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Diagnosis Before Selection: A Co-Created Digital Nudging Framework for Health App Design

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Abstract

Digital nudging is a promising approach for supporting health-related behaviour change through mobile applications, yet existing design frameworks focus on selecting nudge mechanisms while offering little guidance on identifying users' cognitive states beforehand. This study reports the third phase of a three-phase mixed-methods research programme examining how behavioural design frameworks can better support practitioners in applying digital nudges effectively and ethically. Building on prototype testing with 88 users and a mixed-methods study of 38 UX/UI designers, Framework Version 1.0 was refined through a participatory co-creation workshop with ten professional designers; workshop data were analysed using reflexive thematic analysis in MAXQDA. Findings indicate that practitioners require explicit support for diagnosing users' cognitive states before selecting interventions, that ethical evaluation should consider how a nudge influences decision-making rather than only its intended outcome, and that behavioural design frameworks must align with the time constraints of commercial practice. The workshop also identified identity-threat reactance as a distinct consideration in mindfulness-related design. These findings informed Framework Version 2.0, a practitioner-oriented framework integrating cognitive state diagnosis, mechanism-based ethical evaluation, and a sprint-compressed implementation mode into a unified design process. While further validation is needed, the framework offers an initial contribution toward bridging behavioural theory and professional UX practice.

Keywords

Co-Creation, Participatory Design Research, Digital Nudging, UX Practice, Fogg Behavior Model.

Introduction

Digital health applications are increasingly used to support behaviour change, yet sustaining engagement remains difficult: the median objective use of mental health applications falls below 4% within fifteen days of installation (Baumel et al., 2019). Although behavioural theories and digital nudging strategies are well established in behavioural science and human-computer interaction, their translation into everyday UX practice remains inconsistent (Voorheis et al., 2023; Michie & Prestwich, 2010).

Our prior research examined this gap from user and practitioner perspectives. Study 1 (Anonymous Authors, 2025a) tested user responses to nine nudge mechanisms across three health domains (hydration, posture correction, mindfulness) with 88 participants, finding that nudge effectiveness depends on users' cognitive state and delivery context as well as mechanism choice. Study 2 (Anonymous Authors, 2025b) examined behavioural design practice through questionnaires and interviews with 38 professional designers, revealing inadvertent application of behavioural mechanisms, ethical uncertainty, and limited approaches for evaluating outcomes beyond conventional engagement metrics.

The present study reports Study 3, in which Framework Version 1.0 (synthesised from Studies 1 and 2) was evaluated and refined through a participatory co-creation workshop with ten professional UX/UI designers using a Double Diamond process (Design Council, 2005). Rather than evaluating a completed framework, participants acted as co-creators who identified limitations and proposed improvements for professional use.

The central contribution of this paper is a diagnosis-before-selection approach: beginning the design process with cognitive state diagnosis rather than mechanism selection. Two supporting developments emerged from the workshop: mechanism-based ethical evaluation, and a sprint-compressed implementation mode suited to commercial UX workflows. The remainder of the paper reviews existing frameworks, describes the study method, reports workshop findings, presents Framework Version 2.0, and discusses implications for practice and future research.

Research Context

Existing Digital Nudging Frameworks and the Need for Cognitive State Diagnosis

Digital nudging research in health applications draws on three related traditions: behavioural economics, which explains how choice architecture shapes decisions (Thaler & Sunstein, 2008); human-computer interaction, which examines how behavioural mechanisms are implemented in interfaces (Caraban et al., 2019); and UX design research, which addresses how these mechanisms are incorporated into products and services (Mirsch & Lehrer, 2018).

Existing frameworks offer substantial guidance on selecting and implementing nudge mechanisms. Caraban et al. (2019) classify twenty-three digital nudge mechanisms; Mirsch and Lehrer (2018) propose a structured design method; Meske and Amojo (2020) introduce ethical principles for responsible implementation; and Valta and Maier (2025) consolidate this work into a systematic taxonomy. However, these frameworks provide comparatively little procedural guidance for diagnosing users' behavioural states before mechanism selection. Designers are instead expected to interpret theories such as the Behaviour Change Wheel (Michie et al., 2011), the Fogg Behavior Model (Fogg, 2009), and Dual-Process Theory (Kahneman, 2011) and translate them into design decisions without a dedicated diagnostic step.

Evidence from the broader research programme suggests this is a genuine practical obstacle. Study 2 found that many designers apply behavioural strategies without recognising the underlying mechanisms, while Study 1 found that the effectiveness of identical mechanisms varied with users' cognitive states and contextual conditions. Together, these findings suggest that selecting an appropriate mechanism depends on first understanding the user's behavioural state, a premise on which Framework Version 2.0 is built.

Empirical Foundations of Framework Version 1.0

The present study builds directly on the empirical findings of Studies 1 and 2, which informed the initial development of Framework Version 1.0 prior to its refinement through participatory co-creation. Because these earlier studies have been anonymised for double-blind review, only summary methodological information is presented here; full methodological descriptions and citations will be restored following peer review. Study 1 employed prototype-based behavioural testing with 88 participants across three health domains; Study 2 combined a mixed-methods questionnaire with follow-up interviews involving 38 UX/UI professionals. The present paper focuses on Study 3, in which Framework Version 1.0 was critically evaluated and refined by professional designers.

1. *Study 1: User Prototype Testing (n = 88)*

Study 1 (Anonymous Authors, 2025a) investigated user responses to digital nudges through three interactive Figma prototypes (hydration tracking, posture correction, and mindfulness initiation) tested remotely via the Maze platform with 88 participants. The study combined behavioural interaction data with qualitative feedback, analysed using reflexive thematic analysis in MAXQDA. Descriptive frequencies are reported where relevant to indicate the prevalence of themes rather than to support statistical inference; they are used descriptively, to enhance transparency, and should not be read as hypothesis testing.

Three findings informed the initial framework. First, digital nudge effectiveness varied across health domains, indicating that no single mechanism was universally effective. Second, distinct cognitive barriers were identified for each domain suggesting that intervention strategies should be adapted to users' cognitive and motivational conditions. Third, qualitative analysis identified seven cognitive themes (Table 1) explaining how trust, identity, autonomy, habit formation, and social influence shaped users' responses.

Table 1: *Seven cognitive themes from Study 1 (n = 88), with theoretical grounding.*

Cognitive theme	Empirical signature	Theoretical grounding
1. Automation–control tension	Conflict between wanting automatic execution and retaining perceived choice	Dual-Process Theory: System 1 desire coexisting with System 2 vigilance
2. Trust as response gateway	Nudge evaluation indexed on perceived source intent, not content	Elaboration Likelihood Model: trust gates central-route processing
3. Self-identity activation	Identity-aligned framing produced disproportionate, pre-deliberative engagement	Self-Concept Theory; Somatic Marker Hypothesis
4. Reactance: autonomy threat	Perceived autonomy violation produced active avoidance	Reactance Theory (Brehm & Brehm, 1981)
5. Progress visualisation as anchor	Visual progress representations produced strong motivation, notably in hydration	Goal-Gradient Theory (Hull, 1932)
6. Social proof polarisation	Positive for solidarity framing; negative for competitive framing	Social Comparison Theory (Festinger, 1954)
7. Habit-loop initiation	Subset reported post-session behavioural influence within hours	Habit Loop Theory; Lally et al. (2010)

2. *Study 2: Designer Questionnaire and Interviews (n = 38)*

Study 2 (Anonymous Authors, 2025b) examined how professional UX/UI designers integrate behavioural design into practice through a mixed-methods questionnaire completed by 38 designers, with follow-up semi-structured interviews with eight participants. Six themes described the principal challenges: inadvertent application of behavioural mechanisms; limited awareness of underlying psychological mechanisms; reliance on intuitive ethical judgement; commercial pressures favouring engagement over user-centred outcomes; time constraints within agile development; and the absence of practical behavioural design resources. These findings directly informed Framework Version 1.0 and motivated the participatory refinement undertaken in Study 3.

Together, Studies 1 and 2 provided the empirical and practical foundations for Framework Version 1.0. Study 3 extends this research by examining how professional designers critique, refine, and operationalise the framework through participatory co-creation, leading to Framework Version 2.0.

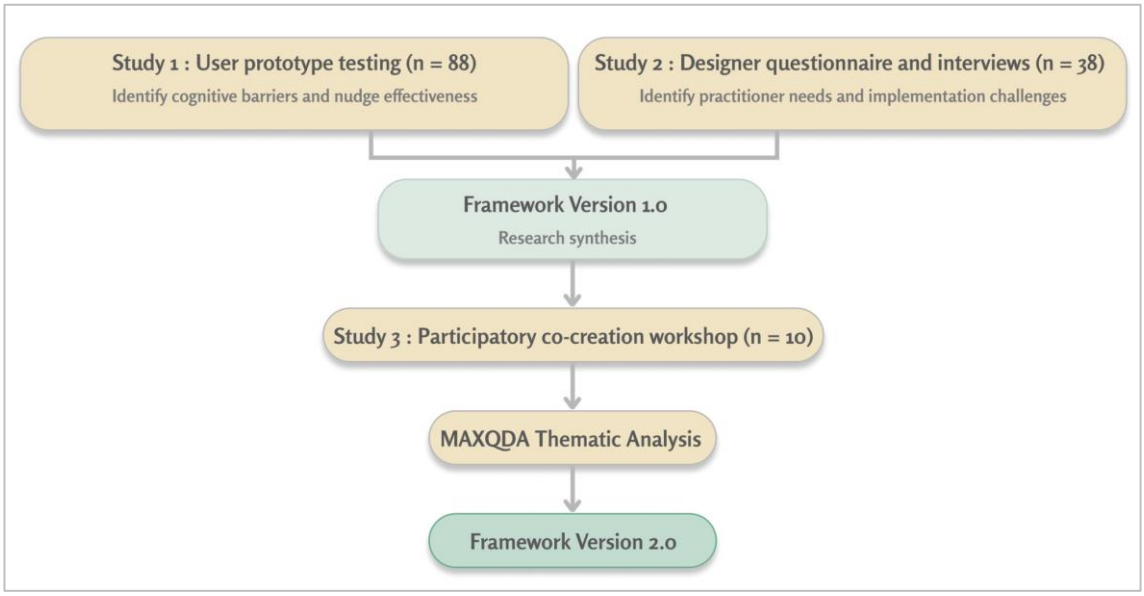


Figure 1: *Overview of the Three-Phase Research Programme*

Methodology

1. *Methodological Rationale*

Study 3 employed a participatory co-creation methodology (Sanders & Stappers, 2008) structured around the Double Diamond design process (Design Council, 2005). Because the framework is intended to support professional UX practice, its refinement required active collaboration with practitioners as co-creators rather than evaluation by research subjects, treating the workshop as a process of knowledge generation.

The Double Diamond was selected because it mirrors the design process embedded in the framework itself, allowing participants to experience the same diagnostic and decision-making sequence under evaluation, and because its alternating divergent and convergent phases suit the dual task of identifying weaknesses and collaboratively refining solutions.

Although the study adopts an interpretive qualitative approach based on reflexive thematic analysis (Braun & Clarke, 2006), descriptive numerical indicators are occasionally reported to convey the prevalence of observations within the broader mixed-methods programme. These values are presented for transparency rather than statistical inference, and interpretation remains primarily qualitative throughout.

2. *Participants*

Ten professional UX/UI designers participated, recruited primarily from Study 2 respondents who had expressed interest in continued involvement and supplemented through professional design networks. Selection criteria included a minimum of three years' professional experience, current or recent involvement in health, wellness, or consumer digital products, and demonstrated interest in behavioural and ethical design practice.

This recruitment strategy ensured familiarity with behavioural design but may have introduced selection bias toward designers with more favourable attitudes to the framework than the broader UX profession; this is addressed further in the Limitations. A sample of ten is consistent with established participatory design practice (Sanders & Stappers, 2008), balancing perspective diversity against the collaborative interaction required for structured co-creation activities.

3. *Workshop Structure*

The workshop comprised seven structured activities across two three-hour sessions held one week apart (Table 2). The interval allowed participants time to reflect between sessions; Session 2 opened with a structured recap to reactivate shared understanding, and no substantive discontinuity in engagement was observed.

Session 1 (divergent phase) covered introductions, presentation of Study 1 and 2 findings, behavioural journey mapping with a think-aloud protocol, and identification of behavioural design pain points. Session 2 (convergent phase) comprised a Framework Version 1.0 walkthrough, a nudge mechanism selection exercise across three scenarios, an ethics stress-test using four vignettes including the countdown-timer case, and a consensus-building discussion using the Nominal Group Technique (NGT).

NGT was selected for its systematic procedure for generating, discussing, and prioritising ideas while balancing participation across the group: participants first generated recommendations independently, shared them in round-robin format, discussed them collectively, and reached agreement through facilitated dialogue. Only proposals with broad support were incorporated into the framework; dissenting views were retained in the analytical record.

Table 2: *Workshop Structure*

Time	Activity	Focus	Primary data generated
Session 1 (3h)	Introductions; Study 1 & 2 findings; behavioural journey mapping (Figma); pain-point identification (Miro)	Divergent phase	Initial reactions; think-aloud diagnostic attempts; documented practice gaps and ethical dilemmas
Session 2 (3h, one week later)	Framework v1.0 walkthrough; mechanism selection exercise; ethics stress-test (four vignettes); consensus-building (NGT)	Convergent phase	Usability friction points; countdown-timer debate; ranked refinement priorities; ideation contributions

4. *Data Collection and MAXQDA Analysis*

All sessions were audio-recorded with consent and transcribed verbatim within forty-eight hours. Data sources included workshop transcripts (approximately 39,200 words), Figma and Miro artefacts, scenario rationales, ethics vignette responses, and consensus-discussion outputs, imported into MAXQDA 2024 and analysed using Braun and Clarke's (2006) reflexive thematic analysis.

Analysis proceeded through three phases. Open coding generated approximately 440 initial codes. Axial coding consolidated these into 48 categories across six clusters, ethical reasoning, diagnostic practice, domain extension, workflow integration, framework-language accessibility, and ideation (the latter kept analytically distinct from evaluative codes). Selective coding produced four overarching themes plus one cross-cutting ideation cluster. The first author conducted the primary coding. Coding decisions and theme boundaries were reviewed through regular discussion with the supervisory team; where interpretations diverged, disagreements were resolved through iterative discussion toward conceptual agreement rather than statistical inter-coder reliability, consistent with reflexive thematic analysis's emphasis on transparency and interpretive rigour over coder-agreement metrics (Braun & Clarke, 2006).

Member checking was conducted with three participants, selected by facilitator judgement to represent varied professional backgrounds and levels of workshop engagement. During the two-week refinement period they confirmed that the themes accurately reflected discussions, offering only minor wording suggestions.

5. *Researcher Reflexivity*

The first author developed Framework Version 1.0, facilitated the workshop, and conducted the primary coding and interpretation. Recognising that this prior involvement could influence data interpretation,

reflexive memo-writing was maintained throughout the analytical process to document emerging assumptions and coding decisions.

Preliminary themes were reviewed iteratively with the supervisory team, allowing alternative interpretations to be considered, and participant feedback obtained through member checking verified that resulting themes accurately reflected workshop discussions. This combination of reflexive documentation, supervisory dialogue, and participant validation strengthened analytical transparency while reducing the influence of individual researcher assumptions on Framework Version 2.0.

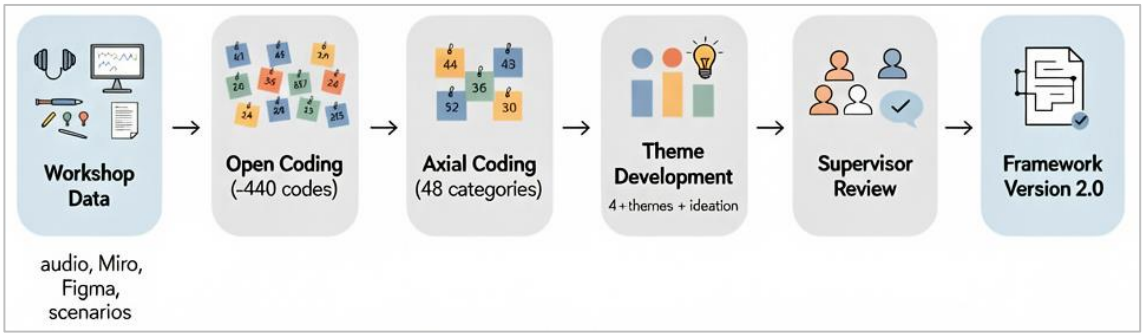


Figure 2: *Summarising the Analytical Process from Data to Framework*

Findings

Reflexive thematic analysis identified four major themes informing the refinement of Framework Version 2.0, spanning ethical guidance, diagnostic process, domain applicability, and workflow integration. Each theme is presented with representative evidence and the resulting framework revision.

1. *Theme 1: Transparency-Based Ethical Criteria Are Insufficient at the Persuasion–Manipulation Boundary*

Participants applied consistent ethical reasoning when evaluating individual nudge mechanisms, but the framework's four transparency-based criteria (transparent purpose, visible opt-out, alignment with user goals, evidence-based justification) proved insufficient for ethically ambiguous cases. The countdown-timer vignette (a fitness application displaying a genuine countdown within a voluntary 48-hour challenge) satisfied all four criteria yet generated persistent uncertainty:

> *"All four criteria pass. But something still feels wrong. Which tells me the criteria are not sufficient."*
> *— Participant 01*

Discussion did not converge, suggesting that transparency-based criteria alone cannot resolve ambiguous cases. Participants proposed that ethical evaluation should also examine the cognitive mechanism through which influence is achieved, distinguishing interventions that support reflective decision-making from those that exploit vulnerabilities such as artificial scarcity or urgency. This informed the addition of a mechanism-based ethical criterion to Framework Version 2.0, evaluating nudges by how influence is generated as well as what they aim to achieve.

2. *Theme 2: Cognitive State Diagnosis as Unfamiliar Professional Practice*

Participants were familiar with major behavioural theories but lacked practical methods for diagnosing users' cognitive states during design activities, an under-recognised gap in professional UX practice. The journey-mapping exercise required participants to identify motivational and cognitive states using the Behaviour Change Wheel, the Fogg Behavior Model, the Transtheoretical Model, and Dual-Process Theory, but many reported difficulties applying these constructs concretely:

"I understand what those things mean in theory. But when I'm looking at a journey map touchpoint and trying to write something concrete, I'm guessing."
— Participant 05

Participants framed this as a limitation of existing frameworks rather than a competency gap, proposing that diagnosis be simplified rather than require independent integration of multiple theories. The most widely supported proposal was a colour-coded triage system classifying users into six behavioural modes, described as a "good enough, fast enough" tool suited to commercial environments. This became Section A of Framework Version 2.0, positioning cognitive state diagnosis as the first step in the design process.

3. *Theme 3: Domain Extension and the Identity-Threat Reactance Construct*

Participants considered the framework applicable beyond the three domains studied in Study 1, proposing extension to physical activity, sleep, and medication adherence, and distinguishing identity-related resistance from more commonly reported timing- or frequency-based reactance. Physical activity was described as involving compounding barriers; self-efficacy, body image, social anxiety, and time constraints:

"You're not designing around a behavior; you're designing around someone's relationship with their own body image."
— Participant 10

Sleep interventions raised a distinct "*screen–sleep paradox*," since the delivery medium itself can contribute to the problem the intervention targets, suggesting a need for ambient or pre-sleep design approaches that reduce screen engagement.

Comparison with the Study 1 mindfulness data indicated that resistance there was often tied to identity rather than timing or frequency: prompts implying an identity user had not adopted (e.g., framing someone as "*a meditator*") generated resistance regardless of delivery timing. This extends existing accounts of reactance in digital nudging (Caraban et al., 2019) by identifying identity-threat reactance as a distinct form of resistance relevant to mindfulness, mental health, and self-care design. These findings informed both the domain extension and the explicit inclusion of identity-threat reactance in Framework Version 2.0.

4. *Theme 4: Sprint-Compressed Cognitive Design as Structural Necessity*

Framework adoption depended not only on theoretical structure but on compatibility with commercial UX workflows. Participants reported that the full diagnostic process required more time than sprints typically allow:

"I've been trying to do this exercise, and it's taking me eight minutes per touchpoint. Our typical sprint has maybe forty minutes of discovery."
— Participant 02

Participants also noted that behavioural reasoning in practice often follows rather than precedes interface development, and proposed a structured behavioural briefing conducted before each sprint, using the diagnostic card system to rapidly agree on the user's cognitive state, the primary barrier, candidate mechanisms, and an initial ethical review:

"Before a sprint starts, you have a one-hour behavioral brief session... that becomes the behavioral constraint that informs the rest of the sprint."
— Participant 06

This proposal received broad support in the consensus-building discussion and was incorporated as a sprint-compressed integration pathway, enabling the framework to operate within agile constraints.

5. *Cross-Theme Ideation Contributions*

Ideation codes, kept analytically separate from evaluative codes, captured proposals not tied to a single theme. The consensus discussion produced a five-question Ethics Audit Checklist addressing user goals, visibility of choice, informed consent, transparency, and preservation of autonomy; incorporated into Framework Version 2.0 as a pre-implementation review tool. Participants also proposed rationale-communication templates enabling designers to explain behavioural design decisions to clients and multidisciplinary teams without specialist terminology, arising from discussions of both workflow constraints (Theme 4) and framework accessibility (Theme 2). Together, these resources support the framework's practical adoption while remaining distinct from its conceptual structure.

Framework Version 2.0: Architecture and Theoretical Logic

1. *Revision Logic*

Table 3 summarises the revisions made to Framework Version 1.0 following the co-creation workshop. Each revision is traceable to a specific workshop theme identified through the MAXQDA analysis. Sections A–E correspond to the five components of Framework Version 2.0: (*A*) Behavioural State Diagnosis, (*B*) Nudge Type Selection, (*C*) Intensity Calibration and Ethical Thresholds, (*D*) Dual-Process Targeting, and (*E*) Health Domain Guidance.

Table 3: *Version 1.0 → Version 2.0 Revision Mapping*

§	Version 1.0 limitation	Version 2.0 revision	Theme
C	Abstract ethical criteria fail on ambiguous cases (countdown-timer paradox).	Mechanism-based ethical criterion; four worked examples added.	1. Ethical ambiguity
A	Diagnosis requires simultaneous COM-B + FBM + TTM application; stage boundaries non-isomorphic.	Six-mode traffic-light card deck; "*good enough fast enough*" triage instrument.	2. Diagnosis unfamiliar
E	Domain guidance limited to three Study 1 domains; identity-threat reactance unspecified.	Physical activity and sleep profiles added [W]; identity-threat construct named.	3. Domain extension
Proc.	Five-step process incompatible with sprint timelines (8 min/touchpoint vs. 40-min discovery).	Sprint-compressed one-hour pre-sprint behavioural brief mode added.	4. Workflow constraint
C	Ethics section lacks operationalised checklist.	Five-question Ethics Audit Checklist added.	Ideation
Tk.	No template for communicating nudge rationale to non-specialist clients.	Stakeholder communication template set added (4 templates).	Ideation

2. *Framework Architecture*

Framework Version 2.0 integrates the Fogg Behavior Model (Fogg, 2009), Caraban et al.'s (2019) 23-mechanism taxonomy, and relevant behavioural theories into a five-section, practitioner-oriented workflow in which behavioural state diagnosis precedes mechanism selection.

Section A — Behavioural State Diagnosis

A six-mode diagnostic system, drawing on the Behaviour Change Wheel, the Fogg Behavior Model, the Transtheoretical Model, and Dual-Process Theory, provides a rapid classification tool for identifying users' cognitive and motivational states before intervention design.

Section B — Nudge Type Selection with Psychological Evidence

The 23 mechanisms identified by Caraban et al. (2019) are organised by Fogg trigger category and annotated with cognitive bias, compatible behavioural states, ethical risk level, and a health application example; mechanisms with elevated ethical risk carry additional usage guidance.

Section C — Intensity Calibration and Ethical Thresholds
Three graduated intensity levels, a mechanism-based ethical assessment, and the five-question Ethics Audit Checklist together support calibrated behavioural influence while preserving transparency, autonomy, and informed decision-making.

Section D — Dual-Process Targeting
Drawing on Kahneman's (2011) Dual-Process Theory, this section aligns interventions with users' cognitive processing mode and flags situations in which mismatched interventions may increase resistance or disengagement.

Section E — Health Domain Guidance
Domain-specific guidance covers hydration, posture, and mindfulness (empirically grounded in Study 1) and physical activity and sleep (practitioner-validated in Study 3), with evidential strength distinguished throughout (Table 4).

Table 4: *Health Domain Cognitive Barrier Profiles and Recommended Nudge Sequences*

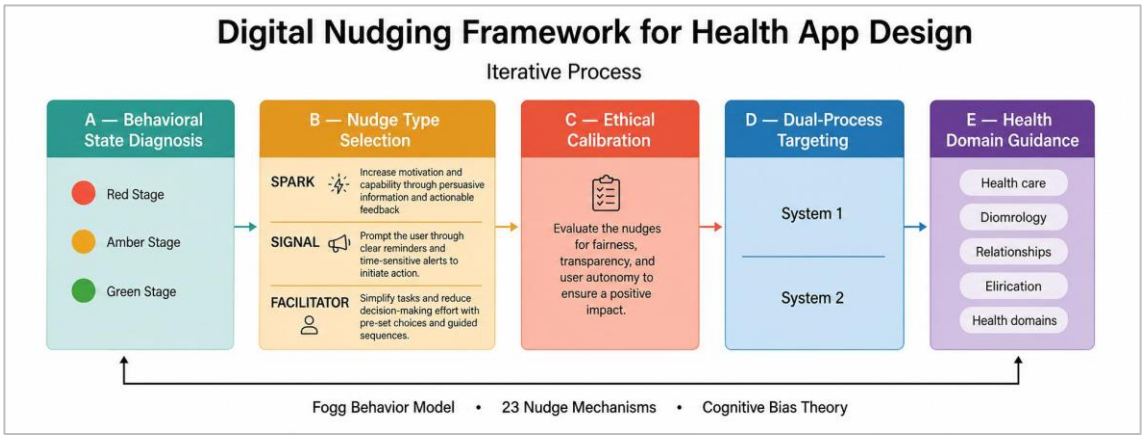
Domain (n)	Primary cognitive barrier	Recommended nudge sequence
Hydration (n=26)	Low awareness	Facilitator (default with opt-out) → Signal (behavioural-state trigger, not fixed clock)
Posture correction (n=25)	Task interruption	Signal (behavioural inactivity trigger) → Facilitator (one-tap completion)
Mindfulness (n=37)	Identity threat	Spark (identity-affirming framing) → Facilitator (micro-session default)
Physical activity [W]	Multiple barriers: self-efficacy, body image, social anxiety, time scarcity	Facilitator (home-based micro-session) → Spark (process-focused identity affirmation)
Sleep [W]	Screen–sleep paradox	Facilitator (wind-down default) → Signal (environmental cue, screen withdrawal)

Note. [W] denotes practitioner-validated domains.

3. *The Five-Step Cognitive Design Process*

The framework operationalises its five sections through a five-step process applicable in both comprehensive and sprint-compressed workflows: identify the user's behavioural state, select an appropriate mechanism, verify cognitive compatibility, calibrate intensity ethically, and evaluate effectiveness using the Nudge Effectiveness Score (NES). This sequence operationalises the framework's central principle that diagnosis should precede selection.

Figure 3: *Overview of Framework Version 2.0*



Evidence: Study 1 (n=88 users) · Study 2 (n=38 designers) · Study 3 Workshop (n=10, MAXQDA) | Theory: Fogg BM · COM-B · Dual-Process · SDT · Habit Loop

Due to space limitations, the complete Framework Version 2.0, including implementation resources, is provided as an online companion. The link has been withheld during double-anonymised review, as its URL would identify the authors, and will be made available upon publication.

Discussion

Diagnosis Before Selection as a Practitioner-Oriented Framework

The principal contribution of Framework Version 2.0 is reorganising the behavioural design process around cognitive state diagnosis before mechanism selection. Two supporting contributions follow from this architectural change: mechanism-based ethical evaluation, and a sprint-compressed implementation mode.

1. *Diagnosis Before Selection (Main Contribution)*

Framework Version 2.0 differs from existing digital nudging frameworks (Caraban et al., 2019; Mirsch & Lehrer, 2018; Meske & Amojo, 2020; Valta & Maier, 2025), which organise interventions primarily by mechanism, by asking designers to identify the user's cognitive and motivational state first. Across the three studies, Study 1 suggested that mechanism effectiveness depends on cognitive state and context; Study 2 suggested that designers struggle to diagnose these states consistently; and Study 3 indicated that practitioners valued an explicit diagnostic tool for rapid classification. Together, these findings support positioning diagnosis before mechanism selection in health-oriented digital nudge design. The framework's contribution is therefore not a new behavioural theory, but a new architectural organisation of existing theory that better supports practitioner decision-making.

2. *Mechanism-Based Ethics (Supporting Implication)*

Once a user's behavioural state is identified, designers must judge whether a selected mechanism supports autonomous decision-making or exploits cognitive vulnerabilities. Workshop findings suggested that transparency-based criteria alone were insufficient for ambiguous cases such as the countdown-timer scenario. Framework Version 2.0 therefore incorporates a mechanism-based ethical assessment alongside established principles of transparency, autonomy, and informed consent (Meske & Amojo, 2020), evaluating not only what a nudge achieves but how influence is generated; consistent with Fogg's (2009) original distinction between persuasion and manipulation.

The workshop also surfaced identity-threat reactance (Section 5.3), extending existing accounts of reactance in digital nudging (Brehm & Brehm, 1981; Caraban et al., 2019) by recognising that resistance can arise from an implied identity users have not adopted, independent of timing or frequency; a consideration particularly relevant to mindfulness, mental health, and self-care applications. Mechanism-based ethics is thus best understood as supporting the diagnosis-before-selection architecture: once behavioural states are identified, ethical evaluation helps ensure interventions remain consistent with autonomy and transparency.

3. *Sprint-Compressed Cognitive Design (Practical Implementation)*

Adoption in professional practice required compatibility with existing UX workflows. Although the diagnostic process was considered valuable, its original form exceeded the time available in commercial sprints. The sprint-compressed integration mode addresses this by enabling a structured behavioural briefing before sprint activities begin, in which teams collaboratively identify the user's behavioural state, agree on the primary barrier, select an intervention strategy, and complete an initial ethical review; preserving the core diagnosis-before-selection sequence while remaining compatible with agile practice.

This finding suggests that behavioural design frameworks require more than theoretical validity: they must also accommodate the organisational and temporal realities of professional design work, since a framework that cannot be implemented within available project constraints is unlikely to be adopted regardless of its conceptual strengths. The sprint-compressed mode therefore represents the practical translation of the framework's central contribution into everyday design practice.

Limitation and Future Research

Several limitations bound the interpretation of these findings. The study builds on two preceding studies (Studies 1 and 2) that remain anonymised for double-blind review; reviewers cannot independently examine their complete methodological descriptions, datasets, or analytical procedures, and only summary information is presented here. This constraint is inherent to anonymous peer review and will be resolved when citations are restored following publication.

Participant recruitment may have introduced selection bias, as most workshop participants were drawn from Study 2 respondents who had volunteered for continued involvement and may therefore have held more favourable attitudes toward behavioural design than the broader UX profession. Relatedly, the first author developed the initial framework, facilitated the workshop, and conducted the primary qualitative analysis; although reflexive memo-writing, supervisory review, and participant validation were used throughout to strengthen analytical credibility (Section 4.5), the interpretation of qualitative findings inevitably reflects researcher judgement. Member checking was similarly limited to three participants, selected to represent varied backgrounds and levels of engagement rather than the full sample. Future studies would benefit from independent research teams, broader participant validation, and recruitment of designers without prior engagement in this research programme.

The workshop also relied on structured design scenarios rather than longitudinal implementation in live commercial projects, and so cannot fully capture the organisational and technical constraints of everyday practice; longitudinal field studies of framework adoption would provide stronger evidence of practical effectiveness. Finally, participants were recruited primarily through Iranian and European professional networks, which may limit the transferability of findings given cross-cultural variation in behavioural responses, ethical expectations, and design practice; broader cross-cultural validation would strengthen the framework's generalisability.

These limitations point to several priorities for future research: longitudinal evaluation of framework adoption within commercial UX teams; empirical validation of the practitioner-derived physical activity and sleep domains using methods comparable to Study 1; investigation of objective approaches to behavioural state diagnosis, such as interaction telemetry or physiological sensing; and further examination of identity-threat reactance as a distinct construct, including its measurement and application across health domains.

Conclusion

This paper reported the third phase of a three-phase mixed-methods research programme investigating digital nudging in health application design, in which a participatory co-creation workshop with ten professional UX/UI designers refined Framework Version 1.0 into a practitioner-oriented framework.

The principal contribution is a diagnosis-before-selection architecture: rather than beginning with mechanism selection, the framework first guides designers in identifying users' cognitive and motivational states, translating established behavioural theory into a structured process more readily applicable in professional UX practice. Two supporting contributions strengthen this architecture: a mechanism-based ethical perspective that considers the cognitive pathway through which behavioural influence is achieved, and a sprint-compressed implementation mode that makes behavioural state diagnosis compatible with commercial agile workflows.

Framework Version 2.0 represents a research-informed foundation rather than a definitive solution; its broader value depends on validation across additional health domains, cultural contexts, and professional environments, for which longitudinal studies within commercial UX teams would be particularly valuable. More broadly, this research suggests that strengthening the relationship between behavioural science and design practice depends not only on new theory but on reorganising existing knowledge into forms

designers can apply in everyday practice; a step toward which the diagnosis-before-selection approach contributes.

Acknowledgments

Acknowledgments have been removed for the purposes of double-anonymised peer review. They will be restored in the final, accepted version of the manuscript. [Removed for double-anonymised review. Acknowledgments to study participants, supervisors, institutional support, and funding sources will be restored in the camera-ready version.]

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