D.; project administration, C.D., and M.T.; funding acquisition, C.D., MG; V.C.. All authors have read and agreed to the published version of the manuscript.

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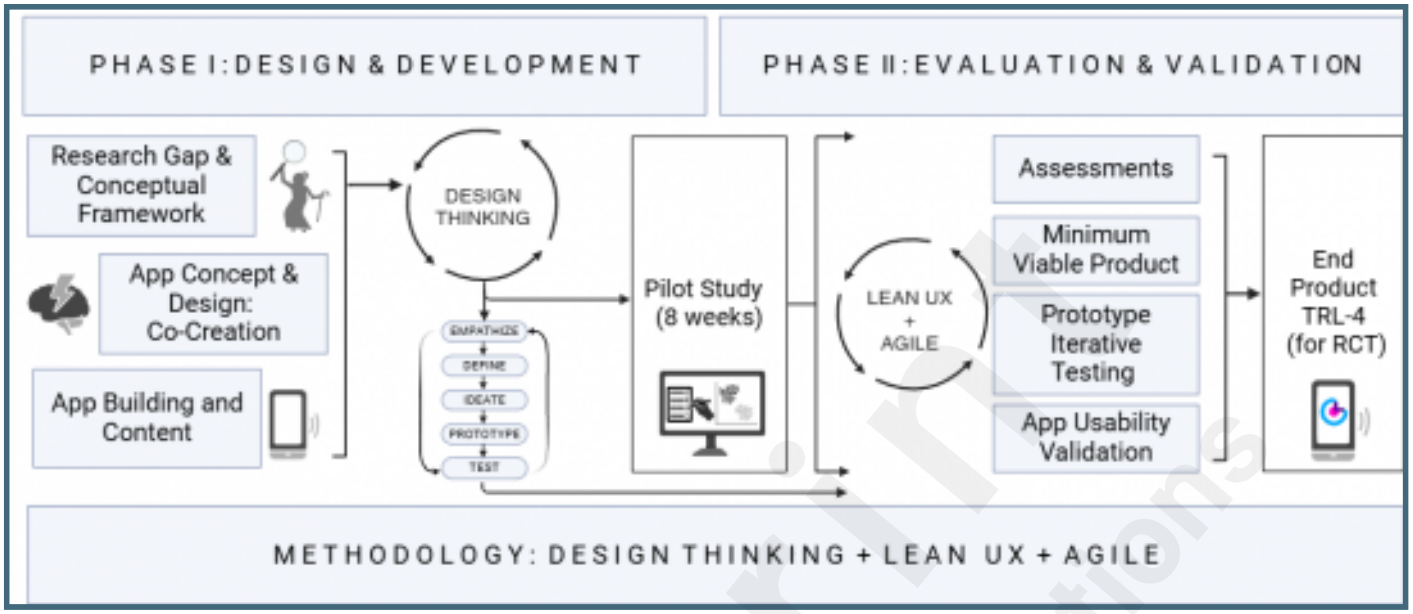
Supplementary Files

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Figures

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Theoretical model of user experience used in NeoMayor Study. Two phases of the NeoMayor App study: I. Design and Development; and II. Evaluation and Validation. Abbreviations: RCT: Randomized Controlled Trial. Created in https://BioRender.com.



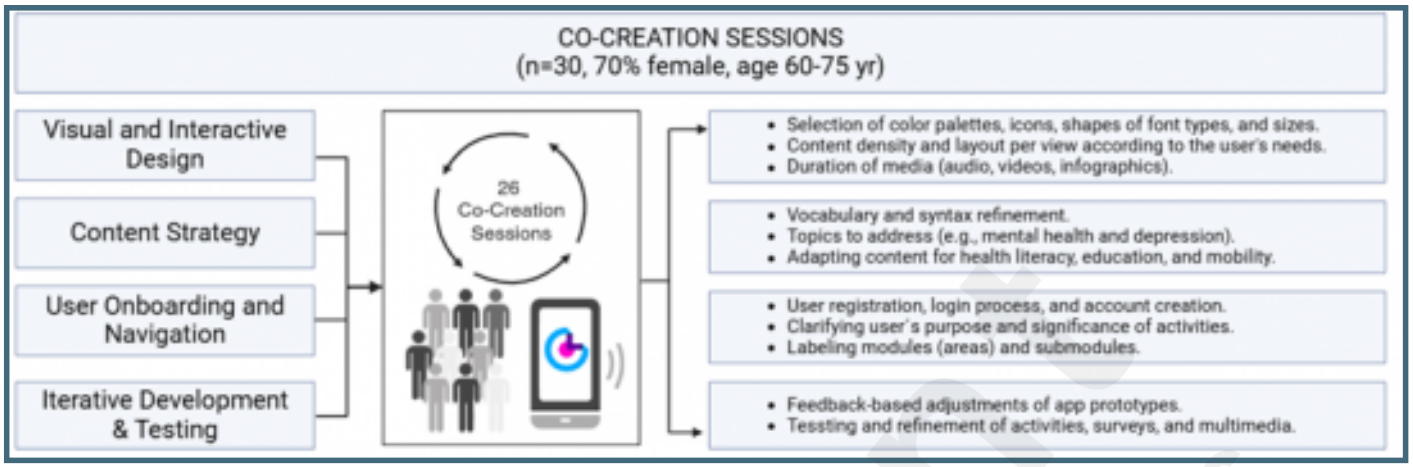
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Screens of the NeoMayor App. A) App Initial menu, recommendations, and goal-directed navigation; B) cardiovascular health categorization.



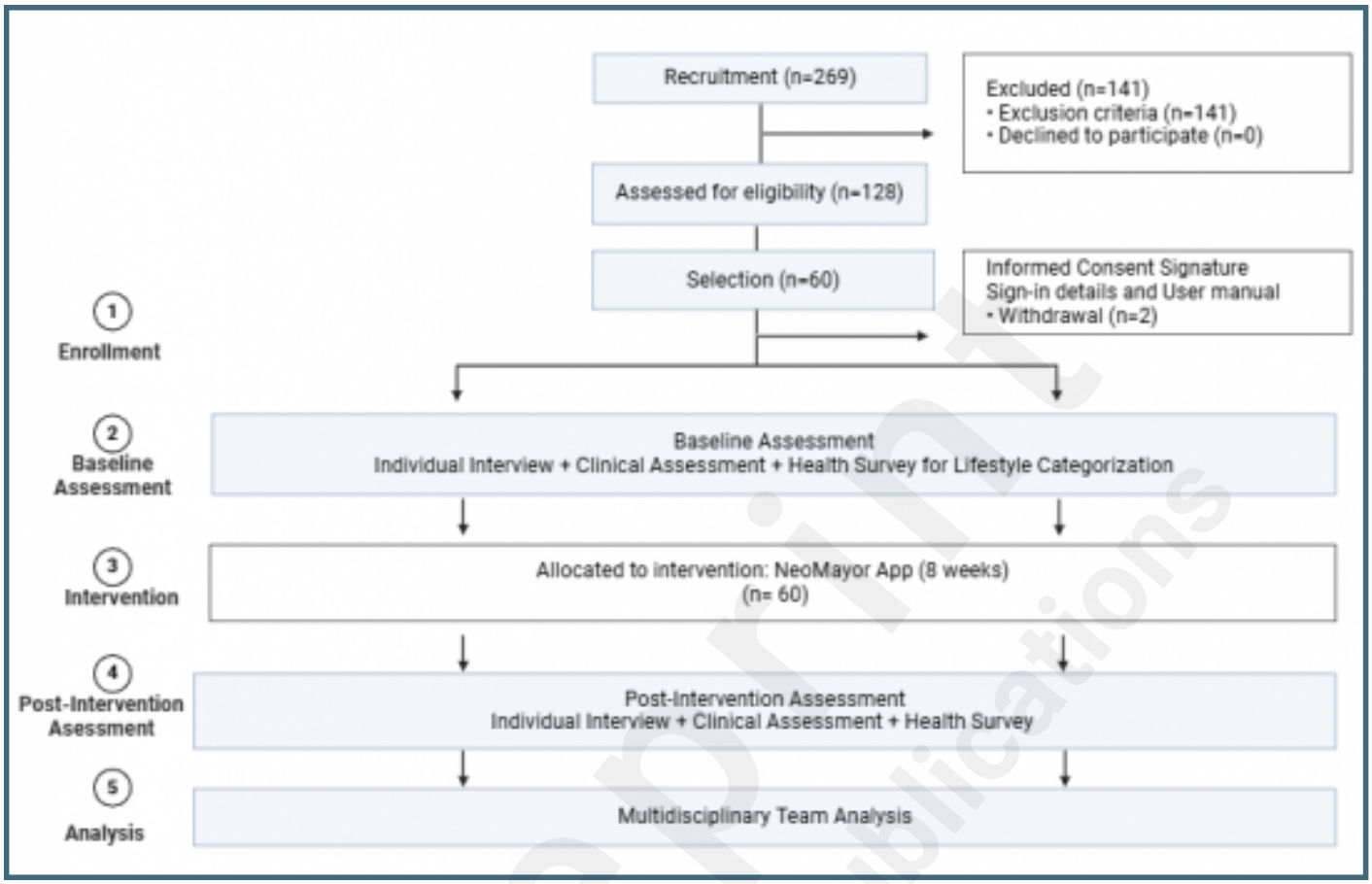
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Co-Creation Sessions. The NeoMayor iterative participative design process. Created in https://BioRender.com.

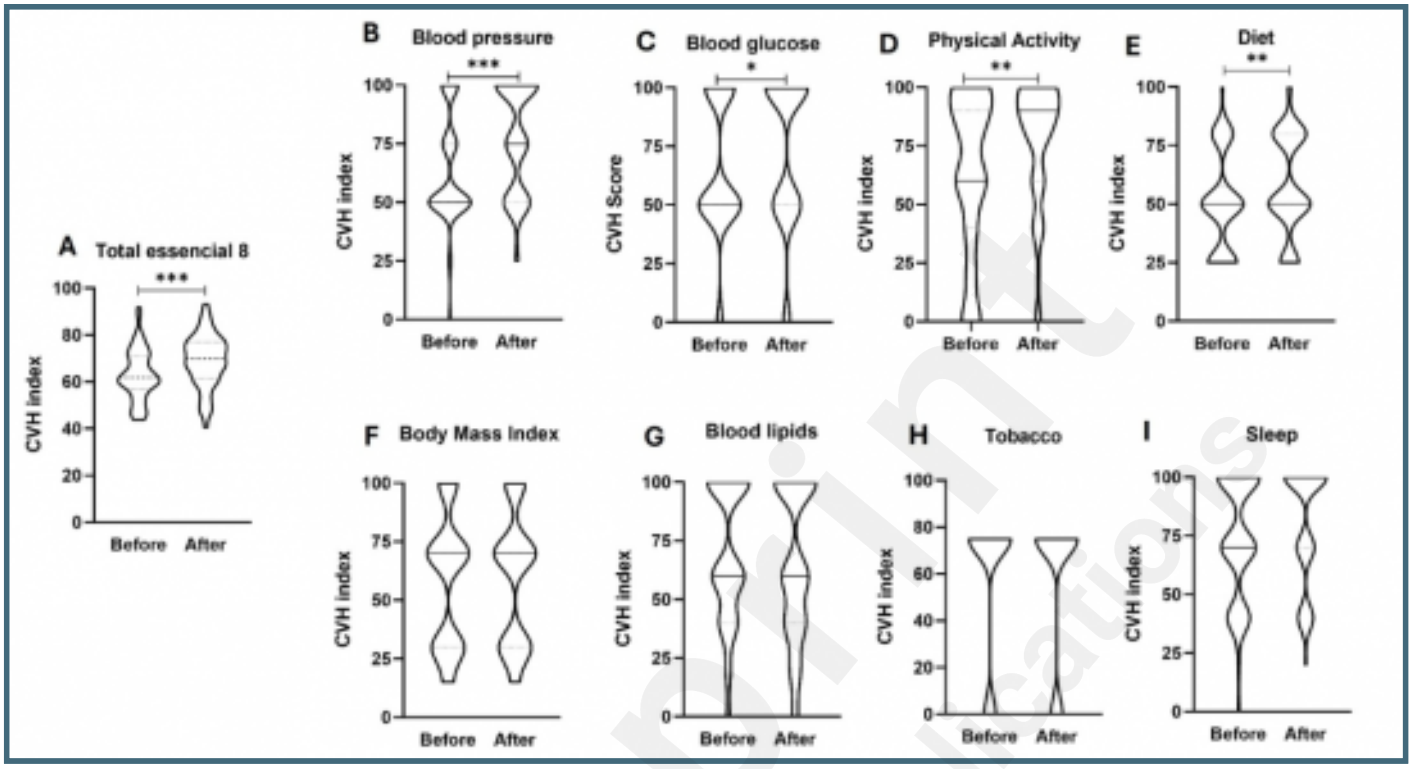


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