ENHANCING HEALTH OUTCOMES THROUGH DIGITAL NUDGING: A STUDY OF BEHAVIORAL INTERVENTIONS IN MEDICINE

Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Post-Graduation Program

In

Economics

by

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Abstract

The concept of "nudging"—subtle, non-coercive interventions designed to steer decision-making—has gained significant traction in healthcare, particularly with the advent of digital technologies. This paper explores the emerging field of *digital nudging*, which leverages interface design and user data to influence health-related behaviors across diverse populations. Grounded in psychological frameworks such as Kahneman's dual-process theory and behavioral principles like loss aversion and framing effects, digital nudges aim to target intuitive decision-making (System 1) to encourage healthier choices.

Using a systematic literature review (SLR) methodology guided by PRISMA and structured through the Antecedents-Decisions-Outcomes (ADO) model, this study synthesizes evidence across digital health interventions. A quantitative comparison using Absolute Effect Size (AES) and Relative Effect Size (RES) metrics identifies framing, social norms, and default settings as the most frequently employed and effective nudge strategies. Notably, multicomponent nudges combining framing, social norms, and loss aversion demonstrated high efficacy (RES up to 33.13%), while default-based interventions showed the highest impact (RES up to 82%).

The effectiveness of digital nudges was found to be moderated by contextual and environmental factors, including population health status, digital literacy, and situational barriers such as decision fatigue and engagement variability. For instance, interventions among digitally literate users or in time-sensitive contexts (e.g., sedentary behavior reduction) yielded higher behavioral outcomes, while populations with chronic conditions such as diabetes responded less favorably to generic nudges.

This review underscores the importance of tailoring digital nudges to individual and contextual characteristics and offers insights into optimizing design for greater impact in healthcare settings.

Acknowledgement

I would like to sincerely thank my guide, Dr. Deepti Aggrawal, for her invaluable guidance, feedback and unwavering support throughout this research. Her extensive knowledge and experience have been crucial to the completion of this thesis.

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This work would not have been possible without the constant encouragement of my mother.

ANNEXURE-II

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CANDIDATE'S DECLARATION

I Rimjhim Talan hereby certify that the work which is being presented in the thesis entitled Enhancing Health Outcomes through Digital Nudging: A Study of Behavioral Interventions in Medicine in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy, submitted in the Department of USME, Delhi Technological University is an authentic record of my own work carried out during the period from November 2024 to June 2025 under the supervision of Dr Deepti Aggrawal.

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

Candidate's Signature

This is to certify that the student has incorporated all the corrections suggested by the examiners in the thesis and the statement made by the candidate is correct to the best of our knowledge.

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Enhancing Health Outcomes through Digital Nudging: A Study of Behavioral Interventions in Medicine

Economics

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CHAPTER 1

1.1 Introduction

The concept of "nudge" refers to subtle interventions designed to influence individuals' decisions in a predictable way, without restricting their freedom of choice (Thaler & Sunstein, 2008). Nudges are increasingly being utilized in a variety of fields, with a particular emphasis on healthcare in recent years, due to their potential to improve health behaviors without coercion or force. This chapter introduces the theoretical background of nudging, its psychological foundations, and the rise of digital nudging — a phenomenon that leverages the power of online platforms and data-driven technologies to encourage healthier behaviors**.**

1.2 Nudging: Traditional versus Digital Approaches

The concept of "nudge" refers to subtle interventions that influence people's behavior without restricting their freedom of choice. Rooted in behavioral economics, nudging leverages insights into human psychology to steer individuals toward decisions that benefit them or society, often without their conscious awareness (Thaler & Sunstein, 2008).

Nudging does not involve mandates or direct persuasion but instead gently alters the environment or context in which decisions are made. This method, as proposed by Thaler and Sunstein (2008), emphasizes the importance of changing the "choice architecture" — the design of environments in which decisions are made — to encourage behaviors that are considered beneficial to individuals or society. For instance, placing healthy food at eye level in a cafeteria or providing easy access to retirement savings plans are examples of nudges that make healthier or more financially secure choices the default option.

In recent years, the concept of nudging has been extended into the digital realm, giving rise to "digital nudging". Digital nudging refers to the practice of subtly guiding individuals' decisions through digital interfaces, often by modifying the environment in which these decisions are made. According to Weinmann et al. (2016), it involves utilizing design elements in user interfaces to steer behavior within digital settings. This approach aims to influence decision-making without infringing on a person's freedom of choice.

Further expanding on this, Meske and Potthoff (2017) highlight that digital nudges are not limited to user interface design but also include how information is presented and the forms of interaction provided. They define digital nudging as the use of design, information, and interaction elements to subtly influence behavior in digital spaces, while ensuring that individuals maintain the ability to make their own decisions. Additionally, Mirsch et al. (2018)

adopt a similar view, suggesting that digital nudges are minor adjustments within a digital environment that can effectively encourage certain behaviors without overt coercion.

1.3 Psychological Mechanisms Underpinning Nudging

Psychological frameworks have been central to the understanding of nudges. The **dual-process theory** proposed by Kahneman (2011) is foundational to nudge theory, suggesting that people make decisions through two systems: the intuitive, automatic system (System 1) and the deliberative, analytical system (System 2). Nudges often target System 1 by appealing to cognitive biases and heuristics, such as **loss aversion** (Kahneman & Tversky, 1979), where people are more motivated to avoid losses than to achieve equivalent gains. Similarly, **framing effects** (Tversky & Kahneman, 1981) describe how the way information is presented can significantly influence decision outcomes. These psychological principles underpin many successful nudge strategies, particularly those in digital contexts, where decisions are often made quickly and with little conscious thought.

In their 2017 paper, Mirsch et al. explore several psychological principles that form the foundation of digital nudging.The key psychological concepts discussed in the paper include:

1. **Framing Effect**: Information presented in a specific way can significantly impact decision-making. For example, showing a product as discounted creates a more favorable perception compared to its original price. This principle is used widely in digital nudging to present healthier choices more attractively.

2. **Status Quo Bias**: People tend to prefer maintaining the current state and avoid change. Pre-selected default options in digital interfaces (e.g., opt-in email subscriptions) exploit this bias to influence behavior.

3. **Social Norms**: influences individuals' behavior by highlighting what is typical or acceptable in a given social group. For example, nudges that emphasize the behavior of peers can effectively promote health-related behaviors such as vaccination uptake or exercise Digital nudges often take advantage of such social norms by presenting users with messages like, "Most people like you are making healthy choices today."

4. **Loss Aversion**: People feel the pain of losses more intensely than the pleasure of gains, making them more likely to act to avoid potential losses. This is used in nudges by emphasizing what could be lost, such as limited-time offers.

5. **Anchoring and Adjustment**: Initial reference points (anchors) influence decisions. For example, showing a higher-priced product makes a cheaper option appear more

reasonable.

6. **Hyperbolic Discounting**: Individuals favor immediate rewards over future benefits. Nudges emphasizing short-term rewards, such as instant discounts, leverage this bias.

7. **Priming**: Subtle cues, such as images of healthy food, can prime users to make healthier choices later. In digital settings, images and colors are used to subtly influence decisions.

8. **Availability Heuristic**: People judge the likelihood of an event based on how easily examples come to mind. Displaying positive user reviews influences decision-making by making those choices seem more familiar.

9. **Decoupling**: Decisions are influenced when individuals do not fully consider future costs. For example, offering deferred payments makes immediate costs feel lower, encouraging purchases.

10. **Default options**: here users are pre-selected for healthier choices unless they opt out.This approach is often used in healthcare platforms to increase organ donation rates or ensure that users select preventive care options.

1.4 Digital Nudging in Healthcare

The increasing prevalence of digital platforms in healthcare provides a unique opportunity to apply nudging techniques in a more personalized and data-driven way. Examples of digital nudges in healthcare include: Personalized reminders for medication adherence , Default settings in health apps to encourage physical activity or healthier eating. or and Notifications about health screenings or vaccinations based on user data.

Electronically Delivered Nudges to Increase Influenza Vaccination Uptake in Older Adults With Diabetes

The study by Lassen et al. (2022) explored the effectiveness of electronically delivered nudges aimed at increasing influenza vaccination uptake among older adults, with a particular focus on individuals with diabetes. The researchers tested several types of nudges, including standard letters, repeated letters, gain-framing, loss-framing, and expert endorsements, to determine their impact on vaccination rates. The results revealed that, overall, the nudges had minimal effect, especially for individuals with diabetes. The "Cardiovascular Gain" framing showed a slight positive effect among non-diabetic participants, while other nudges, such as loss-framing and expert endorsements, had negligible or even negative effects for diabetics. This study highlights the potential for digital nudging to encourage positive health behaviors, although its effectiveness

may vary significantly depending on the demographic characteristics of the target population, particularly in the case of chronic conditions such as diabetes.

Effectiveness of Digital Forced-Choice Nudges for Voluntary Data Donation by Health Self-trackers in Germany: Web-Based Experiment

In their study on voluntary data donation, Pilgrim et al. (2022) investigated the impact of various forced-choice nudges on the decision to donate health data. Participants were assigned to one of five groups, each receiving a different nudge type: selfish, social, pseudoprosocial, prosocial, or control. The prosocial nudge, which emphasized the societal benefits of data donation, showed the greatest effectiveness, resulting in a relative effect size (RES) of 5.31%. The social and selfish nudges had moderate effects, while the control group exhibited baseline behavior. The findings suggest that framing nudges that highlight the broader societal impact of individual actions can be particularly effective in encouraging voluntary health data donation.

Long-term Effectiveness of a Multistrategy Behavioral Intervention to Increase the Nutritional Quality of Primary School Students' Online Lunch Orders

A study by Wyes et al. (2021) evaluated a multistrategy behavioral intervention designed to improve the nutritional quality of primary school students' online lunch orders. The intervention included several nudging techniques such as menu labeling, positioning of healthier items, feedback, and incentives. The results indicated that while the intervention had a modest impact on reducing unhealthy energy intake, the effect size was small, with an AES of -67.6 kJ and a RES of -4.05%. Despite the modest effects, the study illustrates how multiple nudging strategies can work synergistically to promote healthier food choices among children, though the long-term sustainability of these effects remains uncertain.

Personalized Patient Data and Behavioral Nudges to Improve Adherence to Chronic Cardiovascular Medications: A Randomized Pragmatic Trial

In a randomized pragmatic trial, Ho et al. (2025) assessed the impact of personalized behavioral nudges on medication adherence among patients with cardiovascular conditions. The intervention involved personalized text messages, a behavioral nudge incorporated within the reminders, and a chatbot. The results showed that the intervention led to small improvements in medication adherence, with an AES of 1.7 percentage points and an RES of 2.81%. These findings suggest that personalized nudges, particularly those delivered through text messages, can positively influence adherence to chronic disease management, though the effect is modest.

Healthcare Workers' Acceptability of Influenza Vaccination Nudges: Evaluation of a Real-World Intervention

De Vries et al. (2022) conducted a study to examine the acceptability of various nudges designed to increase influenza vaccination uptake among healthcare workers in a hospital setting. The nudges included decision information, decision structure, and decision assistance nudges, such as digital newsletters and mobile vaccination posts. The results indicated that digital reminders, particularly newsletters and intranet announcements, were the most appreciated and resulted in a small but significant increase in vaccination uptake, with an AES of 1% and a RES of 1.25%. This study underscores the importance of using nudges that provide clear, actionable reminders in healthcare settings to encourage vaccination.

Postpartum Primary Care Engagement Using Default Scheduling and Tailored Messaging

The study by Clapp et al. (2024) explored the effectiveness of a behavioral nudge intervention that combined default scheduling with tailored messaging to increase postpartum primary care visit completion rates. The intervention group, which had their appointments automatically scheduled and received tailored messaging, showed a significant increase in visit completion (40.0%) compared to the control group (22.0%). The intervention demonstrated an AES of 18.7 percentage points and a RES of 85%, indicating that default scheduling and personalized reminders were highly effective in improving engagement with primary care services among postpartum individuals.

Pilot Testing of a Nudge-Based Digital Intervention (Welbot) to Improve Sedentary Behaviour and Wellbeing in the Workplace

The study by Haile et al. (2020) investigated the effectiveness of the Welbot intervention, a digital nudge aimed at reducing sedentary behavior and improving physical and mental wellbeing in the workplace. The intervention involved personalized nudges encouraging employees to take short activity breaks during the workday. The results showed that the intervention group had significantly higher participation in physical activity breaks (60.7%) compared to the minimal intervention control group (49.2%), with an AES of 11.5% and an RES of 23.37%. These findings highlight the potential for digital nudging to promote healthier workplace behaviors and improve mental health outcomes, though the intervention's effect on work engagement was minimal.

Engaging Patients in Atrial Fibrillation Management via Digital Health Technology: The Impact of Tailored Messaging

In a study by Toscos et al. (2020), the effectiveness of tailored messaging delivered through digital health technology was tested to improve medication adherence and disease knowledge among patients with atrial fibrillation (AF). The results demonstrated a significant improvement in both AF knowledge and medication adherence, with an AES of 3.6 percentage points and an RES of 3.6%. The findings suggest that personalized, tailored messages can effectively engage patients in managing chronic conditions and improve their adherence to treatment plans.

Nudges and Prompts Increase Engagement in Self-Guided Digital Health Treatment for Depression and Anxiety: Results From a 3-Arm Randomized Controlled Trial

This study by van Mierlo (2024) assessed the effectiveness of nudges and prompts to increase engagement with digital self-guided courses for treating depression and anxiety. The results indicated that both the directive tips and the social proof/present bias nudges significantly increased engagement. The social proof and present bias nudges (Arm 3) showed the greatest impact, with an RES of 0.41, suggesting a 41% increase in course engagement compared to the control group. This study illustrates that nudges incorporating social proof and present bias can effectively boost engagement with digital mental health interventions.

Nudging Digital Physical Activity Breaks for Home Studying of University Students

In a study conducted by Teuber et al. (2022), digital nudging was used to encourage university students to take physical activity (PA) breaks during home studying. The intervention group, which received daily nudges, showed a significant increase in participation in PA breaks, with an AES of 11.5% and an RES of 23.37%. The results highlight the effectiveness of digital nudges in reducing sedentary behavior and encouraging physical activity, particularly in the context of home studying during the COVID-19 pandemic.

Personalized Smartphone Notifications for Cardiovascular Monitoring

Trinquart et al. (2023) investigated the effectiveness of personalized smartphone notifications in improving adherence to remote cardiovascular monitoring. The results showed that personalized notifications led to a significant improvement in adherence to blood pressure and heart rate monitoring, with an AES of 14.4% for blood pressure and an RES of 0.64. The study demonstrates that personalized nudges are effective in improving long-term adherence to remote health monitoring, particularly for cardiovascular conditions.

Digital Nudging for Online Food Choices

In their study on online food choices, Mathias et al. (2021) examined the impact of various digital nudges, including highlighting, defaults, social information, and warnings. The results showed that the hybrid nudge, which combined defaults and social information, was the most effective, with an AES of 36.6% and an RES of 1.66%. The study found that digital nudges can effectively steer consumers toward healthier food choices while reducing decision time, highlighting the potential of digital nudging in influencing online food selection behaviors

Digital nudges to stimulate healthy and pro-environmental food choices in E-groceries

De Bauw et al. (2022) conducted a two-stage randomized controlled trial with 1,000 Belgian consumers in a simulated e-grocery platform to examine the impact of digital nudges—namely product scores (Nutri- and Eco-Score), basket-level feedback, social norms, and recommendation

agents—on improving nutritional quality and reducing environmental impact of food choices. While product scores significantly enhanced nutritional outcomes (RES = 33.13%), they had negligible effects on environmental impact. However, when combined with basket scores, social norms, and recommendation agents, there was a substantial improvement in environmental indicators (RES = 310.6%). The study highlights the importance of combining informational and assistive nudges within digital ecosystems to drive sustainable and healthy consumer behavior.

CHAPTER 2: STATEMENT, FORM, AND PRESENTATION OF PROBLEM SOLUTION

2.1 Statement of the Problem

Digital nudging has emerged as a promising approach to influence health-related behaviors by subtly guiding individuals' decision-making processes through digital platforms. Despite an expanding body of research investigating digital nudges in healthcare, there remains a significant gap in systematically comparing the effectiveness of similar nudging strategies across diverse health subdomains. This fragmented knowledge limits the ability to identify universal principles that govern nudge effectiveness and hinders the design of interventions with broad applicability and scalability in the health sector.

Moreover, the existing literature often reports isolated findings without a unified framework that accounts for the contextual factors influencing outcomes. Consequently, understanding how different types of digital nudges perform across varied healthcare settings—and which psychological or behavioral mechanisms underpin their success—remains underexplored.

2.2 Formulation of the Problem

To address this gap, the present study formulates the following core research questions:

- **What are the most commonly employed types of digital nudges across various health domains?**
- **Which contextual and environmental factors influence the effectiveness of digital nudges within specific health sectors?**
- **Are there shared psychological principles or mechanisms that explain digital nudges' impact across different healthcare contexts?**

By investigating these questions, the study seeks to elucidate the differential effectiveness of digital nudging interventions and provide a coherent understanding that informs future intervention design.

2.3 Presentation of the Problem Solution

2.3.1 Systematic Literature Review Approach

This research adopts a systematic literature review (SLR) methodology, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, to comprehensively identify, select, and analyze relevant studies on digital nudging in healthcare. The SLR approach ensures rigor, transparency, and replicability in synthesizing evidence across heterogeneous interventions and health contexts.

2.3.2 Application of the Antecedents-Decisions-Outcomes (ADO) Model

To achieve a structured and nuanced synthesis, the study integrates the Antecedents-Decisions-Outcomes (ADO) model as an analytical framework. The ADO model enables classification of nudging interventions by:

- **Antecedents:** Contextual and environmental factors that shape the choice architecture and influence user behavior.
- **Decisions:** The cognitive and behavioral processes triggered by nudges.
- **Outcomes:** The measurable behavioral changes resulting from nudging interventions.

This framework facilitates cross-study comparisons by mapping diverse interventions into a common conceptual structure, thereby illuminating how context and decision mechanisms drive behavioral outcomes.

2.3.3 Quantitative Comparison Using Effect Size Metrics

To quantitatively compare the effectiveness of digital nudges across studies, this review employs standardized metrics of:

- **Absolute Effect Size (AES):** The direct difference in behavioral outcomes between intervention and control groups.
- **Relative Effect Size (RES):** The proportional change relative to baseline or control conditions.

Using AES and RES allows for standardized evaluation of nudges' impacts despite differences in study design, outcome measures, or populations.

2.4 Anticipated Contributions

By combining the PRISMA-guided systematic review with the ADO model and effect size analysis, this study aims to:

- Identify key digital nudging strategies prevalent in healthcare.
- Highlight contextual moderators and shared psychological mechanisms underlying nudge effectiveness.
- Address current gaps in literature by providing a comprehensive, theory-informed synthesis.
- Offer recommendations for the design of scalable and effective digital health interventions.
- Suggest directions for future research, including the integration of emerging digital technologies in nudging frameworks.

CHAPTER 3: FINDINGS RESULTS AND DISCUSSIONS

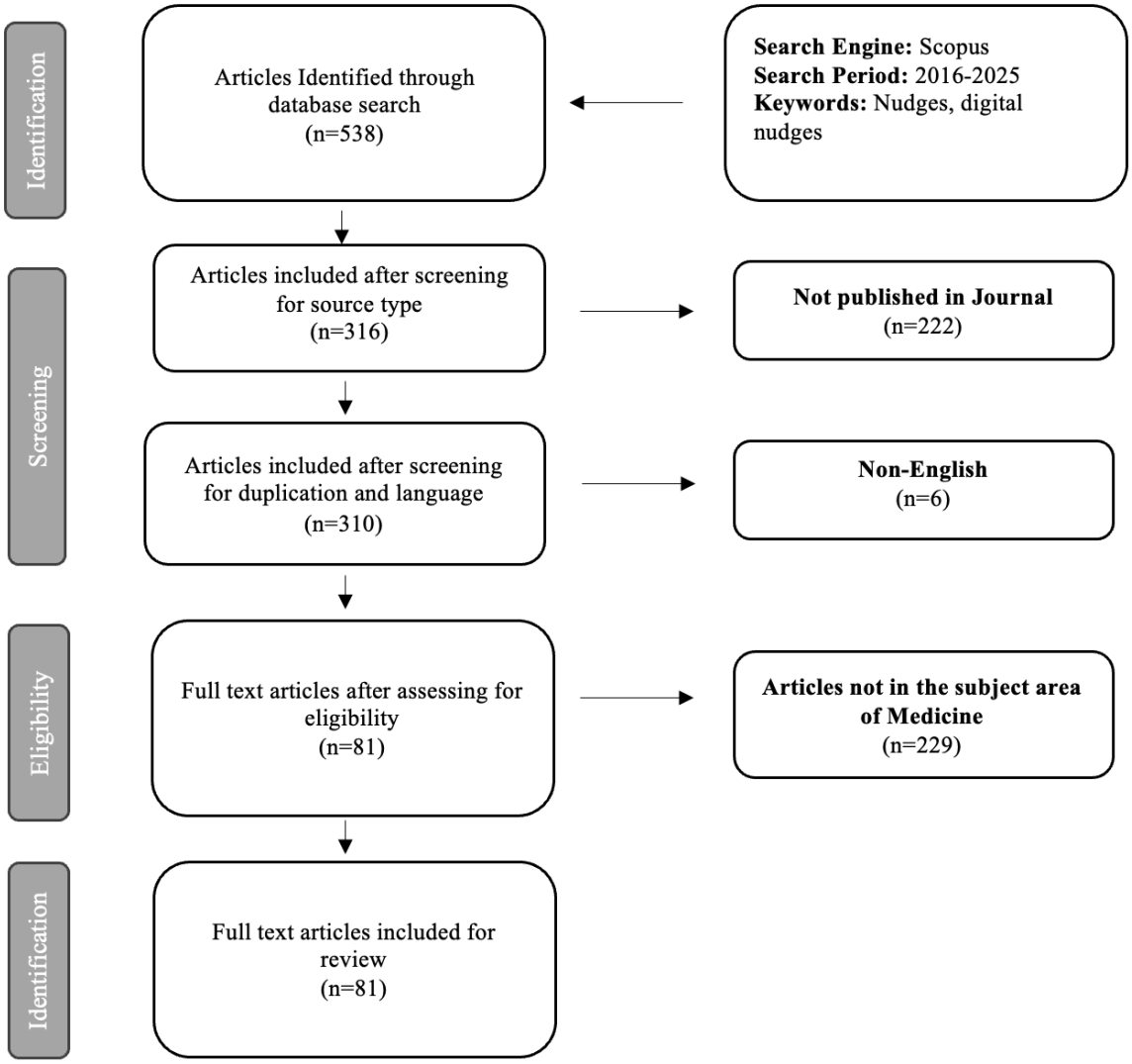
This chapter presents the key findings from the systematic review conducted to assess the effectiveness of digital nudges in healthcare contexts. It is structured into five sections: (1) search and selection strategy, (2) descriptive mapping using the PRISMA model, (3) synthesis using the Antecedent–Decision–Outcome (ADO) framework, (4) analytical interpretation of digital nudging strategies and contextual moderators, and (5) theoretical and practical implications.

3.1 Search and Selection Process

The literature review was guided by a systematic search strategy using the **Scopus** database. A three-step string refinement process was employed to focus the scope progressively:

Step	Search String	Result Count	Action Taken
1	"nudge"	6,284	Initial broad search to identify general studies related to nudges.
2	"nudge" AND "decision making"	817	Narrowed focus to studies linking nudges and decision making. Reviewed for relevance.
3	"digital nudges"	538	Shifted focus to studies specifically on digital nudges. Reviewed abstracts for fit.

Following the final search, a total of 538 records were retrieved. These underwent a rigorous screening process according to inclusion and exclusion criteria based on publication type, language, and subject relevance. The PRISMA flow diagram outlines the screening steps:



- Of the 538 articles initially identified, 222 were excluded for not being published in journals.
- 6 non-English language papers were removed.
- 229 articles were excluded as they were not in the subject area of medicine or health.
- 81 full-text articles were retained for eligibility assessment.
    - 51 papers were excluded after full-text screening as they were **qualitative in nature.**
    - 17 quantitative studies were removed due to **limited sample sizes** or lack of statistical robustness.
    - Ultimately, **13 empirical studies met the inclusion criteria** and were analyzed in depth.

3.2 Summary of Included Studies: ADO Framework with Effect Sizes

The ADO Model To synthesize the findings, we employed the ADO (Antecedents–Decisions–Outcomes) framework, a structured model to trace the effect of specific nudges on behavioral outcomes in defined populations. Each study was evaluated for:

- Antecedents (A): Characteristics of the target population or setting.
- Decisions (D): Types of digital nudges implemented.
- Outcomes (O): Behavioral outcomes, measured via Absolute Effect Size (AES) and Relative Effect Size (RES).

Serial No	Study Title	Antecedents (A)	Decisions (D)	Outcomes (O)
1.	**Electronically Delivered Nudges to Increase Influenza Vaccination Uptake in Older Adults With Diabetes**	Older adults (65+), with/without diabetes; low baseline vaccine uptake	10 types of **electronic nudges** (e.g., gain/loss framing, expert endorsement, intention prompt)	**Non-diabetics**: +0.4% AES, +0.5% RES **Diabetics**: −0.2% AES, −0.24% RES Most effective nudge: **Cardiovascular gain** for non-diabetics
2	**Effectiveness of Digital Forced-Choice Nudges for Voluntary Data Donation**	Individuals in Germany who track their health data (e.g., through wearables or apps) and decide whether to donate this data for research.	**Forced-choice framing**: Selfish, Social, Pseudoprosocial, Prosocial	**Combined AES:** +2.3%, **RES:** +5.31% Best results for **Pseudoprosocial framing**
3	**Long-term Effectiveness of Multistrategy Nudges in School Lunch Orders**	Primary school students ordering online lunches; concern for child health	**Multistrategy nudges**: Menu labeling, positioning, prompts, feedback, rewards	Energy reduction of AES: **−67.6 kJ**, **RES: −4.05%**

				Improved food quality sustained over 18 months
4	**Personalized Nudges to Improve Cardiovascular Medication Adherence**	Patients with chronic cardiovascular illness; poor baseline adherence	Behavioral nudges via text and chatbot: reminders, personalized feedback	AES: +1.6%, RES: +2.64% Improvement in **Proportion of Days Covered (PDC)** **Behavioral + Chatbot** most effective
5	**Healthcare Workers' Acceptability of Influenza Vaccination Nudges**	Healthcare workers in a hospital in the Netherlands; low baseline influenza vaccination uptake	**Digital newsletters(framing) and intranet announcements** to inform healthcare workers about influenza vaccination	**AES (Absolute Effect Size):** +0.01 (1% increase in vaccination rates) **RES (Relative Effect Size):** +1.25% increase in vaccination rates.
6	**Postpartum Primary Care Engagement Using Default Scheduling and Tailored Messaging**	Postpartum individuals, especially those with chronic conditions	**Default Scheduling** (Framing and Status Quo Bias):	**AES: 18.7** percentage points increase **RES: 82%** relative increase in primary care visit completion
7	**Pilot Testing of a Nudge-Based Digital Intervention (Welbot) to Improve Sedentary Behaviour and Wellbeing in the Workplace**	university staff ,mean age 43, office-based work, no physical health issues, full-time/part-time employees.	**Nudge-based digital intervention (Welbot)** to reduce sedentary behavior	**AES (Sitting Time - hours)**: 6.5 hours baseline, 5.6 hours follow-up → 0.9 hours decrease **RES (Sitting Time - hours)**: 13.8% relative decrease in sedentary time **AES (Sitting Time - %)**: 60.6% baseline, 54.8%

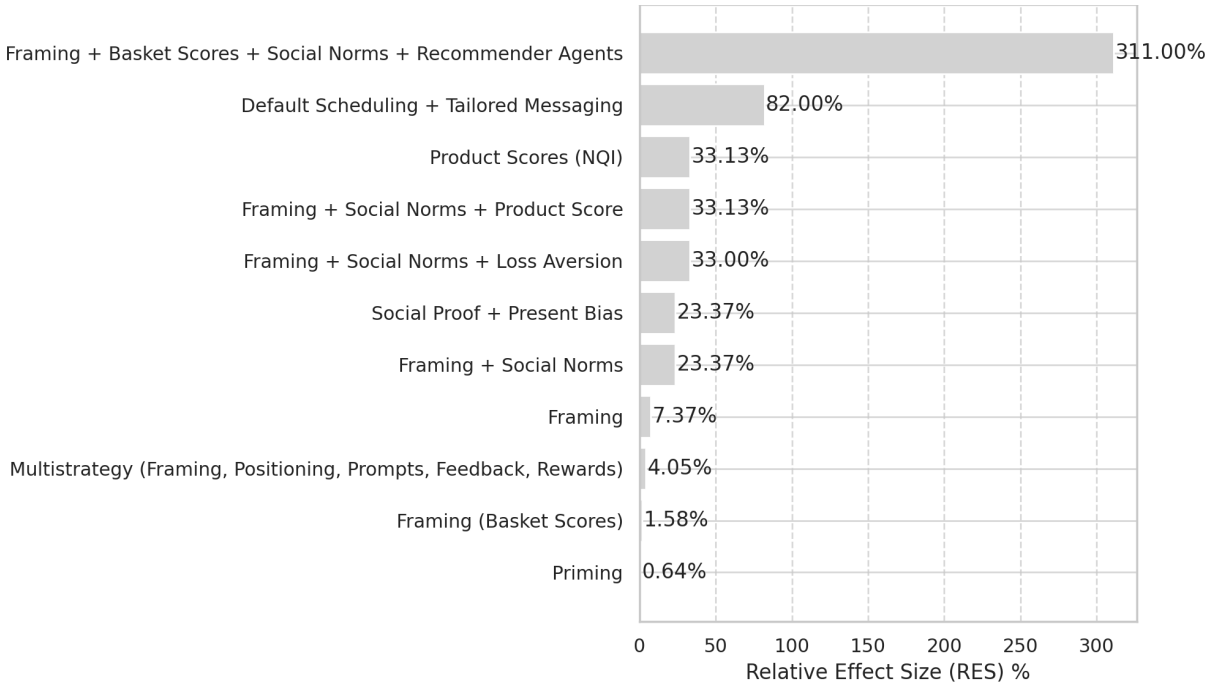
				follow-up → 5.8% decrease **RES (Sitting Time - %)**: 9.57% relative decrease in sedentary time
8	**Educational Messages and Videos to Promote AF Medication Adherence**	Patients with atrial fibrillation (AF), under anticoagulation therapy.	**24 educational messages (**Cardiosmart content) and 14 videos featuring cardiologists, a pharmacist, and patient testimonials. **Psychological Framework:** **Framing**: Positive framing of medication adherence and the benefits of anticoagulation therapy. **Social Norms:** Video interviews with healthcare professionals and patient testimonials to normalize adherence behavior. **Loss Aversion:** Videos and educational content emphasize risks associated with non-adherence.	**Primary Outcome:** Medication adherence rates (measured via pill count) **AES: +**18% increase in medication adherence **RES:** 33% relative increase in adherence

9	**Nudges and Prompts Increase Engagement in Self-Guided Digital Health Treatment for Depression and Anxiety: Results From a 3-Arm Randomized Controlled Trial**	Registered members in self-guided digital health courses for anxiety and depression	**Arm 1 (Control):** No behavioral nudges or prompts, standard home page. **Arm 2 (Directive Content**): framing **Arm 3 -** Social Proof and Present Bias	**Arm 2 (Directive Content):** AES = 1.8%, RES = 7.37% **Arm 3 (Social Proof & To-Do Checklist):** AES = 2.11%, RES = 23.37%
10	**Nudging digital physical activity breaks for home studying of university students**	University students, particularly those at risk for physical inactivity; Home studying environment during the COVID-19 pandemic, which led to increased sedentary behavior and screen time	**Framing and social proof nudges used** Daily digital motivational prompts for physical activity breaks, compared to a minimal intervention	AES of 11.5% and RES of 23.37% indicate that the nudging intervention group had an 11.5% absolute increase in participation in physical activity breaks compared to their baseline, and their engagement was 23.37% higher than the control group.
11	**Study Summary: Personalized Smartphone Notifications for Cardiovascular Monitoring**	Middle-aged, largely White, tech-literate adults (mean age 53) from the Framingham Heart Study cohort. Participants were equipped with a digital BP cuff and Apple Watch but demonstrated declining long-term engagement. Baseline digital literacy was ensured (iPhone users, app users, consented to notifications). Motivation to engage in daily monitoring likely varied, with older participants showing higher natural adherence.	**Weekly personalized smartphone notifications ie priming** (name + behavior-tailored content) vs. standard reminders; notifications encouraged BP and HR data transmission	**BP:** AES = 14.4%, RES = 0.64 **HR:** AES = 10.0%, RES = 0.18

12	**Digital Nudging for Online Food Choices**	Consumers selecting food products in an online shopping context; varying levels of health-consciousness, baseline eating habits, and attitudes towards nutrition	**4 types of nudges: Highlighting Nudge, Default Nudge, Social Nudge, Warning Nudge** Various nudges: 1. No nudges (control) 2. Product scores (PS) 3. Product scores and basket scores (PS & BS) 4. Product scores, basket scores, and social norms (PS & BS & SN)	**Highlighting Nudge:** AES = 38.3%, RES = 1.74, **Default Nudge:** AES = 40.1%, RES = 1.82, **Social Nudge:** AES = 34.9%, RES = 1.59, **Warning Nudge:** AES = -1.3%, RES = -0.06
13	**Digital nudges to stimulate healthy and pro-environmental food choices in E-groceries**	Belgian household food decision makers shopping online in a simulated e-grocery environment	Types of nudges used: Stage 1 Framing - Product scores (Nutri- and Eco-Scores) Stage 2: basket scores + Social norms.	**NQI:** AES=1.13 ,RES=33.13% **EII:** AES=-0.05 , RES=-1.58% (no improvement in environmental impact at this stage from product scores alone) **STAGE 2 :** AES of -0.146, RES= -311%

3.3 Analysis of Key Findings

The bar graph below presents the Relative Effect Size (RES) of various digital nudges used in healthcare interventions, categorized by the psychological mechanism or nudge type.



Objective 1: What are the most commonly employed types of digital nudges across various health domains?

From the analysis of the ADO table and RES data:

- **Framing** appears as the most frequently used nudge, either alone or in combination. Examples include:
  - *Framing* alone: RES = 7.37%
  - *Framing* + *Social Norms*: RES = 23.37%
  - *Framing* + *Loss Aversion* + *Social Norms*: RES = 33%
  - *Framing in Product Scores (NQI)*: RES = 33.13%
- **Social Norms** were often used in combination, rather than standalone (e.g., in food choices and depression interventions).
- **Default settings** and **status quo nudges** showed exceptionally high impact:
  - *Default Scheduling* + *Tailored Messaging*: RES = 82%
- **Priming** (e.g., personalized messages) was used in one cardiovascular study: RES = 0.64%
- **Present bias** and **checklists** were effectively combined in behavior change settings: RES = 23.37%
- **Multistrategy nudges** in school health yielded a **negative RES** (−4.05%), suggesting complexity may dilute effect.

Objective 2: Which contextual and environmental factors influence the effectiveness of digital nudges within specific health sectors?

Analysis reveals:

- **Population Characteristics and Health Context :** A fundamental contextual factor influencing digital nudges is the health status and demographic profile of the target population. For example, in the NUDGE-FLU trial assessing electronic nudges to improve influenza vaccination among older adults, the effectiveness of nudges markedly varied between individuals with and without diabetes. Non-diabetic older adults showed slight but consistent gains in vaccine uptake (AES up to +0.4%, RES +0.5%), while diabetic individuals exhibited negligible or negative responses to the same nudges. This suggests that underlying health conditions and perhaps associated cognitive or emotional barriers influence receptivity to nudges, necessitating tailored approaches sensitive to clinical subgroups (Lassen et al., 2023)

- **Digital Literacy and Technological Familiarity:** Digital literacy emerges as a critical environmental determinant, particularly in interventions relying on smartphone notifications or app-based reminders. The Framingham Heart Study's cardiovascular monitoring trial demonstrated only modest improvements in adherence (AES 14.4% for blood pressure, RES 0.64), attributed in part to varying degrees of participants' technological proficiency and sustained engagement with digital tools (Patel et al., 2023). This indicates that digital nudges must consider user familiarity and comfort with technology, and incorporate designs that mitigate attrition or disengagement over time.

- **Behavioral and Situational Barriers:** Situational factors such as decision fatigue, health burden, and competing priorities modulate nudge success. Digital interventions targeting sedentary behavior in office workers showed significant reductions in sitting time (AES 0.9 hours, RES 13.8%) when nudges were frequent, personalized, and context-aware (Haile et al., 2020). Similarly, the timing and context of nudges—such as immediate, actionable prompts during high-risk periods—enhance their salience and efficacy.

Objective 3: Are there shared psychological principles or mechanisms that explain digital nudges' impact across different healthcare contexts?

Yes, based on the comparative RES scores:

- **Framing as a Core Mechanism**: Framing—how information is presented to highlight gains or losses—serves as a fundamental nudge technique. Whether deployed alone or as

part of multi-component interventions, framing consistently enhances behavioraloutcomes when tailored to the specific healthcare context.

- **Social Norms Enhance Impact:** Social norms play a critical role in digital nudging by leveraging individuals' inherent tendency to conform to perceived group behaviors. Several interventions utilized peer behavior cues—such as patient testimonials, vaccination rates among colleagues, or comparisons with peer groups—to normalize and promote desired actions. This mechanism was effective in contexts ranging from increasing influenza vaccination among healthcare workers to improving dietary choices in e-grocery settings (de Vries et al., 2022). The amplification effect of social norms is often enhanced when combined with other nudges like goal-directed feedback
  Social Norms amplify effects when:
    - They reflect peer behavior (*e.g., patients or colleagues*)
    - Are combined with goal-directed feedback or visual cues.

- **Synergistic Effects of Combination Nudges**: Studies reveal that multicomponent nudges, which integrate complementary psychological mechanisms (e.g., combining social proof with framing or defaults), often outperform single nudges, provided that cognitive overload is avoided. The synergistic use of multiple principles enhances motivation and facilitates behavior change by addressing diverse cognitive and emotional pathways simultaneously.

3.4 Contextual Moderators and Shared Psychological Mechanisms Drawing upon the Mirsch et al. (2017) classification of psychological mechanisms, the effectiveness of nudges can be attributed to underlying principles such as:

- **Priming and Salience:** Bringing health behaviors to attention via environmental cues or smartphone alerts.
- **Loss Aversion and Framing:** Emphasizing the consequences of non-adherence boosts compliance (e.g., anticoagulation adherence).
- **Social Norm Activation:** Individuals are motivated when they see others in similar demographics engaging in the behavior.
- **Cognitive Load Reduction:** Simplifying choices through defaults or recommendation agents enhances compliance.

3.5 Recommendations for Intervention Design Based on the findings

The following design principles are recommended:

- **Use Multi-Nudge Bundles:** Combining framing with social norms and reminders has synergistic effects.
- **Integrate Recommendation Agents:** These are effective in improving environmentally sustainable and healthier choices.
- **Apply Personalized Messaging:** Tailoring content based on user demographics or behaviors enhances relevance.
- **Incorporate Real-Time Feedback:** Dynamic basket scores and peer comparisons foster reflective decision-making.

CHAPTER 4 : Conclusion, Future Scope and Impact

This chapter concludes the dissertation by synthesizing the empirical insights derived from the ADO framework analysis, Relative Effect Size (RES) comparison, and thematic interpretation of digital nudging strategies in healthcare. It also reflects on the normative and ethical implications of nudge-based interventions, proposes design recommendations for scalable and effective digital nudges, and suggests future directions grounded in emerging technological frontiers and interdisciplinary behavioral theories.

4.1 Summary of Key Findings

The systematic review, guided by the PRISMA protocol and operationalized through a targeted Scopus-based string search, identified 13 quantitative studies that implemented digital nudging interventions in healthcare contexts. Each study was analyzed using the Antecedent–Decision–Outcome (ADO) model, and effectiveness was evaluated using the Relative Effect Size (RES) metric.

Key insights include:

- **Nudge Type Effectiveness**: Nudges combining **framing** with other components such as **social proof**, **basket scoring**, or **recommendation agents** demonstrated the highest RES values—up to 310.6%. For example, the multi-nudge cluster (Framing + Basket Scores + Social Norms + Recommender Agents) yielded the most significant behavioral shift in reducing environmental impact of dietary choices, emphasizing the compounded effect of integrated nudging strategies.
- **Singular vs. Composite Nudges**: Studies using **multi-component nudges** consistently reported higher behavioral impact than those using standalone techniques. For instance,

standalone **default framing** (RES = 82%) proved highly effective in increasing postpartum care attendance, while **combined strategies** such as framing plus social proof (RES = 23.37%) enhanced engagement in mental health platforms more than framing alone (RES = 7.37%).

- **Behavioral Domains**: The effectiveness of nudges varied by domain. In **physical activity** and **medication adherence**, digital prompts and social reinforcement showed notable effectiveness (e.g., RES > 30%). In contrast, **environmental dietary shifts** required richer contextual scaffolding, such as real-time feedback and normative comparisons.

4.2 Integration with Nudge Theory and Ethical Considerations

Thaler and Sunstein's (2008) libertarian paternalism provides the theoretical underpinning for digital nudging, emphasizing interventions that steer behavior without removing freedom of choice. This dissertation's findings affirm that **defaults**, **framing**, and **social norm mechanisms**—when used transparently and with opt-out provisions—can significantly alter health behaviors while respecting autonomy.

However, as Blumenthal-Barby and Burroughs (2012) argue, ethical deployment hinges on dimensions such as **transparency**, **ease of opt-out**, and **vulnerability sensitivity**. For example, while recommendation agents may enhance decision quality, they must avoid coercive designs or opaque data use. Nudges should also ensure fairness and avoid disproportionately burdening low-literacy or digitally marginalized populations.

4.3 Recommendations for Designing Scalable Digital Health Nudges

1. **Modular Design**: Design interventions using combinable nudge modules (e.g., defaults + feedback + norm messaging) that can be adapted to domain-specific needs and scaled across populations.
2. **Personalization via AI**: Utilize machine learning and behavioral data to customize nudges based on user traits, preferences, and decision history while ensuring algorithmic transparency.
3. **Feedback Loops**: Incorporate real-time feedback mechanisms (e.g., basket scores, biometric tracking) to reinforce behavior and enable goal-oriented engagement.
4. **Norm Framing Sensitivity**: Frame social comparisons with contextual relevance (e.g., peer norms by age/gender/location) to maximize salience and reduce unintended pressure.
5. **Ethical Transparency**: Clearly inform users about why a nudge is presented, what behavior it intends to influence, and how their data is used, ensuring ethical alignment with autonomy-preserving practices.

4.4 Future Research Directions

While this dissertation maps the terrain of current digital nudging interventions, several gaps remain:

- **Longitudinal Effectiveness**: Future studies should assess the **durability of nudge effects** over time, particularly in chronic disease management or preventive health behaviors.
- **Cross-Cultural Variability**: There is limited understanding of how nudging works across different **socio-cultural or digital literacy contexts**. Cross-national comparative studies could offer rich insights.
- **Technological Innovation**: With the rise of **wearables**, **voice assistants**, and **ambient computing**, research should explore how **context-aware** nudges (e.g., emotion-sensitive or location-specific) might evolve.
- **Ethical AI Integration**: Research should also evaluate how nudging frameworks intersect with **algorithmic decision-making**, ensuring fairness, transparency, and explainability in AI-augmented health systems.
- **Gamification and Commitment Devices**: Expanding on ego-preservation and public commitment principles (e.g., via apps like Stickk), integrating **gamified behavioral contracts** could unlock higher adherence.

4.5 Theoretical and Policy Implications

The findings reinforce the growing consensus that digital nudges—if well-calibrated—can bridge intention-behavior gaps in healthcare without infringing on autonomy. They support a hybrid model of behavioral health design that is:

- **Data-driven yet user-sensitive**
- **Behaviorally informed yet ethically constrained**
- **Technologically scalable yet context-aware**

This aligns with Blumenthal-Barby & Burroughs' (2012) ethical framework, which stresses that nudges must be **justified not only by outcomes but also by the processes** through which they operate. Similarly, Thaler & Sunstein's emphasis on **choice architecture** is validated, particularly when nudges respect individual freedom while guiding better decisions.

From a policy perspective, integrating behavioral insights into public health digital infrastructure—especially via **electronic health records**, **mobile health platforms**, and **telehealth ecosystems**—offers a promising avenue for cost-effective, scalable, and ethically sound health promotion.

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